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FOREWORD

The Proceedings Book is consisted of 134 abstracts and full papers written by more than 420 authors from 36 countries. Topics of the World Congress of Performance Analysis of Sport XII are: sports performance, analysis of referees, coaching process, coach behaviour, biomechanics, analysis of technique, technical effectiveness, tactical evaluation, patterns of play, neuromotor control, movement in sport, motor learning and feedback, work rate, physical demands, performance analysis technology, analysis of elite athletes and teams, effectiveness of performance analysis support, performance analysis in health and senior sport, performance analysis in youth sport, observational analysis of injury risk, technology and performance analysis systems, gymnastics & dance, doping, nutrition and supplementation influence on performance. Papers and abstracts that will be presented at the Congress are intended for sports scientists, kinesiologists, coaches, athletes and others interested in any aspect of performance analysis of sport.

We are especially proud that Soccer day is the part of this year's Congress. Soccer day is organised in cooperation with Croatian Football Federation and it will be a great opportunity to analyse the World Cup 2018 held in Russia and other aspects of performance analysis in soccer.

We would like to express our gratitude to partners and cooperating institutions like Faculty of Teacher Education, University of Zagreb, Croatia, Faculty of Physical Education and Sport, University of Priština "Hasan Prishtina", Kosovo, Faculty for Sport and Physical Education, Nikšić, University of Montenegro, Science and Research Centre, Koper, Slovenia, Faculty of Education, University of Travnik, Bosnia and Hercegovina, Faculty of Physical Education and Sport, University of Niš, Serbia, Faculty of Electrical Engineering and Computing, University of Zagreb, Faculty of Sport and Physical Education, University of Sarajevo, Bosnia and Herzegovina, Faculty of Kinesiology University of Split, Croatia, School of Natural Sciences and Health, University of Tallin, Estonia.

At the end, special thanks goes to the members of Organising and Scientific Committee, international reviewers and all others included in the preparation and organisation of this Congress for their effort. We sincerely hope that all participants of the Congress will gain new knowledge and contacts for the future collaboration in various scientific and professional projects in performance analysis of sport.

Editors

Contents

Opening Lecture

Performance analysis perspectives

Nic James

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The notation of sports events to create an objective record of behaviour can be traced back to the notation of dance (Laban, 1948), baseball (Fullerton, 1912) and basketball (Messersmith and Corey, 1931). The first hand notation system for racket sports in the UK was developed for tennis (Downey, 1973) but due to its complexity was never used to gather data (Hughes, Hughes and Behan, 2007). The works of Reep and Downey inspired researchers at Liverpool Polytechnic who started the first sports degree, independent of Physical Education, in the UK in the mid-1970s. From the staff, some influential researchers emerged, including Reilly and Thomas (1976) who coded football players' movements into standing, walking, trotting, running and sprinting categories. This relatively simple analysis had profound consequences as football coaches were able to match training schedules to actual match demands for the first time.

Today performance analysis research is published in all of the top Sports Science journals, utilising new methodologies, large and small data sets and presenting findings on topics such as performance profiles, performance indicators, home advantage, perturbations etc. Some criticisms have been levelled at this research, most notably that researchers sometimes fail to consider relevant independent variables to contextualise findings and research findings are sometimes not useful to applied practitioners (Mackenzie and Cushion, 2013).

The number of performance analysts and the complexity of the data gathering devices having grown exponentially over recent years. This has meant that the goals of this support network have similarly changed, from providing relatively simple information to providing complex analyses, with the aim of making the increasingly smaller improvements in athletic performance. Current trends in performance analysis have seen the proliferation of different forms of data analysis using terms such as analytics, mining and visualisation, each representing the shift towards interpreting large data sets using techniques developed in the computer science and engineering domains.

The future of performance analysis is likely to be dominated by the cooperation of experts in sports coaching (deriving the questions), the data analyst (to collect and analyse the data) and the performance analyst (to interpret and visualise the data in a format understandable and applicable to the coach and players). Without this symbiotic relationship, messages get misinterpreted and the added value diluted. The necessity of building specialised teams is therefore suggested as essential for competitive elite sport.

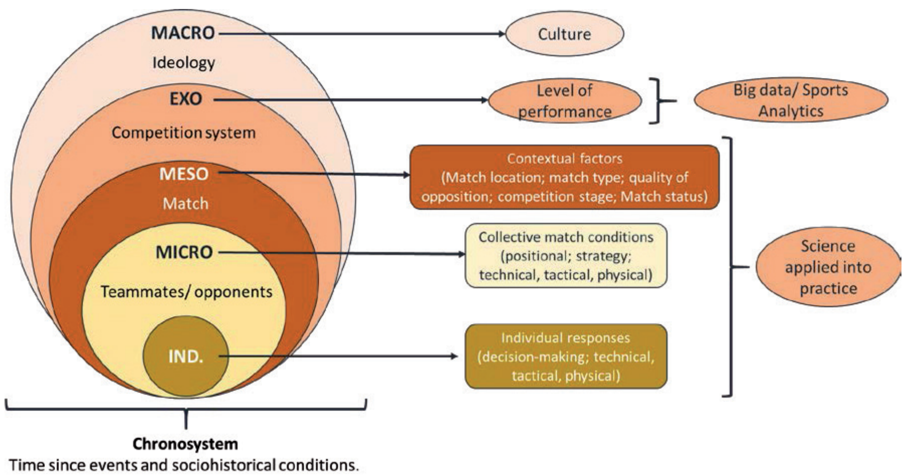
Keynote speakers

Science into practice of performance analysis in sport (physical, technical and tactical factors)

Miguel-Ángel Gómez

Faculty of Physical Activity and Sports Sciences, Technical University of Madrid, Spain

Nowadays performance analysis in sport is an excellent resource for coaches, players, managers, performance analysts and fans, in order to better know the performances during trainings and competitions (O'Donoghue, 2014). The use of performance indicators based on a high-order description of players and team's dynamics (i.e., the use of positional, physical, technical and tactical parameters) allows to have specific information from science that can be applied into training tasks and competitions (Rein & Memmert, 2016). This approach can be defined under the ecological perspective that accounts for all the factors that may affect the performance from macro to individual levels. Specifically, the figure summarises the theoretical model of ecology of performance analysis in sport. The levels presented were: macro (culture and ideology of the country/ region), exo (the level of performance/ competition or global context of performance), meso (contextual factors around the match/es played), micro (collective match and training conditions), and individual (player's responses in each specific situation during matches and training tasks).



The application of ecology to performance analysis in sport (adapted from Bronfenbrenner, 2002).

The importance of the chronosystem is focused on the time of events (match, task, competition or training) that affect the control/ management of performance. With this model the application of science into practice is crucial from an exo level when using big data and sport analytics (use of large datasets of player's and team's performances), and more specifically when controlling for contextual factors, and collective and individual behaviours (meso, micro and individual levels). This approach would allow to design and prepare specific training tasks according to the match/ competition demands. Then, the future of research in performance analysis in sport is the scientific support of coaches, teams and players when training and competing in different contexts (sex, age, competition level, period of the season) due to the increased ecological knowledge of what, how, where and when of the sport performance demands.

The use of video-based performance analysis in the coaching process

Ryan Groom

Manchester Metropolitan University, United Kingdom

Performance analysis in sport has received considerable academic interest over the past 20 years (e.g., Hughes and Franks, 1997, 2004, 2008). Typically, academic writing within the discipline has largely been focused upon technological choices, system design, patterns in sports performance data, and the identification of key performance indicators (Hughes and Franks, 1997, 2004, 2008; James, 2006; O'Donoghue, 2010). Hughes (2005, p. 1) has suggested that performance analysis has gained a growing recognition throughout the world and is "recognised both as an academic subject and as an invaluable support mechanism in the coaching process". More recently, a growing body of research exists drawing upon a qualitative interpretive perspective, which examines the use of performance analysis *in practice*. For example, the early work of Groom et al. (2011) examined the pedagogical choices that underpinned the delivery of video-based feedback by elite football coaches. Groom et al. (2012) further examined how video-based feedback was delivered to elite youth football through a conversational analysis *in situ*. Similarly, Nelson et al. (2014) and Taylor et al. (2017) detailed how athletes in ice-hockey and field hockey, respectively, experienced video-based feedback sessions. This body of work has started to paint a rich and detailed picture of the *what*, *how* and *why* of coaches use of video-based performance analysis feedback, and also the *what*, *how* and *why* of athletes' experiences in practice. Future possibilities exist to examine how the use of technology such as 'the video-wall', drones, instant mobile video messaging, telestrator technology, online performance analysis TV channels, wearable technology, data visualisation, and sports analytics to contribute towards supporting the development of the coaching process and fan engagement in the field of sports performance analysis.

The Power of the Pause - A chance to reflect, review and refine

Vinny Hammond

Irish Rugby Football Union & University College Dublin, Ireland

ABSTRACT
From time to time, it is important to pause and take stock. Drawing from over a decade of applied experience in professional sport, this keynote aims to take a snapshot in time and discuss both applied successes, and failures, of performance analysis. Using a variation of a SWOT analysis approach, the keynote will address the broader strengths, weaknesses opportunities and threats that apply to this dynamic discipline.
Modern technologies have afforded analysts and coaches to explore performance and its associated data with increasing levels of scope and detail. With both software and hardware becoming financially more accessible, the opportunities to analyze performance have never been better. However, the translation of this analysis and data must provide meaningful insights or changes in behavior to render it worthwhile. The current levels of data produced have not always been met with the same levels of competency to optimally assimilate and filter the information.
The role and scope of the professional performance analyst itself is ever evolving. Governing bodies, teams and educational institutions are now employing an ever growing number of performance analysts in their organizations. In professional sport, the role of the performance analyst is often poorly defined with large role variances from sport to sport and even within a sport itself. The role of the performance analyst is not regulated in the same manner as strength and conditioning, medical and nutritional roles within sport. This leads to its own set of human resource challenges.
The keynote aims to provide an evaluation of the discipline from an experiential viewpoint, discussing both the personnel and technological challenges alongside the growing opportunities, that exist for the performance analyst in 2018.

How to use performance analysis data in strength and conditioning

Eldin Jelešković

Faculty of sport and physical education, University of Sarajevo, Bosna and Hercegovina

Great contribution for further increase in sport performance and result are founded in valid scientific S&C performance measures. It is evident that a great number of info and performance measures are available, and based upon scientific facts, training staff must decide regarding the choice of training methods and exercises to achieve optimal and positive sport performance. Aim of this paper is to show the importance on usefulness of the performance analysis data in creating and planning training program in soccer.

For the analysis and evaluation in performance staff uses different methods mainly based and divided in two directions external loading (distance, speed, duration) and internal loading (biological markers, heart rate, rated perceived exertion). This can be very useful for creating training sessions.

Remarkable aspect for success in soccer is the ability to performed repeated explosive activities. Aldo the quantity of these activities has not drastically progressed in past decades it is evident that their intensity and frequency suffered major changes. Players continuously push the boundaries for total distance at maximal running velocity which is visible in the number of the performed soccer actions and tackles. This is confirmed by the various technologies based on GPS tracking and analysis of a game.

Performance analysis of the athlete has become essential in creating training programs which determines the way for preparing of the competition. These data can help to adequality prepare the player and to maintain their physical abilities at optimum through competitive season.

However, to create continuous progress in sport specific performance it is essential to have solid founds at baseline. This can help in increasing high level of performance through time by maintaining and developing specific and conditioning abilities.

Sports Analytics - How (commercial) sports data create new opportunities for sports science

Daniel Link

Department of Sport and Health Sciences, Technical University Munich, Germany

Background: This talk introduces the field of Sport Analytics and discusses its relevance for performance analysis. The term originates from the US and has become a synonym for the collection, analysis and application of sports data in many countries (Alamar, 2013, Link 2018). There are different goals and interests, which vary according to the different stakeholders. Professional sport clubs use the data for match analysis, regulation of training load, prevention of injuries and supporting transfer decisions. Media companies differentiate themselves from other market players by enhancing their sports program using innovative statistics. The world's largest IT companies use sports data as a showcase for their data analytics products. In addition, the academic world can benefit from the huge volumes of information. The data enable sport science to analyse the structure of sports performance, test the effectiveness of interventions and find new paradigms for modelling. Computer science can use the data to improve their algorithms for big data analytics, data mining and machine learning. Many scientific conferences, textbooks, special issues in scientific journals and a subject-specific journal are indicators of the ongoing academic institutionalization of sports analytics.

Against this background, the talk firstly gives an overview about sports analytics and discusses related epistemological issues. After this, it gives examples how commercial sports data can be used for performance analysis. The examples originate from an innovation program at German soccer Bundesliga, which intends to develop smart performance indicators for professional clubs based on spatiotemporal data. One example describes an approach to quantification of attacking performance in football – – we refer to this as dangerousity (Link, Lang & Seidenschwarz, 2016). Our procedure determines a quantitative representation of the probability of a goal being scored for every point in time at which a player is in possession of the ball he calculation is based on the spatial constellation of the player and the ball. We use these metrics to analyse individual actions in a match, to describe passages of play, and to characterise the performance and efficiency of teams over the season.

Network centrality analysis to determine the tactical leader of rugby union game

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Purpose: The goal of this study was to clarify the defensive structures that play a decisive role in the game of Rugby football, which is a competitive team sport.

Method: The study used data from games played under the Rugby Union code, and particularly on turnovers made during defensive plays in the 2015 Rugby World Cup. Social network centrality analysis was applied to analyze organizational strategies. A correspondence analysis performed using centering resonance techniques was shown to deepen our understanding of relationship structures in network mapping, while the application of network analysis was able to improve the description of complex passages of play.

Result: Eigenvector centrality would reflect the specific network structures of one's neighbor vertexes. It also reflects the centrality of all other vertexes that can be further reached from directly involved ones.

Conclusion: Team sports rely on cooperation between teammates. The applications of network analysis would be one viewpoint of representing a society in which decision-making behaviors are taken on the basis of human relationships. We will further discuss our last paper (Sasaki, et al., 2017).

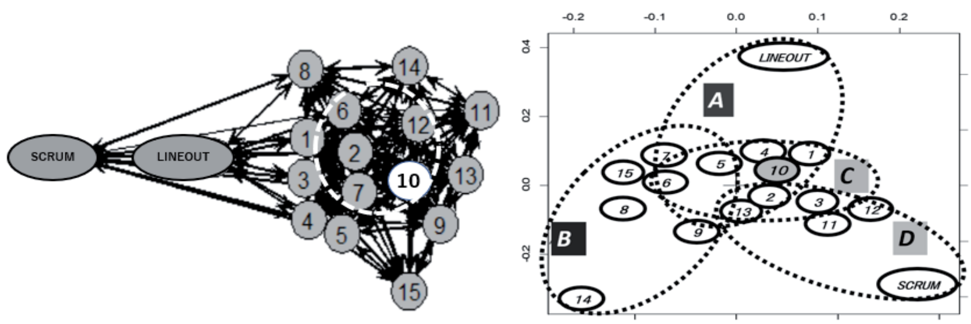

Figure 1. The multi men tackle turnover contributors' network centrality map of the top winning 5 unions (Left) and the correspondence analysis among the top 4 unions in Rugby World Cup 2015 (Right).

Sports performance

Differences in parameters of situational efficiency of service returns between tennis players who won and lost at the 2014 Australian Open

Anja Benjak, Petar Barbaros Tudor, Zlatan Bilić

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ABSTRACT

The purpose of this research was to determine the differences in parameters of situational efficiency of service returns between tennis players who won and lost matches at the 2014 Australian Open. For many years, focus was made on developing the service and winning service gems, while the just mentioned fact quite naturally also initiated enhancing the return of service and the evolution of specific trainings for such improvements. Consequently, the return of service is nowadays becoming an increasingly important part of tennis, as in addition to winning one's service, it is also extremely important to break the opponent's service. Thus, precisely for this reason, the subject of this study is the return of service and its effect on a tennis match.

For the purpose of this research, secondary data was used, i.e. the available statistical indicators for the first three sets of singles men's tennis matches played during the 2014 Australian Open tournament. Central and dispersive statistical indicators were calculated for all the variables – arithmetic mean, standard deviation, minimal value and maximal value, whereas the t-test for independent samples was used in order to calculate the differences of situational efficiency between the tennis players who won and lost the matches.

The results of this research demonstrated statistically significant differences in variables of *total return points won, total first service return points won* and *total second service return points won*. It can be observed that the players who were winning had a higher number of *total return points won*, as well as the *total first and second service return points won* in all sets, all on a level of $p \leq 0{,}05$. In addition, a statistically significant difference was also observed for the variable of *total return winners*, where the players who won the matches also demonstrated better results. Likewise, statistically significant differences on a level of $p \leq 0{,}05$ also appeared for the variable of *total return points* and *total first and second service return points*. All these variables showed an advantage in favour of the winners.

Upon summarizing the obtained results and attempting to produce final conclusions, one can determine the following; in all three sets, the winning players showed a higher number of winners after the service return, as well as the total first and second service return points won. In addition, in the second set and at the same level of significance, the winners had a higher number of total first and second service return points. All the above-stated statistically significant indicators point to the conclusion that players who won the matches had better control of their opponents' service, and as a result of that, they won more return points, which in most cases ultimately resulted by winning the match. These results further emphasize the importance of quality training and preparations for service

returns, as the results indicate that the mentioned factor can have a direct impact on the overall result of a tennis match.

Key words: training, preparation, analysis, winner, men's singles

Introduction
Returns of service ("returns") are nowadays becoming an increasingly important part of tennis. After emphasis having been made on the service and field play in tennis over a period of many years, recent studies and scientific research are increasingly published precisely focusing on improving the efficiency of service returns. It is exactly for that reason that service returns and their impact on the outcome of a tennis match were chosen as the subject of this scientific paper.
The aim of this study was determining the differences in parameters of situational efficiency of service returns between tennis players who won and lost tennis matches at the 2014 Australian Open tournament.
Returns of service, which are most commonly known by the English term "returns", are one of the hardest and most difficult shots in tennis. Li and Zhou (2013) point out in their work that in modern tennis service returns have a significant importance and influence on the course of a tennis match. As the player who is serving has an advantage over his opponent, the player who is returning the service must make a greater effort in order to break the opposing players' service. In order to do so, a tennis player must work on improving the quality of his service returns. Hedelund and Rasmussen (1997) also point to the above-mentioned facts, in addition to observing that through developing the service technique, the development of service returns also took place at the same time. One of today's most renowned world tennis coaches, Nick Bollettieri, also stated in one of his papers that he believed that service returns were at that point in time, and as well in the future, the most neglected part of the training process in tennis (Nick Bollettieri, 1995:1). Bollettieri (1995) also considered that a quality training of service returns almost always required two players, i.e. one player who would practice his returns and a quality server who can simulate different types of services in various conditions and at different speed. Likewise, Hedelund and Rasmussen (1997:6) noted that it was extremely important to be familiar with a player's physical and technical abilities while preparing trainings for service returns, i.e. to know if the player shall be able to properly execute the required shots, as well as whether the chosen tactics shall comply with his playing style and physical predispositions.

Methods
For the purpose of this study, secondary data was used, i.e. the available statistic indicators for singles men's tennis matches played during the main tournament of the 2014 Australian Open. The mentioned data was retrieved from the official statistics of the competition and were downloaded from the official website of the tournament.
Central and dispersive statistical indicators were calculated for all the variables by using a statistical programme – arithmetic mean, standard deviation, minimal value and maximal value, whereas the t-test for independent samples was used in order to calculate the differences of situational efficiency between the tennis players who won and lost the matches.

Sample of examinees
The sample of examinees was limited by the possibilities of statistical monitoring of the competition, as some courts did not include statistical monitoring of the examined parameters that were later analysed, and thus due to this fact, all tennis matches that were played during the 2014 Australian Open tournament were not included in this

research. Likewise, as data analysis was performed for each set separately, and as a result of the fact that there was a small number of matches that were played in more than three sets, this analysis included the first three sets of each of those matches so that the chosen sample would be representative and include most of the matches played at the tournament. In addition, several matches ended by forfeit in one of the first three sets, and for this reason, there are slight differences in the sample for each particular set.
Finally, after taking into account the above-mentioned limitations and in relation to each set, the studied sample was the following: first set – N=104; second set – N=103; and third set – N=99. There was a total of 127 tennis matches played at the Australian Open, and therefore it is evident that the chosen sample, despite all the above-mentioned limitations, is representative, as it refers to no less than 77,96% of the overall number of matches played at the tournament.

Sample of variables

The variables that were analysed in this research are the following: TOTAL RETURN WINNERS – the total number of winners (directly won points) after the return of service; TOTAL RETURN UNFORCED ERRORS – the total number of unforced errors after the return of service; TOTAL RETURN POINTS – the total number of points played after the return of service; FIRST SERVICE RETURN POINTS – the total number of points played after the return of the first service; SECOND SERVICE RETURN POINTS – the total number of points played after the return of the second service; TOTAL RETURN POINTS WON – the total number of won points after the return of service; TOTAL FIRST SERVICE RETURN POINTS WON – the total number of won points after the return of the first service; TOTAL SECOND SERVICE RETURN POINTS WON – the total number of won points after the return of the second service.

Results

After statistical analysis of the obtained data collected from secondary sources, the overall results are demonstrated in Table 1. The mentioned analysis of these results resulted in new insights on the difference in parameters of situational efficiency of service returns between tennis players who won and lost in tennis matches of the men's main tournament at the 2014 Australian Open.

Table 1. Descriptive statistical parameters (AS, SD) and statistically significant differences between tennis players who won and lost according to the variables for evaluating situational efficiency of service returns

N=104 VARIABLE	Set					
	N1 AS ± SD 1st set	N2 AS ± SD 1st set	N1 AS ± SD 2nd set	N2 AS ± SD 2nd set	N1 AS ± SD 3rd set	N2 AS ± SD 3rd set
TOTAL RETURN WINNERS	3,19* ±1,89	2,40* ±1,74	3,65* ±2,34	2,15* ±1,68	3,35* ±1,86	2,34* ±1,88
TOTAL RETURN UNFORCED ERRORS	4,76 ±2,74	5,29 ±3,25	4,77 ±3,09	4,69 ±3,10	4,61 ±3,42	4,85 ±2,82
TOTAL RETURN POINTS	32,61 ±9,24	30,96 ±8,68	32,25* ±8,87	29,12* ±8,24	31,43 ±8,79	30,00 ±9,33
FIRST SERVICE RETURN POINTS	19,60 ±6,30	18,89 ±5,92	19,84** ±6,59	18,12** ±5,82	19,65 ±7,14	18,92 ±6,16
SECOND SERVICE RETURN POINTS	13,01 ±5,09	12,07 ±5,27	12,41** ±4,88	11,00** ±4,34	11,79 ±4,05	11,08 ±4,95

TOTAL RETURN POINTS WON	13,17* ±4,04	9,76* ±4,46	12,90* ±4,60	8,88* ±4,41	12,56* ±4,11	9,27* ±4,98
TOTAL FIRST SERVICE RETURN POINTS WON	6,17* ±2,90	4,41* ±2,79	6,16* ±3,21	4,07* ±2,63	6,27* ±3,02	4,17* ±2,97
TOTAL SECOND SERVICE RETURN POINTS WON	7,00* ±2,91	5,31* ±3,04	6,75* ±3,24	4,82* ±2,86	6,28* ±2,59	5,10* ±3,14

Statistical difference (p<.01); ** Statistical difference (p<.05)

The obtained results for the first set imply a statistically significant difference for the variable *total return points won*. Evidently, players who won the first set had a higher total number of points won after returns of service (13,17/9,76), as well as a higher number of points won after returns of the first (6,17/4,41) and second service (7,00/5,31) on a level of p≤0,05. This type of result is not unusual considering the fact that in most tennis matches players gain advantage precisely due to their play during the opponent's service, i.e. by winning points with their returns. In addition, a statistically significant difference was also observed for the variable *total return winners* where the players who won matches also demonstrated better results (3,19/2,40). Even though there were no statistically significant differences for other variables, it should be noted that players who won the matches usually played more points after the return of the first and second service, which automatically results in the fact that they also played a higher total of points after service returns (*total return points*). It was equally noted that players who won had a slightly lower number of unforced errors after service returns (*total return unforced errors*).

The variables that also showed statistically significant differences in the second set were *total return points won* (12,90/8,88), as well as the *total first service return points won* (6,16/4,07), *total second service return points won* (6,75/4,82) and the *total return winners* (3,65/2,15). Identically as in the case of the first set, these variables also imply an advantage for the player who is winning in the second set. However, as opposed to the results for the first set, there were statistically significant differences on a level of p≤0,05 in the second set for the variable of the total number of points played after the return of service (32,25/29,12), as well as for the variables of the total number of points played after the return of the first (19,84/18,12) and second service (12,41/11,00). The mentioned variables also showed an advantage in favour of the player who won the match. All the above-mentioned implies that the players who won matches were more efficient in other monitored variables when compared with the results obtained for the first set.

Statistically significant differences between players who won and lost the third set on a level of p≤0,05 also appear for the identical variables that showed to be notable in the first two sets, i.e. the total number of points won after the return of service (12,56/9,27), the total number of points won after the first service return (6,27/4,17) and the second service return (6,28/5,10), as well as the total number of winners after the return of service (3,35/2,34). The afore-mentioned results once again show an advantage in favour of the player who was winning. The variable of the total number of points played after the return of service did not indicate a statistically significant difference, as it was the case for the second set. The reason for this fact can be found in the difference between the total numbers of points played after the second service return for players who were winning. The mentioned result for this variable indicates the appearance of fatigue and lack of concentration by the player who was winning while executing service returns in the third set.

Discussion

The obtained results indicate that players who won matches were more efficient during the first set in parameters for evaluating their efficiency of service returns. The above-mentioned points to the fact that they were more successful in neutralising the first and second service of their opponent and that they thus had a better chance of winning points during the opponents' service, which is demonstrated by the above-mentioned results. Statistically significant differences on a level of $p \leq 0{,}05$ between the players who won and lost the second set were noticeable for the identical variables as in the first set, however, also for some of the other monitored variables.
In addition, it was observed that the player who was winning further adapted after winning the first set, by putting even more emphasis in his game on quality service returns in the second set in order to increase his lead and his chances for winning the match. When compared with the first and third sets, the result that was unexpectedly different during the second set was the total number of unforced errors. Players who were winning made slightly more unforced errors than the players who were losing. Although the mentioned difference is not a statistically significant one, it can be observed as either indicating an increased risk in the style of play of the winning player, or a change of tactics by the opposing player. Despite the fact that there is a possibility that the player who eventually won the match also lost the first set, there was a minor number of such cases. On the other hand, based on the obtained results, it can be presumed that the player who had won the first set tactically concluded that the second set could be the moment where he could direct the entire match to his advantage, and he therefore decided to take more risk in his style of play, which in turn resulted in a higher number of unforced errors during service returns. In addition, the player who had lost the first set at the same time tried to reduce his number of unforced errors and decided to change his tactics in the second set, as he was aware of the fact that a two set advantage was hard to overcome. After comparing the results of players who won and lost the first and second set, one tends to make conclusions closer to the second statement because the winners show they remain on an identical number of unforced errors (4,76/4,77), whereas players who lost the first set significantly reduce their average number of unforced errors (5,29/4,69). Upon considering all three sets, another difference between the variables also becomes notable, and this difference is directly related with the previously mentioned research. Both players who are winning and losing demonstrate in all three sets an increase of the total number of won points after the return of the second service (*total second service return points won*) in relation to the total number of won points after the return of the first service, provided that the difference is more pronounced in players who lost, which thus bring one to the conclusion that players who are winning demonstrate a better reaction and return both services from their opponents, whereas the players who are losing more often use their opportunities for winning points on the second service. The above-mentioned results are in keeping with the results and conclusions presented by Gillet et al. (2009) and Kleinöder (2001) in their research, as they state that players win more points during returns after the second service, which is a result of a somewhat weaker service, as well as due to the change of playing tactics that a player applies in relation to the return after the first service.

Conclusion

Upon resuming all the obtained results and producing overall final conclusions, the following findings can be presented; in all three sets the players who are winning had more winners, more won points after the return of the first and second service, as well as more points played after the return of the first and second service in the second set at the same level of significance. All the above-mentioned statistically significant indicators

point out that tennis players who won had better control of their opponents service and that, as a result of that fact, they won more service return points, which consequently most often further resulted in winning the match. The results of this study further point out the importance of quality trainings and preparations for service returns, as they imply that the afore-mentioned can have a direct impact on the final result of a tennis match, as it was previously also determined by the above-cited authors and their research.
This conducted research can only be considered as a starting point for future studies of situational efficiency parameters of service returns. Should the aim be to confirm the results obtained through this study, similar research should be conducted both with male and female tennis players, as well as on several different levels of competition and on various types of courts or surfaces, in order to obtain the most accurate and complete data on the effect of parameters of service returns on the overall outcome of tennis matches.

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Comparative analysis of the changes in blood chemistry among long-distance swimmers during workouts at middle and low altitudes

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ABSTRACT
The paper describes differences between the responses of the body to training load among stayer athletes preparing for swimming competitions at middle or low altitude. This was reflected in the extent of biochemical factors of blood' alterations. During the studies both groups of sportsmen demonstrated the same dynamic of change in blood biochemical factors. There was a slight initial decrease in the majority of blood values (leukocytes, hemoglobin, erythrocytes, neutrophils) with further increase up to the starting point. However, among long-distance swimmers of the treatment group, trained at middle altitudes, showed a higher range of blood value fluctuations. It was found, that they recover faster after training load than the swimmers, trained at low altitudes. It reflects the fact, that a post-workout recovery speed depends on a range of blood chemistry fluctuations.

Key words: long-distance swimmers, biochemical blood values, training workload, middle and low altitude conditions

Introduction
The higher attention is now being given to updating methodology of long-distance swimmers' aerobic capacity improvement (Bakaev et al., 2016; Bakaev et al., 2015; Bakayev & Bolotin, 2017). It is related to the emergence of long distance and marathon swimming sports. Long distance and marathon swimming places a high demand on state of body functional systems of long-distance swimmers. Blood chemistry values can serve as the main indicator of competition capability of long-distance swimmers. It is true that these values are volatile and affected by altitudes, beyond physical load (Bakaev et al., 2016; Bohuslavska et al., 2017; Bolotin & Bakayev, 2017; Bolotin & Bakayev, 2016; Ivashchenko et al., 2017; Rodríguez & Mader, 2011). Workouts at middle altitudes – between 1000 and 2500 meters high – are considered as being of the greatest interest when practicing sport (Bakayev & Bolotin, 2017; Pityn et al., 2017). For the purpose of comparing effectiveness in attainment high-level results during long-distance and marathon swimming competitions, the long-distance swimmers' workout under these conditions are of high interest as compared to similar workouts in lowland areas.
Purpose of the survey – comparative analysis of the nature of blood chemistry changes among long-distance swimmers during trainings in middle and lowland areas.

Objectives of the survey.

1. Appraise initial blood chemistry of *long-distance swimmers* before the start of workouts at middle and low altitudes.
2. Study fluctuations of initial blood biochemistry among long-distance swimmers under physical load at middle and low altitudes.
3. Identify the nature of recovery after the training load among long-distance swimmers on the basis of changes in blood chemistry.

Methods

Two groups of long-distance swimmers were examined during the research, each consisted of eight sportsmen. The first group (TG-1) trained in the lowland area, the second (TG-2) at altitude of 1800 meters. The research was conducted during their preparation to long-distance swimming competitions. The level of physical fitness of long-distance swimmers in both groups was similar. Blood samples were taken in the lowland conditions two months before competitions. Further, 45 days after a training load in middle altitude conditions they were examined again. The last blood test was conducted two days prior to competitions. The detailed blood analysis was made at all stages of preparation to competitions, with the study of dynamics change of blood consistency (Tables 1, 2). Every blood component mean was calculated, as well as error of the mean. Dynamics of intensity of changes of all values under training load in middle and lowland areas was appraised.

Table 1: Description of blood chemistry in TG-1, training at low altitude (Clinical blood analysis)

Blood indicators	U.M. (unit of measurement)	Input (X±m)	45 days after training (X±m)	Before competitions (X±m)
Leukocytes	10^3/mmc	4.49±0.10	4.47±0.12	4.65±0.17
Erythrocytes	10^6/mmc	4.85±0.05	4.88±0.03	4.99±0.02
Hemoglobin	g/dl	15.1±0.08	15.3±0.08	15.5±0.12
Hematocrit	%	45.2	45.9	45.8
Corpuscular volume	fl	93.3±0.04	93.6±0.03	93.8±0.01
M.C.H. (mean corpuscular hemoglobin)	pg	31.5±0.02	31.7±0.02	31.9±0.04
M.C.H.C.(mean cell hemoglobin concentration)	g/dl	33.8±0.09	33.9±0.11	34.1±0.10
Relative leukogram: NEUTROPHILS LYMPHOCYTES MONOCYTES EOSINOPHILS BASOPHILS L.U.C.	 % % % % % %	 40.7 41.8 7.7 7.2 0.3 2.4	 40.4 40.6 6.5 6.7 0.3 2.3	 40.1 40.2 7.2 7.1 0.4 2.1
Absolute leukogram: NEUTROPHILS LYMPHOCYTES MONOCYTES EOSINOPHILS BASOPHILS L.U.C.	 10^3/mmc 10^3/mmc 10^3/mmc 10^3/mmc 10^3/mmc 10^3/mmc	 2,10 1,85 0,32 0,28 0,02 0,11	 1,65 1.68 0.28 0.25 0.01 0.08	 1.74 1.76 0.29 0.31 0.02 0.11
THROMBOCYTES	10^3/mmc	255	258	254

Results and discussions

It was found during the study, that long-distance swimmers, training at middle and low altitudes under similar loads, had different blood values fluctuations. At the primary

stage a decrease in oxygen saturation of blood of long-distance swimmers of TG-2 was observed, as compared to TG-1 examinees. It was found that in TG-2 the oxygen saturation decreased under a muscle strain. The decrease in aerobic capacities of long-distance swimmers in TG-2, training under middle altitude conditions, led to increase of anaerobic mechanisms of energy supply.
It was determined that anaerobic capacities of long-distance swimmers in the midland area hardly diminish. Rarefied middle land atmosphere makes for “scavenging” of CO2 out of the body, leading to shift in acid-base balance toward alkaline. This contributes to increase in lactic and anaerobic resources of long-distance swimmers.

Table 2: Description of blood chemistry in TG-2, training at middle altitude (Clinical blood analysis)

Blood indicators	U.M. (unit of measurement)	Input (X±m)	45 days after training (X±m)	Before competitions (X±m)
Leukocytes	10^3/mmc	4.47±0.12	3.97±0.11	4.55±0.17
Erythrocytes	10^6/mmc	4.84±0.05	5.71±0.03	5.59±0.02
Hemoglobin	g/dl	15.0±0.09	16.3±0.08	16.2±0.12
Hematocrit	%	45.3	47.9	48.6
Corpuscular volume	fl	93.1±0.04	95.6±0.03	95.3±0.01
M.C.H. (mean corpuscular hemoglobin)	pg	31.5±0.05	33.5±0.02	33.9±0.04
M.C.H.C.(mean cell hemoglobin concentration)	g/dl	33.8±0.09	34.7±0.11	34.5±0.09
Relative leukogram:				
NEUTROPHILS	%	40.2	39.4	38.9
LYMPHOCYTES	%	40.7	35.6	35.2
MONOCYTES	%	7.3	6.1	7.2
EOSINOPHILS	%	6.1	4.1	4.3
BASOPHILS	%	0.2	0.4	0.5
L.U.C.	%	2.2	2.1	1.9
Absolute leukogram:				
NEUTROPHILS	10^3/mmc	2.08	1.67	1.72
LYMPHOCYTES	10^3/mmc	1.82	1.62	1.64
MONOCYTES	10^3/mmc	0.33	0.23	0.32
EOSINOPHILS	10^3/mmc	0.28	0.21	0.25
BASOPHILS	10^3/mmc	0.03	0.02	0.03
L.U.C.	10^3/mmc	0.12	0.10	0.11
THROMBOCYTES	10^3/mmc	254	271	257

During the study it was found that the adaptation of bodies of long-distance swimmers, training at middle altitude, on the one hand, consists in strengthening of organs and systems, responsible for consumption, transportation and use of oxygen in the body, on the other hand – in increase in anaerobic capacities, compensating a lack of oxygen flow. Changes occur at cellular and body levels. At body level there occurs a strengthening of respiratory and cardio-vascular functions, improvement of their regulation.
As it is seen from table 2, TG-2 examinees showed a particularly intensive growth of erythrocytes volume in blood, increasing respiratory surface among TG-2 examinees, compared to TG-1. TG-2 examinees showed more intensive increase of hemoglobin concentration, compared to TG-1. The blood contained more newly formed erythrocytes – reticulocytes. There was observed the increase of myoglobin in muscles, number of mitochondria, activity of aerobic metabolism enzymes. This affected recovery rate of long-distance swimmers in TG-2, compared to TG-1 examinees.
The enhanced role of anaerobic reactions during long-distance swimmers training at middle altitude resulted in the increase in anaerobic capacities. At the origin of this

increase lie the increase in concentration of creatine phosphate, glycogen, increase in number and activity of glycolysis enzymes, buffer capacity of TG-2 long-distance swimmers. It is established, that training of long-distance swimmers under middle altitude conditions significantly improves adaptation to changes. Adaptation was provided by enhancement in chromoproteins synthesis – hemoglobin, myoglobin, cytochromes, etc. It was determined, that the first obvious signs of adaptation to load are observed after 14-15 days of training long-distance swimmers at middle altitude. It was found out, that the adaptation rate gradually drops in case of an extended stay under mid altitude conditions. After 45 days of training in middle land areas the rate of these changes becomes very low. That is why this period should be considered optimal for training sessions of long-distance swimmers at middle altitude.

Conclusions

Training at middle altitude cause a range of biochemical and regulatory developments in the bodies of long-distance swimmers, which make for increase in aerobic and anaerobic capacities. After descent to lowlands it provides increase in general and specific working capacity of long-distance swimmers. Body changes after a period of middle altitude training last for 1 month after descent. Lowland workouts do not lead to such a dramatic blood values fluctuation. The majority of main values (leukocytes, hemoglobin, erythrocytes, and neutrophils) increases gradually over the starting point. It is established, that low altitude workouts do not provide significant increase in working capacity of long-distance swimmers, as is observed among trainees under middle altitude conditions. This must be considered when preparing long-distance swimmers to competitions.

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Comparative fractal analysis of the heart rhythm variability among female biathletes with different training statuses

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ABSTRACT
The paper notes a strict coherence between hormone and nerve regulation components of female biathletes' heart rhythm as primarily indicative regarding the training status. Harmonization of both heart rhythm regulation components reveal the high adaptive features of athletes' bodies upon exertion.
Obvious heart rhythm regulation components imbalance bespeaks the low exercise tolerance. By analyzing the female athletes' heart rhythm deviations, one can effectively assess their functional reserves and identify an adequate physical exertion throughout a training process.

Key words: heart rhythm variability, fractal analysis, female biathletes, training status, physical exertion

Introduction
Nowadays, a state of the cardiovascular system of female biathletes due to the level of competitiveness is absolutely demanding. The heart rhythm variability bespeaks the state of the cardiovascular system of female biathletes. At the same time, the present-day prevention strategies for cardiovascular disorders among female biathletes are mainly based on assessment of exercise tolerance.
Assessment and evaluation of cardiovascular system state among female biathletes play crucial role when planning a training process. To achieve a high training status of female biathletes the adjustment to physical exertion based on defining its optimum level is essential (Bakaev et al., 2015; Bunevicius et al. 2016).
Adaptation to physical exertion is closely associated with identifying an optimum functional state of female biathletes. Adaptation is a personal adjustment response of female athletes' bodies to physical exertion. Adjustment is based on metabolic, regulatory and functional manifestation of cardiovascular working capacity (Bakaev et al., 2015; Bolotin & Bakayev, 2016; Bolotin & Bakayev, 2017; Bunevicius et al., 2016; Cooper, 1989; Daniel, 2009).
Practice indicates that the training process among female biathletes does not consider the capacities of nerve (rapid) regulation and neurohormonal (slow) regulation mechanisms of cardiovascular systems of their bodies (Bakaev et al., 2015; Bolotin & Bakayev, 2017; Bunevicius et al., 2016). This has adverse effects upon exercise tolerance of female athletes. Variability and fractal analysis of heart rhythm defines the effectiveness of interaction between nerve and neurohormonal cardiovascular regulating mechanisms among female biathletes. Thus, surveying indicative dynamics of heart rhythm nerve and

hormonal regulations' balance among female biathletes with different training statuses would help address physical exertion tolerance of athletes' bodies.

Aim of the survey – comparison of interaction trends' indicators of nerve and hormonal heart rhythm regulation among female biathletes with different training statuses.

Objectives of the survey

1. To assess trends of rapid and slow heart rhythm regulation indicators' interaction among female biathletes with different training statuses and under equal training exertions.
2. To reveal distinctions in neurohormonal heart rhythm regulation indicators' dynamics among female biathletes with different training statuses under equal physical exertions, and to articulate patterns, defining variability of female biathletes' heart rhythm.

Methods

The two female athletes – A and B – going in for biathlon, aged 19, being members of national Russian squad at the IBU Cup were examined. The first three training micro cycles on snow in November and December after a substantial running workload of the summer-fall snowless period were chosen for comparison. Before training on snow, Athlete A got 1700 km of running workload, athlete B – 1000 km. Throughout the first three on snow training micro cycles the both athletes had equal physical exertion in terms of amount, value and intensity. Every day 300 RR-intervals were taken – twice at rest and once upon training workload. The received data was subject to analysis and variegated statistical processing.

During the study the fractal analysis of heart rhythm variability among the female biathletes was performed. As well as qualitative and quantitative assessment and comparison of RR-intervals time series of Athletes A and B in order to identify the effectiveness of fractal components functioning in the blood circulatory system.

The following were identified as heart rhythm fractal analysis indicators: characterizing the cardiac function as such (A1 and A2), neuro-vegetative constituent (B1 and B2), state of pituitary-hypothalamic system (C1 and C2) and central nervous system (D1 and D2). A1, B1, B2, C1, D1 were identified as rapid (nerve) regulation indicators (RRI), while A2, C2, D2 – as slow (hormone) regulation indicators (SRI).

In the course of a study there were surveyed: A1 – indicator of regulation cumulative effect; A2 – indicator of own cardiac regulation; B1 – indicator of vegetative homeostasis of heart rhythm; B2 – indicator of heart rhythm regulation sustainability; C1 – indicator of pituitary-hypothalamic system regulation level (neuro component of regulation); C2 - indicator of pituitary-hypothalamic system regulation level (endocrine component of regulation); D1 – indicator of “rapid” adjustment to exertion; D2 – indicator of “slow” adjustment to exertion.

Based on the data received, the neurodynamic analysis of the heart rhythm was performed among female biathletes, along with the neurodynamic pyramid formation. Indicators on the left side of the pyramid (anabolism) and on the right side (catabolism) were identified as the neurodynamic pyramid indicators. Left and right pyramid side correlation characterized dynamics of anabolic and catabolic processes in the bodies of the female athletes upon training exertion. The left side was proportional to energy resources' accumulation time, the right – energy resources' consumption time. It was recognized, that the more the volume of the energy pyramid, the less are energy costs for an identical work of the female athletes. It was an equivalent of minimum involvement of this level of heart rhythm regulation among the female athletes. Heart contraction rhythm data was obtained by “VNS-Rhythm” device, based on calculation and assessment of statistic variables of RR-intervals time series, variation pulsometry and auto-correlation analysis. They are presented by a complex of indicators in the form of static summary of RR-intervals time series, RR-intervals histogram, auto correlogram and variability of spectral analysis of heart rhythm. For cardiointervalogramm processing and heart rhythm variability analysis the "Varicard 2.51" device was used.

Statistical performance of RR-intervals time series was assessed by standard deviation normal to normal (SDNN). SDNN denoted cumulative effect of exertion on sinoatrial node of sympathetic and parasympathetic parts of autonomic nervous system of the female athletes. The SDNN increase denoted hypersthenia of parasympathetic part of autonomic nervous system. SDNN value is exceedingly sensitive for heart rhythm regulation mechanisms' assessment among female athletes. SDNN increase denotes the increase in autonomous regulation, i.e. the extent of respiratory impact on the heart rhythm of the female athletes. SDNN decrease was associated with enhancement of sympathetic regulation of heart rhythm.

R-R intervals histogram or variation pulsometry were assessed by a wide range of numerical characteristics. The variation pulsometry numerical characteristics were: mode (Mo), variation range (AX) and mode amplitude (AMo).

Mode amplitude (AMo) was studied, which was a percentage of the total amount of RR-intervals. AMO indicator reflected stabilizing effect of a centralized heart rhythm regulation. This indicator was based on activity level of sympathetic part of autonomic nervous system of the female athletes. It was considered, that with the increase of AMo indicators there goes the enhancement of sympathetic heart rhythm regulation among the female athletes.

We also examined derived measured variables of pulsometry. Out of derived measured variables of pulsometry we examined regulatory system stress index or stress-index (SI) and autonomic balance index (ABI).

Stress-index reflected the level of centralization of heart rhythm regulation. It characterized sympathetic heart rhythm regulation mechanisms' activity among the female athletes and was calculated according to formula: $SI=AMo/(2+\Delta X+Mo)$.

Autonomic balance index (ABI) defined correlation between sympathetic and parasympathetic regulation of the female athletes' heart rhythm and was calculated according to formula: $ABI=AMo/\Delta X$.

Use of auto correlogram was focused on exploring internal structure of RR-intervals time series. Auto correlogram was presented in the form of coefficient of correlation flow chart. It defined the nature of dependence between consecutive RR-intervals time series and displayed heart rhythm wave structure parameter variations. Along with auto correlogram indicators, the level and nature of central mechanisms impact on self-regulation process of heart work were assessed.

Auto correlogram ascent indicators were studied: Iк (value of auto correlation function in the first strike-slip) and the rate of decay - mo (strike-slip of auto correlation function, at which it became negative at first time). Auto correlogram helped to identify the extent of a relationship and nature of dependence between central and autonomic circuits of heart rhythm control.

It was considered, that in the context of strong links between central and autonomous regulation mechanisms the ascent (Iк) increases, the rate of decay (mo) decreases. The initial rapid auto correlogram decay (Iк) with subsequent slow decay (mo) denoted conflicting impact of autonomic regulation on heart contraction rhythm.

By means of variation analysis of heart contraction rhythm the heart rate was studied (HR). It not only reflected the general state of cardiovascular system, but of the body as the whole. Depending on body requirements, its energy expenditures and nervous tension at the moment, the heart rate varied significantly.

During the study the spectral analysis of heart rhythm variability was used. It enabled a quantitative assessment of different heart rhythm fluctuation frequency components and explicitly displayed graphically the correlation of different heart rhythm components,

reflecting activity of certain points of regulating mechanism. The following spectral components were studied: high-frequency (HF), low-frequency (LF), very low-frequency (VLF). It was considered, that the principal constituent of HF-waves is vagal activity; LF-waves characterize a state of sympathetic part of autonomic nervous system; VLF-waves are sensitive indicators of control over metabolic processes.
During a statistical processing of acquired data there were calculated: arithmetical mean (x); squared deviation (G); standard error of the mean (m); significance of differences upon Student's t-criterion (P).

Results and discussions
During the study the assessment of heart rhythm regulatory systems' stress rate among the female athletes at rest was performed. In this respect the main parameters of heart rhythm variability among the female biathletes was researched. Variability of the female athletes at rest heart rhythm data are summarized in Table 1.
Judging at Table 1 heart rhythm variability, Athlete A has a more discernible parasympathetic nervous system activity (SDNN) and low-wave structure (HF, LF, VLF) as opposed to Athlete B. That grounds for the statement, that Athlete A has optimum level of regulatory systems activity, which can't be said about Athlete B. She displayed the increased rate of heart rhythm regulatory systems' tension at rest.

Table 1: Key parameters of heart rhythm variability among the female biathletes with different training statuses at rest

Parameters	Athlete A	Athlete B
SDNN (ms)	91	47
AMo (%)	24.8	45.7
Si (r.u.)	21	97
TP (ms2)	8.17	2.41
HF (ms2)	2.78	0.81
LF (ms2)	3.75	0.64
VLF (ms2)	1.65	0.89
HR (beats/min.)	57	61

Analysis of the available data shows that rapid regulation indicators RRI (neuro component) of Athlete A at rest at any day of the survey, regardless the training micro cycle, significantly exceeded slow regulation indicators SRI (hormone component). The quantitative proportionality of these indicators at rest varies according to the training status and level of fatigue of the female athlete (Table 2).

Table 2: Dynamics of heart rhythm rapid and slow regulation indicators of Athlete A during 3 micro cycles

State	RRI (%)					RRI average (%)	SRI (%)			SRI Average (%)
	A1	B1	B2	C1	D1		A2	C2	D2	
1 micro cycle										
At rest										
x	84.6	62.8*	86.2	78.8	83.4	79.2	40	41.2	35.8	38.5
± m	4.9	7.9	7	5.1	7	5.2	3.2	9.3	6.5	7.7

After training										
x	77.6	36.6	70.2	79.6	77.6	68.3	35	51.4	36.6	44
± m	5.6	5.1	8.3	2.7	5	4	2.7	14.5	6.1	10
2 micro cycle										
At rest										
x	74.6	50	83	85.2	89.4	76.4	53.4	75	48.8	61.9
± m	5.1	8.1	7.9	4.9	3.1	5.2	4.1	10.3	4.5	7.2
After training										
x	74.6	50	83	85.2	89.4	76.4	53.4	75	48.8	61.9
± m	5.1	8.1	7.9	4.9	3.1	5.2	4.1	10.3	4.5	7.2
3 micro cycle										
At rest										
x	84.6*	64	86.2*	81.2	84.2	80	69.8	65.4	37.8*	51.6*
± m	3.8	8.3	6.5	5.3	4.8	5.6	1.4	9.4	4	6.4
After training										
x	63.6	35.6	66.6	74.4	69	61.8	71	83	53.2	68.1
± m	7.1	11.4	5.8	8.9	8.9	8	1.7	3.1	5.1	3.9
*p<0.05										

Note: RRI - rapid regulation indicators, SRI - slow regulation indicators, * - significance of differences upon Student's t-criterion

It was established, that normally under the impact of everyday training Athlete A demonstrates decrease in nerve regulation indicators, and increase in hormone regulation. It underlines the harmonization of both neurohormonal regulation components at the normal conditions in 1 and 2 micro cycles. Studies show that during a significant strain on the body under inadequate exertion there happens a dissociation of nerve and hormonal regulation. Specifically, the athlete during the 3 micro cycle, as compared to the previous two, showed nerve regulation indicators (A1, B1, B2) increase, hormone regulation indicators (C2, D2) significant decrease, which is illustrative to nerve component prepotency, and suppression of hormone components in neurohormonal regulation system. The implication seemed to be, that the wellness and fitness of the athlete were not possible without clear harmonization of two parameters of neurohormonal regulation. Table 3 presents dynamics of heart rhythm rapid and slow regulation indicators of Athlete B.

Table 3: Dynamics of heart rhythm rapid and slow regulation indicators of Athlete B during 3 micro cycles

State	RRI (%)					RRI average (%)	SRI (%)			SRI Average (%)
	A1	B1	B2	C1	D1		A2	C2	D2	
1 micro cycle										
At rest										
X	88	59.2	61	60	60.2	65.7	45	5.5	11.2	8.4
± m	8.2	9.3	10	3.3	7.7	4.2	4.2	4.6	3.9	2.9
After training										
X	87.8	51.8	66.8	60.6	59.6	65.3	40	12.4	19	15.7
± m	2	4	4.7	5	8.2	2.9	3.4	6.7	4	4.7

2 micro cycle										
At rest										
X	98.6*	67.2*	54.6	62.6*	47.6	66.1*	75.6	0.8	14.8	7.8
± m	1.2	6.7	4.2	3.6	8.7	4.4	1.2	0.4	0.9	0.3
After training										
X	83.6	40.2	48.8	50	33.8	51.3	73	2.6	17.8	10.2
± m	4.7	4.4	3.6	3.9	6.6	4	2.4	1.1	2	1.4
3 micro cycle										
At rest										
X	99*	77.8	63	64	59.3	72.6	67.3	0	13.5	8.8
± m	0.6	3.1	2.5	3.2	3.6	1.2	0.8	0	1.2	2.5
After training										
X	94.3	66.3	67	56	62	69.1	65.5	0	15.3	7.6
± m	1.9	5.7	4.5	3.4	8.5	4	0.9	0	2.2	1.1
*p<0.05										

Note: RRI - rapid regulation indicators, SRI - slow regulation indicators, * - significance of differences upon Student's t-criterion

Heart rhythm regulation comparative indicators among Athletes A and B point to the fact, that heart rhythm slow regulation indicators of Athlete B are significantly lower than those of Athlete A. This suggests that on snow workload was excessive for Athlete B. These suggestions were confirmed by ECG changes in II standard lead (appearance of negative T wave, QRS complex increase and S-T segment decrease), pointing to the repolarization disturbances development due to progressing overexertion of Athlete B. During the studies there was performed the comparative analysis of variation pulsometry, which was evaluated along a number of quantitative characteristics. We studied mode amplitude (AMo), which was a percentage of the total amount of RR-intervals. (Figure 1).

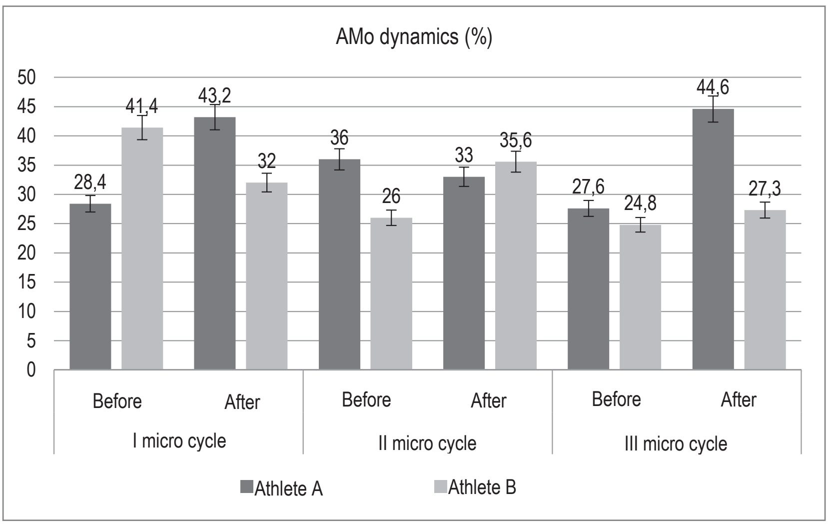

Figure 1: Comparative analysis of Athletes A and B AMo indicators

AMo indicator reflected a stabilizing effect of centralization of heart rhythm controls among Athletes A and B during identical workload on snow. This indicator's comparison among Athletes A and B points to the higher level of sympathetic part of autonomic nervous system' activity of Athlete A. (fig.1). The difference is most noticeable at the end of the 3rd micro cycle. Judging at this fact, with the increase of AMo there was the enhancement of sympathetic regulation of heart rhythm of Athlete A. This was not the case with Athlete B.

We studied the level of exertion impact on sinoatrial node of sympathetic and parasympathetic parts of autonomic nervous system of Athletes A and B by standard deviation normal to normal (SDNN). Statistical characteristics of RR-intervals time series among Athletes A and B during the experiment is shown in Figure 2.

Sharp downward trend in standard deviation normal to normal (SDNN) of Athlete B during the second micro cycle points to the fact, that the total exertion effect on sinoatrial node of sympathetic part of her autonomic nervous system is adverse regarding exertion tolerance. SDNN decrease points to hypersthenia of parasympathetic part of autonomic nervous system.

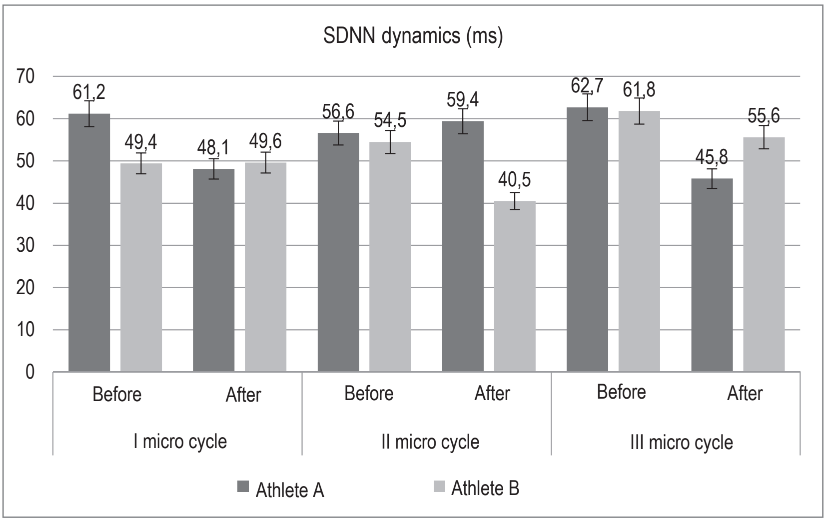

Figure 2: Comparative analysis of Athletes A and B SDNN indicators

SDNN value appeared to be exceedingly sensitive for heart rhythm regulation mechanisms' assessment among Athletes A and B. The SDNN increase denoted the increase in autonomous regulation of Athlete A heart rhythm. The SDNN decrease among the both athletes we associated with enhancement of sympathetic regulation of heart rhythm. The comparative analysis of Si indicators among Athletes A and B is presented in Figure 3.

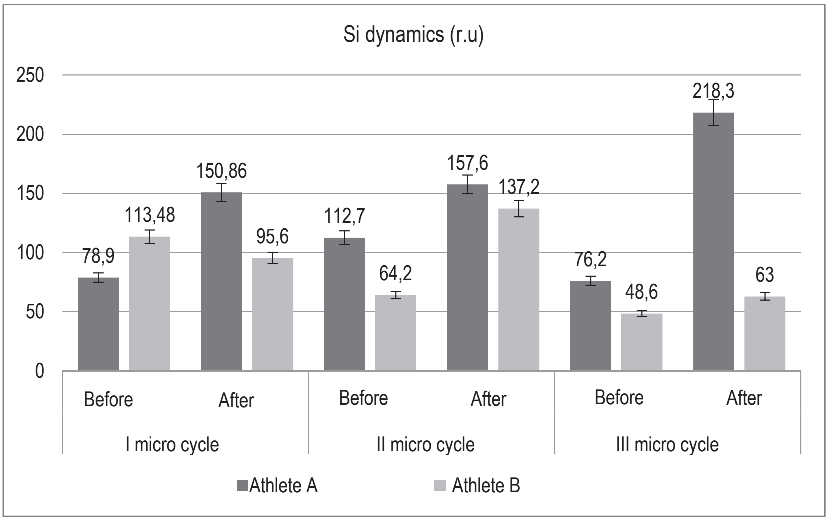

Figure 3: Comparative analysis of Athletes A and B Si indicators

The study of regulatory systems stress index (Si) points to the level of activity of heart rhythm regulation of Athletes A and B. Athlete A at rest Si indicators are volatile between 70 and 112 r.u., after exertion – between 150 and 218 r.u. The same reaction to exertion displayed Athlete B. However, the fluctuation range was significantly lower, than that of Athlete A. It reflects the lower functional reserves of Athlete B, as opposed to Athlete A. In that manner, Si stress-index highlights the level of centralization of heart rhythm control among the both Athletes – A and B.

Strong emphasis was put on assessment of central circuit tension state of Athletes A and B according to Ik index. (Figure 4).

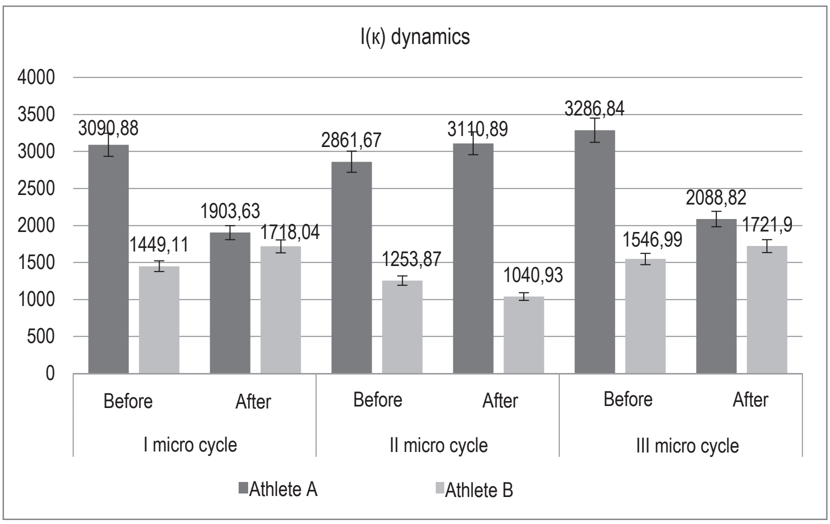

Figure 4: Comparative analysis of Athletes A and B Ik indicators

It was found, that Athlete A's Ik after training decreases by 35 %. It reflects the enhancement of central mechanisms' effect on heart rhythm.
It was found, that Athlete B's Ik after training decreases by 16 %. It reflects the significant tension of the central circuit of Athlete B.
Consequently, it can be stated, that the workload is excessive for Athlete B.
During the study we assessed autonomic balance index (ABI). It defined correlation between sympathetic and parasympathetic regulation of heart rhythms of Athletes A and B. (Figure 5).
It was found, that Athlete A's autonomic balance index after training grew steadily. It reflects the lasting balance of sympathetic and parasympathetic regulation of heart rhythms of Athlete A.
Athlete B' autonomic balance index after training remained almost unchanged, while at the first micro cycle it decreased. It reflects the imbalance of Athlete B's regulation of heart rhythms.

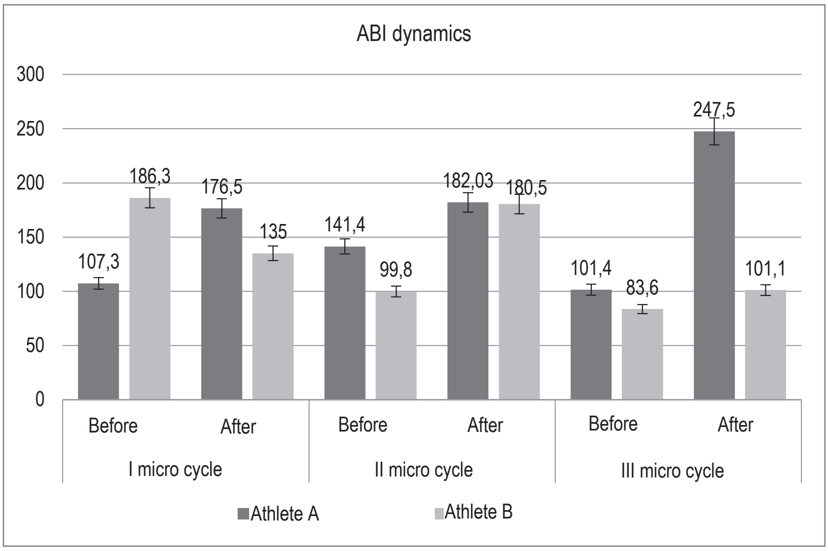

Figure 5: Comparative analysis of Athletes A and B ABI

Conclusions
Hence, it is noteworthy, that the basic training status' characteristic of the female athletes is a clear coherence between nerve and hormone components of heart rhythm regulation. Convergence and harmonization of both regulation components of Athlete A and the disparity (high RRI and low SRI) of Athlete B's readings denote different adjustment capacities to exertion of the female athletes' bodies: significantly higher in case of the first athlete, and on the contrary – lower in case of the second one.
Besides, the obvious disparity between the two levels of neurohormonal regulation of Athlete B (a low endocrine regulation profile), apparently is the result of a lasting tension due to the exceeding physical exertion, incompatible with the level of physical readiness and body functional reserves.
Based on the studies, carried out, it was found, that all heart rhythm rapid and low regulation indicators, without exception, of Athlete A were significantly higher during all the three micro cycles, both before and after trainings, as opposed to Athlete B.

The comparative fractal analysis of heart rhythm variability among A and B biathletes highlighted the following trends:

- female biathletes heart rhythm variability depends on optimum interaction of hormone and nerve regulation of blood circulatory system;
- rapid decrease in hormone heart rhythm regulation indicators of the female athletes points to their body resources decrement;
- enhancement of the own cardiac nerve regulation upon exertion points to imbalance between anabolism and catabolism processes;
- heart rhythm nerve and hormone regulations disparity leads to a significant decrement of body functional reserves of the female athletes and their overfatigue.

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Towards an automated workout compliance model

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ABSTRACT
Training schedules are commonly constructed and reviewed manually, relying solely on the expertise of the coach. This extra imposed workload, alongside designing training schedules, testing and communication, is often neglected and underestimated. This paper tries to implement a straightforward, understandable, but maybe even most important, an automated way to determine how well athletes follow their planned training sessions. The implemented solution produces this info in the form of a single percentage, but it is calculated from different (sub)compliance scores.
The weighted compliance model was built around three decision variables being Training Impulse-score (TRIMP), which is essentially heart rate weighted duration, workout duration as a standalone parameter, and dynamic time warping (DTW) being the average difference between synchronized planned and executed heart rate values. The model allows quick and easy comparison between planned and completed workout data, after they have been first converted to a machine readable format. The proposed compliance score allows athletes and coaches to instantly verify the quality of the executed training session without thorough manual analysis.
The model is easily expandable to allow effortless elaboration of possible future technological or scientific improvements. It can be used to make modifications in future training sessions, but it can also be used to gather knowledge about the relationship between training quality and other environmental and physiological factors such as stress, sickness, work schedule and many other.

Key words: compliance, training analysis, workout file analysis, TRIMP-score, DTW, GPS-file

Introduction
The participation of people in sports is on the rise (Borgers et al., 2013). A large fraction of them are looking for a structured and systematic way to practice sports, with the help of a professional coach. This way they are trying to improve their performance or simply looking for somebody who motivates and helps them to stick to their plans (Eyck et al., 2006). Endurance sports, which are typically executed individually and at submaximal intensities for a longer duration, are gaining a lot of interest from people who want to push their boundaries. An endurance sports oriented trainer nowadays coaches both recreational and (semi)professional runners, cyclists, triathletes and other types of endurance athletes. A big group of the first category is usually aiming towards a particular goal (Janssen et al., 2017). This ambition can range from running a marathon under the mythical 3 hours, over finishing a 200 km Granfondo or even to start exercising and just lose a couple of pounds.
Currently, the coaching process can be subdivided in three different stages (ICCE, 2013). First, there is an intake procedure. During this stage, especially in endurance based sport

disciplines, the athlete completes a physiological test that tries to estimate his/her initial fitness level. In the second stage, with the test outcome in mind, a basic training schedule is constructed considering the physical, motivational and sociological characteristics of the athlete. Once the schedule is ready, the athlete bears the responsibility to follow this (semi-)personalized planning as accurately as possible. In the final stage, coaches and their athletes communicate regularly to evaluate the past training block and make changes if necessary. Those modifications are ideally elaborated in a next training block in which the athlete again tries to complete everything accurately.
However, this way of coaching is not always the most optimal one for athletes due to 2 reasons:

- Training schedules are often fixed for a longer time span, typically ranging from two weeks up to two months. This is mainly the result of a price/quality trade-off the athlete has to make. Most personal trainers are coaching multiple athletes. It is thus virtually impossible for a coach and would also be too expensive for an everyday athlete to strive for 24/7 personal support.
- The training schedule does not take into account the unforeseen circumstances that might happen every now and then. External factors such as mental stress, illness or weather might obstruct athletes from correctly following their workouts, potentially giving a coach a false image of the obedience of an athlete.

This amount of uncertainty in the verification of the workout might lead to some consequences for the athlete. When a coach cannot detect an issue in time, it cannot be solved appropriately. This might lead to the failure of reaching certain goals or it might even demoralize the athlete to such extent that he/she gives up exercising (in a structured way). Additionally, human beings are proven to be susceptible for feedback (Strube, strand, 2015). This means that giving appropriate feedback on a workout at the right time might influence the motivation and the resulting performance of a well-informed athlete. Additionally, insight in an athlete's stress, sleep and work situation can be beneficial in certain circumstances. It is known that an athlete who is under great stress, caused by external factors is prone to injury when he is ignoring this factor (Wakefield, Neustaedter, 2013)(Andersen, Williams, 1998)(Galambos, 2005).
First, to build a personalized and appropriate training schedule, containing all the planned workouts for a given timespan, the quality of previous executed training sessions must be verified. This paper tries to assist coaches in the workout verification process by the use of data analysis of planned and executed workout data that was collected. Currently, the verification mostly depends on a coach or the athletes themselves. Coaches can manually check an athlete's workout log, which can be emailed spreadsheets or this log is available on an online coaching software suite, or the athlete can periodically brief his/her coach how well a certain training block went. The previously mentioned training software suites, e.g. TrainingPeaks or Today's Plan, already provide some kind of compliance measurement. TrainingPeaks is currently using duration, distance and a single intensity parameter (based on power, TSS) as the default decision variables. This paper further investigates tries to improve this basic compliance model by reviewing the current parameters and weighing a basic, being duration, and some advanced workout parameters, being TRIMP score and average heart rate difference of planned and executed graphs based on Dynamic Time Warping (DTW).
A reliable and automated compliance verification technique can be considered as a first step towards making adaptive and personalized schedules available to the masses. Currently those kind of training plans are mainly for the pro or real enthusiast because of the high cost to manually and constantly construct and adapt them with a personal coach.

Methods

A correctly functioning compliance model heavily relies on data and sports physiological science. The needed data can be subdivided in two categories: the planned and the executed workout data. In the following sections both types will be further explained and the scientific knowledge on which the proposed model will ultimately rely, will be briefly explained.

Planned workouts

Coaches usually employ workout planning software to construct training schedules, e.g. TrainingPeaks or Today's Plan. Some coaches use spreadsheets or handwritten plans. The first approach has some major advantages in the context of the automated compliance model. An athlete can easily verify which training is on the menu for a given day. When a planned workout session is formatted, it can easily be exported to a GPS-enabled head unit or smartwatch, which will definitely contribute in successful completion of the planned workout. Furthermore, with the rise of controllable cycling indoor trainers and treadmills, the desired intensity can even be controlled by these devices themselves, based on the intervals defined in a structured workout file. If the workouts are structured, no conversion process is required to allow processing by a computer algorithm. This is a huge plus for the automated compliance model because no data gets lost during the conversion of unstructured planned training session data. The more traditional coaches, offer an additional challenge because the planned workout data might range from semi-structured to entirely unstructured. In the worst case scenario, those plans consist of complete sentences in natural written language. As mentioned, to get a computer-driven compliance model we need data which can be processed and is interpretable by a machine, so appropriate conversion techniques should be adopted.

Executed workouts

To capture the data from the executed workouts and use it in the compliance model, the only thing required is that an athlete owns some kind of GPS-powered device and a heart rate monitor. A power meter is definitely a nice addition but is not required for the functioning of the proposed compliance model. GPS devices record and display geospatial data, but also use communication standards like ANT+ or Bluetooth Smart to get external sensor data from e.g. heart rate monitors, power meters and cadence sensors. A structured log of all the data captured by the head-unit can be exported to common file standards like gpx, fit, tcx, pwx and srm.

Compliance model

The final step consists of comparing the planned and completed workout data is the implementation of the compliance model linking planned and completed data. The implemented model is heavily relying on the core principles of training thus a basic definition of it should first be defined. People who train typically tend to strive towards a certain objective. This training process consists of systematically and thoughtfully putting exercise load on the athlete. Training load is a good mixture of 3 important parameters: intensity, duration and frequency (Smith, 2003). In order to achieve the previously mentioned goals, training load is carefully and repeatedly being put on the body. According to the "the overload principle (Lambert, et al., 2009)", this is generally accomplished by putting just a bit more load on the body than it is accustomed to. However, this load should be increased in a responsible and planned way. Too high or much chronic load can fatigue the body too much to achieve the intended goals.

Data conversion

As previously mentioned, a conversion from colloquial speech to a structured format is necessary in the building process of a functioning compliance model. The language use might be different from coach to coach. Some coaches tend to use a lot of abbreviations for certain training zones and others use full sentences. All those ways to describe a planned workout need to be translated to a structured format. With the clarified notion of training load in mind a planned workout can be described by duration and a measurement of intensity. A planned workout often contain repetitions (reps). This concept allows to alternate between high and low intensities. This made the choice to convert every planned workout to a set of reps, called intervals, obvious. A schematic overview of this conversion process can be consulted in Figure 1.

As illustrated there is often a big gap between the language of coaches and the one of machines.

Unfortunately, human language cannot (yet) (Young, et al., 2017) directly be processed or understood by computers. Luckily, some techniques exist to perform the required conversion. The branch of computer science which tackles this kind of human-to-machine translation problems is called Natural Language Processing (NLP) and often relies on advanced machine learning models, such as deep learning, to achieve state-of-the-art accuracy rates. However, due to the conversion process, inevitably valuable information might get lost.

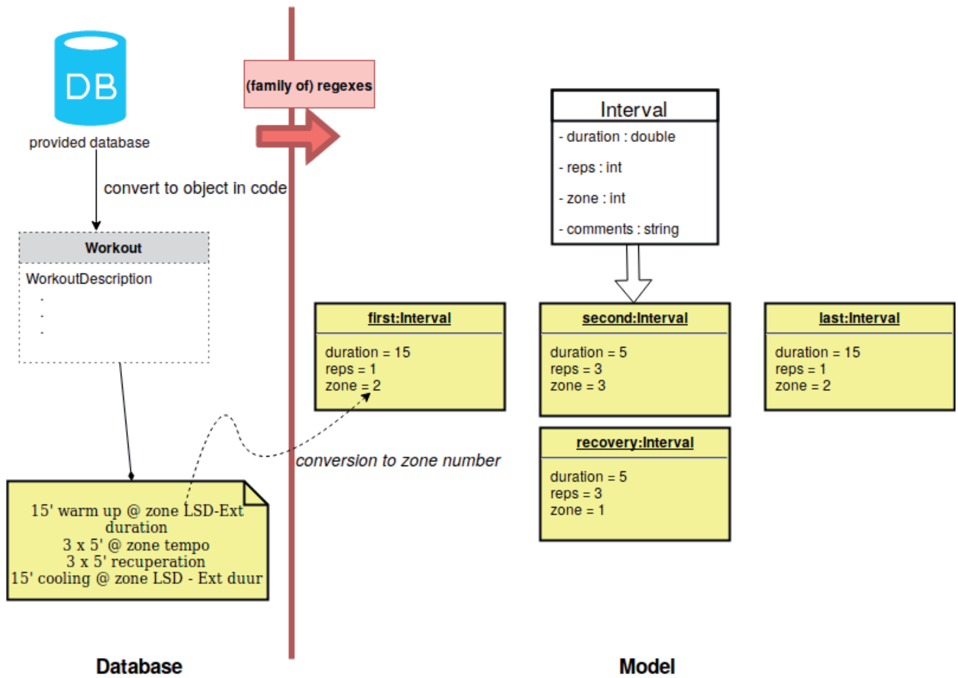


Fig. 1. Conversion process of a semi-structured workout text description to interval objects

The above advanced NLP-techniques would take the focus too far away from the actual compliance model implementation, so a more straightforward approach was adopted. Each type of endurance sport has its own characteristics and are different in the way how the planned workouts are described. Two (families of) regular expressions were developed to get the essence from the planned training session. The regular expressions are tailored to get both repetitions, duration and intensity from the sentences. The finer details (cadence, rating of perceived exertion, etc.) were omitted during this extraction.

The conversion process produces a list of several intervals. An interval has a duration, training zone and the number of repetitions as its properties. The produced intervals are part of a planned workout session, usually planned on a specific day.
A big hurdle in the conversion process is the determination of the intensity for a certain interval. Coaches use a lot of different ways to describe the intensity of an interval. For this specific sub problem training zones were introduced. A huge list of synonyms for certain zones were constructed. Next, by using those zone synonyms, the sometimes cryptic intensity specifications can be linked with a zone (and the corresponding zone number). Once the zone number is determined it can easily be converted to a heart rate or power range. This can be achieved by linking the athlete's zones, which are determined by a fitness test or a formula, to the zone numbers in the translated intervals (Friel, 2009).
Nonetheless, all the arguments mentioned in previous paragraphs should ideally convince coaches, who are willing to adopt an automated compliance check, to structure their planned workout data. Several file standards to structure training sessions exist. Popular formats are erg, mrc, fit or zwo and handy tools exist to construct these structured planned training files.

Compliance model

Physiological characteristics representing compliance

The building process of a reliable and automated workout verification platform should bear the previously cited basic principles of training in mind. Training plans should be built around the concept of load and a compliance model should check if all of the separate parameters of the prescribed training load were respected.
The selection procedure of the parameters for the compliance model started with the selection of five possible compliance measurements. These were the duration of a session, the sampled heart rate and power values and finally also rate of perceived exertion (RPE) was considered.
RPE, which is a numerical value based on the feeling of the athlete during exercise, was omitted from the candidate list because it's too hazardous and it contradicts the aim to fully automate the workout verification process as a manual estimation is necessary for this parameter.
For the initial model that was composed in this paper, heart rate was chosen instead of power. Heart rate is an internal load indicator (Akubat, Barrett, Abt, 2014). It shows the response of the cardiovascular system to an effort. Power is an external indicator. It shows the actual power output that the body produces (Allen, Cogan, 2010). In comparison with heart rate monitors, which are widely available at relatively low cost, power meters are still relatively expensive and are considered for serious athletes or the real enthusiasts.
After all, it is also a fact that an automated workout verification platform could maybe even be the most beneficial for novice athletes, who cannot justify the higher expense of a power meter or the price of real intensive coaching, which makes this initial choice a good approach.
With the initial considerations in mind three different parameters were retained to include in the first version of the advanced compliance model. The proposed compliance model was built in such a way that in the future other relevant parameters can be included in the model.

Duration (planned versus completed)

It is true that two sessions with identical duration can be entirely different. These sessions can for instance have entirely different intensities (e.g. the first one a low intensity endurance workout and the second an all-out high intensity session). On the other hand, it is really hard to replicate the physiological demands of a 4 hour session in a 1 hour one, making the concept of "pure execution time" crucial in the compliance model.

Heart rate (intensity)
This parameter tries to take the intensity of the imposed training load into account. The idea of exercise intensity based on heart rate can be implemented by the concept called Training Impulse (TRIMP) score. Several methods to calculate this score exist, but in this paper the model of Banister will be used (model, see Equation 2). The selected model provides a good trade-off between accuracy and the available parameters of a workout. More advanced TRIMP models exist (Halson, 2016), but they often rely on lactate curves. Current development on wearable lactate monitors is on-going but it is not yet readily available to the masses (Driller, Plews, Borges, 2016, 06)(Driller, Borges, Plews, 2016, 03).

$$TRIMP = duration_{(min)} \times (a \times \Delta HR \times e^{b \times \Delta HR})$$

with

$$a = 0.64(male)\ or\ 0.86(female)$$

$$b = 1.92(male)\ or\ 1.67(female)$$

$$\Delta HR \frac{HR_{value} - HR_{rest}}{HR_{max} - HR_{rest}}$$

Eq. 2. The Banister TRIMP model (Cejuela, Esteve-Lanao, 2011)

The contribution of the TRIMP score to the compliance model can be considered as a parameter representing "weighted" duration. Heart rate weighs the duration, which means basically that a second at higher intensity (thus higher heart rate) will have a higher impact on the resulting TRIMP score than one at lower intensity. The model of Banister consists of an exponential curve which translates a heart rate (in beats per minute) to a certain intensity value. The conversion of linear heart rate to an exponential intensity measurement value is considered particularly realistic because an all-out effort puts more load on the human body than a more moderate effort (both of the same duration). This thought is further strengthened by the experimentally observed exponential relationship between heart rate and the lactate concentration in the body (Calvert, et al., 1976)(Desgorces, 2007).

DTW(heart rate)
The previous parameters already capture intensity and duration (time and frequency) from the training load concept. A third parameter was captured by DTW, as exemplified below.
Two sessions of both 1 hour are used in this example. Both sessions consist of 30 minutes at low and 30 minutes at higher intensity. In the first session those 30 minutes are done in 1 single block (so without rest) after a 15 minute warm up. The session is also finished with a 15 minute cool down. The second session splits the 30 minute block into six 5 minute blocks with 5 minutes of rest in between. Both training sessions will possibly result in similar TRIMP scores. But, for instance, how can be determined if session 2 wasn't done when an athlete should have completed the first one? As this example shows, this way of analysis could basically provide more insight in what the athlete did at which moment in time. Execution of the right type of exercise on the right time is also very important to systematically improve fitness.

DTW can possibly cover this extra dimension of compliance. DTW is a technique which finds the distance between two synchronized time series. When both planned and executed heart rate curves are provided to a DTW-algorithm it can tell how much they differ. The DTW-implementation used for this model was optimized to speed up the sometimes slower “Vanilla’’ DTW algorithm, which was necessary to use in real-life applications. The calculated DTW-value can now provide an answer to the question if the session wasn’t mistakenly swapped with another one.

Unifying the parameters in one model

The three proposed parameters for the compliance model all look at different aspects of workouts and their corresponding influence on general training load. The biggest goal of the investigation however was to provide a quick and reliable way to verify workout compliance. Therefore, the 3 different parameters were incorporated into a single valuable compliance score. Having this single score is especially beneficial for coaches because it will show them really quick which of his/her athletes are doing well.

The first step of the conversion process consists of unifying the parameters. This means that the parameters should be comparable with each other. Unfortunately, it is not possible to directly compare time, TRIMP-score and the average BPM difference (DTW). A conversion of those values to percentages will allow this comparison.

For the TRIMP score and duration this conversion process is rather straightforward. The percentage can be calculated by the ratio of planned and completed values.

For DTW values the conversion to a percentage was a bit less conventional. The sum of the distances between the time-synchronized planned and completed heart rate values on the curve were first averaged (divided by workout duration). This results in a value which is a number united by beats per minute (BPM). To convert this average BPM difference to a percentage the following thought process was followed. The planned and completed heart rate graphs of a perfectly executed training session would have little to no differences. In this case the DTW-compliance percentage should be 100. On the other hand, when an executed workout is the exact opposite of what was planned (e.g. resting when going maximal and vice versa) the DTW percentage should ideally be 0. These 2 points produce a linear relationship between a certain percentage and a DTW-value (in BPM) (see Fig. 3.).

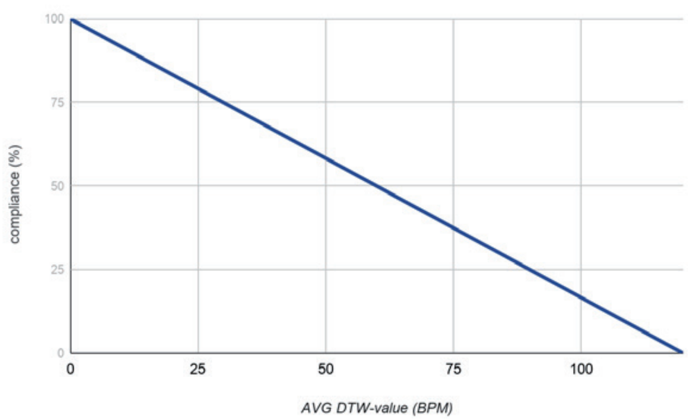


Fig. 3. The linear relationship between a DTW-value and compliance percentage

The second point, which is basically the maximum possible average difference between a planned and completed graph was not picked by hand. It was however approximated’ with the help of a linear programming method.

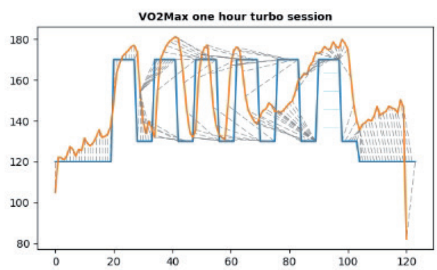
Results

To get the initial weights and the slope of the DTW-curve a set of 21 structured planned workouts were collected. The corresponding executed training sessions were hand labeled to indicate how well they were executed, with a score from 0, representing a badly executed one, to 5, representing a good one.

Now that the three compliance percentages are calculated, they can be brought together in one single percentage, by assigning a weight to each one of them. The decision about these weights was also assigned to a linear programming method with the help of 21 workouts.

The weights produced by the test data are 0.57 for duration, 0.36 for TRIMP and 0.07 for DTW-value. This is realistic since a mismatch in duration most likely implies a badly executed training.

In a next stage, the implemented compliance model should be tested and checked against some workouts. The ultimate goal of the proposed model is to give a quick and easy to understand insight in the quality of the executed workout. Off course this can be achieved by thorough analysis of the produced data, but a single compliance score gives a quick initial idea of how well the prescribed training schedule was performed. Further, deeper analysis can always be performed when this compliance value is too low. If the compliance score is rather low possible reasons might exist. These can be stress, busy schedule, sickness and many other external factors. Fig. 4 shows such a workout. The planned workout consisted of a VO2Max session, which is a workout which trains the body's ability to use oxygen, and is considered rather demanding on a human's body. However, the athlete indicated in the previous days that he felt somewhat sick. The planned workout was stopped somewhere in the middle and the athlete was not able to reach the prescribed intensities and durations. In the basic TrainingPeaks compliance model this workout was given green light, meaning that everything was alright. The implemented model in this paper showed a compliance score of 93%. If additional training data for the compliance model becomes available the weights will further bring down this percentage. As could be seen from the individual components of the weighted compliance score, TRIMP score and DTW from heart rate show significantly lower percentages.

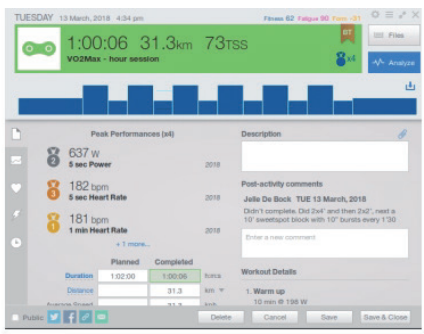


Advanced compliance model feedback

Parameter	Planned	Executed	Percentage
Time (seconds)	3616	3720	100%
TRIMP	154	133	84%

Parameter	Value	Percentage
DTW (bpm)	11.11	88%
DTW(pwr, watts)	28	*Not used in model*

Unified, weighed compliance **93%**



TrainingPeaks feedback

"Green" = all okay

Fig. 4. Implemented Compliance Model vs. TrainingPeaks compliance feedback on a "semi-failed" workout, only 2 of 6 intervals were executed as planned, the others failed and the last one was replaced by a longer one.

Discussion

A visualization tool for the compliance model was built using the Python programming language and its front-end (display) framework called Django. Files of executed training sessions can be uploaded in gpx, fit, tcx, pwx and srm format. For the planned training sessions a lot of unstructured data was made available in the form of a Mongo database including planned workouts, athletes and their training zones. The available planned workouts can be converted to interval objects using the previously explained regular expressions. Unfortunately, these techniques only tend to work for semi-structured descriptions. This makes the use of this dataset for the actual calculation of the weights for the compliance model unacceptable as the data for this purpose should be fully reliable. As indicated previously, additional data for this sake was gathered. The 21 sessions consisted of a structured planned workout and the corresponding executed workout file of a cyclist. The sessions were also hand labeled to get an expert score telling how well the executed matched the planned. The added sessions provided a solid starting point for determination of the initial weights for the compliance model.

The proposed weights and parameters and the resulting compliance score are working as expected with the first batch of test data (see Fig. 4). The training sessions which are labeled as “well executed” get higher compliance scores than the mediocre and badly executed training sessions. Nevertheless, the model still has a lot of room for improvement. However, the model could be further improved and tweaked with the inclusion of extra, high-quality labeled planned and executed training data. The more data available, the more universal the weights would eventually become. It might be even useful to use separate compliance weights and DTW-slopes for different genders, fitness levels and a lot of other athlete specific characteristics.

Currently, the model provides a quality measurement of the executed workouts. As shown in the experiments, the use of additional compliance measurement parameters are highlighting additional insights in the workout execution. This extra understanding should ultimately assist coaches and athletes in their way to an optimal coaching/ training process. The benefit of having a fast but also reliable measurement of training compliance will certainly outweigh the effort to structure their planned workouts. Furthermore, combining the workout data with external data (such as weather, stress or sleep information) might even provide insights that go beyond the initial purpose of the implemented compliance model.

Conclusion

The compliance model provides a way to rapidly check the 3 main principles of training load; being duration, intensity and frequency. It returns 3 separate values which were converted and brought together as a single percentage. This score gives the ability for an initial comparison of the executed and the planned training load. This can serve as a sort of a first pass for professional coaches, since this score can filter out the good from the bad training sessions.

Additionally, as more labeled training sessions would be gathered, the model becomes more universal. Future research might include the implementation of more advanced data processing techniques like deep learning or decision trees to fully benefit of already available data. This paper tried to emphasize that structured planned training sessions are the way to a reliable and universal compliance model. Another improvement, mainly for cyclists but in the near future maybe also for runners (Vance, 2016), would be the inclusion of power data in the model.

Another interesting experiment might be the connection with external factors such as weather, stress, sleep and various other types of “external” data. When such links are made a lot of insight in the body and its interaction with the environment would be gathered. This knowledge might even help to further improve and personalize training schedules in a (semi-)automated or manual way. Experiments with the provided compliance model are still ongoing but initial results show that it is even possible to predict a compliance value for a certain athlete on a given day, providing the planned workout session and an athlete's physiological properties.

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An analysis of the statistical parameters of goalball matches which might provide team advantage

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ABSTRACT
Goalball is a team sport played exclusively by blind or visually impaired athletes (Davis, 2011). As in every team sport, in goalball there are also significant indicators of the matches, which point out which parameters will bring an advantage. Thus, the aim of this research was to determine the differences in some statistical game indicators of winning and losing teams in the quarter final of the goalball tournament played during the Paralympic Games in Rio. One group included the teams from Brazil, Lithuania, the US, and Sweden, which had won in the quarter final, while the second group included the losing teams of China, Germany, Canada and Turkey. The t-test was used to determine the statistically significant difference between 11 statistical match parameters. The winning teams had better results for all the parameters of the matches. Parameters of special emphasis are game efficiency and total efficiency. The obtained effect size for these parameters is large and indicates a significant effect on the success of goalball teams. Based on the results and their analysis, special attention should be paid to increasing efficiency by preparing various tactical elements of the game.

Key words: throws, blocks, efficiency, men

Purpose
Goalball is a team sport for people with visual impairment. It was designed in 1946 by Hanz Lorenzen and Sepp Reindletog with the aim of expediting the rehabilitation of the World War 2 wounded with sight impairment. Goalball is played on a 9 by 18m court, with the goal posts 9m apart. Each team features 3 players. The objective of the game is for the team to follow the defense of their own goal by regaining possession of the ball and making a score into their opponents' goal (Davis, 2011). The sport featured for the first time at the Paralympics in Toronto, Canada, in 1976, while the first World Championships were held in 1978 in Vocklamarkt, Austria (Van Rheenen, 2016).
As all sports, goalball has its own distinct features in terms of technical, tactical and physical preparation. It is also important to emphasize match preparation in terms of specific statistical parameters pertaining to the match as well as performance analysis. Performance analysis has been conducted for several Paralympic team sports, primarily wheelchair basketball (Wang, et al., 2005; Gomez, et al., 2014), sitting volleyball (Marszalek, et al., 2015) as well as wheelchair rugby (Chua, et al., 2010).
In goalball it is also possible to trace the statistical data from matches, as in the aforementioned Paralympic sports, which can facilitate the team's achievement of maximum sports results. Thus, the *aim* of this research was to determine the differences in some statistical game indicators of the winning and losing teams in the quarter final of the goalball tournament played during the Paralympic Games in Rio.

Methods

Participants

National goalball teams from 8 countries which took part in the quarter finals of the Goalball tournament at the Rio Paralympics in 2016 were included in the study. For the purposes of the study, the teams were divided into two groups. The first group consisted of the national teams of Brazil, Lithuania, the US, and Sweden, which all qualified for the semi-finals, whereas the second group comprised the national teams of China, Germany, Canada, and Turkey, which lost in the quarter final.

Game parameters

The study included 11 statistical parameters tracked during the quarter-finals matches of the Goalball tournament at the Paralympic Games in Rio in 2016. The data was pooled from the official statistics of the completed Goalball tournament, that is, from the score sheet (Pacheco, 2016). The following is a description of the statistical parameters of the game:

1. game goals (GG) – the number of goals scored during the game proper;
2. game throws (GT) – the number of throw during the game proper;
3. game efficiency (EFG) – efficiency during the game proper, calculated according to the formula GG*100/GT, and expressed in %;
4. scored penalties (SP) – the number of goals scored from a penalty situation;
5. throw penalties (TP) – the number of executed penalties;
6. efficiency of penalties (EFP) – the efficiency of the executed penalties, calculated according to the formula SP*100/TP, and expressed in %;
7. total number of goals (TG) – the total number of goals scored during a match;
8. total number of throws (TT) – the total number of throws during a match;
9. total efficiency (EFT) – the total efficiency, calculated according to the formula TG*100/TT, and expressed in %;
10. defense blocks (DB) – the number of successful blocks, i.e., throw defenses;
11. penalties made for the opponents (PM) – the number of penalties made to the advantage of the opponents.

Statistical analysis

To assess the difference across statistical parameters of the game between teams which won in the quarter finals and those which lost, the t-test was used. Data obtained for each individual variable is presented as a mean and standard deviation. The data was processed using the IBM Corp. Released 2010. IBM SPSS Statistics for Windows, Version 19.0. Armonk, NY: IBM Corp.

Results of the study

Table 1. Results of the Independent Samples Test

Variables	BTP (mean±SD)	WTP (mean±SD)	t	df	Sig. (2-tailed)	Effect size
GG(n)	5,5± 1,29	2,75± 2,06	2,261	6	,064	0,46
GT(n)	97,75± 6,29	99,75± 5,25	-,488	6	,643	0,04
EFG(%)	5,67± 1,54	2,77± 2,15	2,195	6	,071	0,45
SP(n)	1,25± 1,26	,75± ,50	,739	6	,488	0,08
TP(n)	1,75± 1,5	1,0± ,82	,878	6	,414	0,11
EFP(%)	58,33± 50,0	62,5± 47,87	-,120	6	,908	0,00

TG(n)	6,75± 2,36	3,5± 2,08	2,064	6	,085	0,42
TT(n)	99,5± 5,2	100,75± 5,74	-,323	6	,758	0,02
EFT(%)	6,86± 2,64	3,49± 2,16	1,977	6	,095	0,39
DB(n)	82,5± 7,85	78,5± 6,45	,787	6	,461	0,09
PM(n)	1,0± ,82	1,75± 1,5	-,878	6	,414	0,11

Legend: n- number, BTP- best teams parameters, WTP- worst teams parameters, GG- game goals, GT- game throws, EFG- game efficiency, SP- scored penalties, TP- throw penalties, EFP- efficiency of penalties, TG- total numbers of goals, TT- total number of throws, EFT- total efficiency, DB-defense blocks, PM- penalties made for the opponents.

The study results presented in Table 1 indicate that there is no statistically significant difference in the studied statistical parameters for matches played during the quarter finals of the Goalball tournament at the 2016 Rio Paralympics. The parameters for which the difference was closest to a statistical significance at the level $P \leq 0.05$, with a considerable effect size, were: game goals (GG), game efficiency (EFG), total number of goals (TG), and total efficiency (EFT).

Discussion

The results obtained in the study, presented in Table 1, indicate that there is no statistically significant difference in the studied match parameters between the winning and losing teams in the quarter finals. Although there were no statistically significant differences, the numeric values of all the parameters studied favored the winning teams. With parameters pertaining to the number of goals scored, (GG) and (TG), the expectation was for the numeric values to be in favor of the winning team. Such results were confirmed by (Lehto, et al., 2010). Their study examined the results of 15 matches played at the European Goalball Championships in 2011. The results showed that the winning teams had achieved a statistically significant higher number of goals, as well as that they had had a higher number of successful defenses. The number of successful blocks (DB) was also in favor of the winning teams in our study. This indicates a need to work on enhancing the goal defense during the training process. This can be achieved by training all three players to cover the field more efficiently, and to perform correctly the defense blocks in relation to the direction of the ball's movement following the opponents' throw. The number of penalties in favor of the opponent (PM) was higher in the defeated teams, indicating that the more successful teams cause fewer penalty situations, thus providing their opponents with fewer opportunities to score "easy" points.

What needs to be emphasized is the difference between the winning and losing in terms of efficiency both during the game (*EFG*) and in total (*EFT*). The difference obtained across these parameters was close to statistical significance, namely 0.071 and 0.095. The significance of this difference is further emphasized by the values for the effect size. Across these parameters, the effect size demonstrated a significant influence, 0.39 and 0.45 according to Cohen (1988). We consider the cause for the absence of a statistically significant difference in these parameters to be the small sample of participants in the study (a total of 8 participants, i.e., a goalball national team), which makes possible a type II error, namely that the power of the test was reduced. In view of the rules and the mode of playing goalball, where a team is required to immediately follow the defense of its own goal with an attempt at the opponent's goal without transferring the ball across the opponent's half of the court, their efficiency, i.e., the number of goals achieved in relation to the total number of throws, is what separates the more successful goalball teams from the less successful ones.

In view of the results obtained in this study, coaches should develop tactical elements in the preparation for a match, namely, by working on increasing both EFG and EFT. This could be achieved by developing a strategy of confusing the opponent by changing the position from which the ball is thrown, as this can affect the mode of defense, i.e., the positioning of players during a block. As far as technical elements are concerned, it is advisable to practice spin throw and throw which bounce the ball off the surface, as such throws are more difficult to defend against. This is confirmed by the results of the research (Lehto, et al., 2010), which showed that the highest number of goals was achieved from the spin throw.

Although the present study hasn't confirmed this, we also propose that the number of goals achieved from a penalty situation (SP), as well as the efficiency of the penalty kicks performed (EFP) are very important game parameters, since in a penalty situation an athlete makes an attempt at a 9m-wide goal defended by a single player. It is therefore considered an extraordinary advantage for the team awarded a penalty.

The results obtained in the present study are difficult to compare to other studies conducted to date on the statistical parameters of the game, due to the specificity of this sport. As it has already been noted, is the only team sport for persons with visual impairment which has no counterpart with persons with no sight impairment; consequently, there is no sport to compare it against. Another reasons for comparison difficulty is the paucity of studies into the statistical parameters of the game for goalball, with only a few conducted to date (Lehto, et al., 2012; Molik, et al., 2015; Morato, et al., 2017)]. The majority of the studies conducted have focused on assessing the effects of practice on the development of certain motor abilities in goalball athletes (Colak, et al., 2004; Karakaya, et al., 2009; Atan, & Ayca, 2015; da Cunha Furtado, et al., 2016; Bednarczuk, et al., 2017), on morphological profile (Caliskan, et al., 2011; Scherer, et al., 2012; Gawlik, Zwierzchowska, & Rosołek, 2015;; Karakoc, et al., 2017), or on postural status (Aydog, et al., 2006; Đorđević, et al., 2018).

Conclusion

The study conducted indicates that efficiency during the match proper and total efficiency are crucial match parameters which need to be worked on during match preparations, as parameters effectively separating the teams performing better from those with a worse performance based on the statistical results for the Goalball tournament held at the 2016 Paralympics in Rio. However, the scarcity of similar studies means that we are currently unable to make any generalizations from the results obtained, and that further similar studies for other international competitions are called for.

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Assessment of effort and pain after compak sporting competition using three different over&under shotguns

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ABSTRACT
The recoil of a shotgun can result in both an increase in perceived exertion and pain by the shooter and the occurrence of muscle fatigue phenomena. This represents a critical aspect of the disciplines of clay pigeon shooting where it is expected to hit a large number of targets by means of a firearm, which is typically the over/under shotgun. Therefore, this study aims to evaluate the effects of the recoil on the shooter and how the use of different weapons can modify these effects. Both qualitative and quantitative tests allowed to assess effort and pain perceived by the shooter (Rate of Perceived Exertion, RPE, and Visual Analog Scale, VAS) and his muscular force variation (Hand Grip Test, HGT, and Isometric Maximum Voluntary Contraction, IMVC) between rest condition and after the competition.

8 shooters (age 26.8±4.6 years; BMI 22.9±1.5 kg/m^2) with at least 4 years of shooting experience were recruited. Each shooter has fired with three different shotguns having different technical characteristics (balance and ergonomics) during three Compak Sporting competition.

The reproducibility of rest conditions during the three competition days was assessed by Intraclass Correlation Coefficient (ICC). Subsequently, Wilcoxon signed-rank test was used to compare the results of each test before and after the shooting session. Moreover, to determine any dependence on the technical features of the shotgun on the shooter's fatigue, an analysis of variance (ANOVA) was applied to highlight any differences between the three tested weapons. Significance was set a priori at $p<0.05$ for all tests.

Thanks to the proposed experimental protocol, significant differences were observed between rest condition and after Compak Sporting competition on HGT ($p=0.036$) and ET ($p=4.5\cdot10^{-5}$) for muscle fatigue and VAS ($p=1.5\cdot10^{-5}$) and RPE ($p=1.4\cdot10^{-3}$) for self-perceived fatigue. Significant differences in muscle fatigue levels were found when comparing the three types of gun, especially with regard to the upper part of the non-dominant shooter's body.

Key words: pain evaluation, effort evaluation, sports application, compak sporting

Introduction

Clay pigeon shooting is a precision sport discipline where flying discs have to be hit with firearms (Albert F. et al, 2016). Over the years, several competitions have flourished within this discipline including Compak Sporting (75 total clays, 3 series, 1 day, 120

maximum cartridges), where flying discs simulate the movement of animals (birds, hares, etc...). Specifically, targets follow different trajectories that are defined by the position assumed by the clay machines installed in the shooting camp.
In general, within this competition regulated by FITASC (Federation Internationale de Tir Aux Armes Sportives de Chasse), the most commonly used weapons are the over/under shotguns and the cartridge load is restricted to a maximum of 28gr (FITASC, 2016). The over/under are shotguns characterized by two barrels arrange one above the other. These shotguns are used both in hunting and in sports competitions. The sportive over/under shotgun differs from the hunting one in weight, length of barrels, chokes, balancing adjustments and other modifications applied to the trigger, to the stock and to the recoil pad.
In the practice of sport, the shooter may suffer muscle fatigue and feel pain because of both the weight and balancing of the shotgun and the recoil phenomenon that occurs with every shot. Weight and balancing in sportive over/under shotgun are very important for its stability both during the tracking of the target and after the shot. In addition, the weight also affects the recoil of the shotgun, which represents the semi-final phase of the shot in which any weapon moves backwards according to the law of momentum conservation. At this stage it is very important that the shooter can continue to chase the target in case the first shot has not been successful. Therefore, in addition to a possible decrease in sports performance, the effect of recoil can lead to fatigue and to the onset of pain perceived by the shooter.
Several studies in different experimental conditions have demonstrated that recoil can cause objective superficial lesions within the anatomical area of the shooter in contact with the shotgun (Harper W. et al, 1996) (Blankenship K. et al, 2004) and lead to an increase in localized pain perception (Wanamaker W.M., 1974) (Shyu W.C. et al, 1993).
Based on these observations, this paper focuses on the definition of an experimental protocol to evaluate the effort and pain perceived by the shooters in shooting competition by means of qualitative and quantitative tests.
Qualitative tests adopted in this work were *Visual Analog Scale* (VAS) and *Rate of Perceived Exertion* (RPE). In fact, previous studies have shown that VAS scale can be used to assess perceived pain (McCormack H.M. et al, 1988; Mattacola C.G. et al, 1997; Salwa R. et al, 2015; Coriolano K. et al, 2015) while RPE is an appropriate index to the evaluation of perceived effort (Pfeiffer K.A. 2002; Robertson R.J. 2004).
On the other hand, qualitative assessments were accompanied by quantitative tests such as Hand Grip Test (HGT) and Isometric Maximum Voluntary Contraction (IMVC). HGT was used to evaluate the force peak of the right and left arms (Helen C. Roberts 2011; Gerodimos V. 2012), while IMVC allowed to investigate muscle fatigue by means of the variations on the isometric maximum voluntary contraction (Troiano A., et al. 2008) of the Upper Trapezius (UT).

Material and methods

Participants

Subjects for this study were selected from a group of 44 male shooters holding a firearms license for sporting use. The selection was made on the basis of physical and sports performance criteria. The physical exclusion criteria were: BMI > 25 Kg/m^2; dominance of the left upper limb; previous musculoskeletal traumas involving the upper body and upper limbs. Physical characteristics and health status of all subjects were ascertained with a preliminary questionnaire.
In addition, subjects had to have a shooting experience of at least 4 years, which has been proven by a Compak Sporting competition (75 clays, 3 consecutive series) performed in a Federal shooting range. The requirements to be met in terms of sporting performance

were: hit at least 40/70 clays, shoot a maximum of 100/120 shots.
The result of the selection consists of 8 shooters (age 26.8±4.6 years; BMI 22.9±1.5 kg/m^2), who achieved a score of 50,6±5,9 during the Compak Sporting competition.
All subjects provided written informed consent to participate.

Measurements
Three different under/over sportive shotguns were used for this study (technical details are shown in Table 1). The choice to use three shotguns is linked to the will to investigate a possible influence of the tool in fatigue perceived by the shooter. In this case, the different technical solutions in terms of balance and ergonomics are examined as the targeting settings have been kept as similar as possible between the shotguns. Only 28 gr. lead cartridges (Official Sporting, Fiocchi ammunition) were used during the Compak Sporting competitions (75 total clays, 3 series). To ensure that all shooters could shoot with all different shotguns, three competitions were organized (Day 1-3), which were interspersed by two weeks of rest from each other so that an optimal recovery by shooters could be guaranteed. Shooters were asked to perform all evaluation tests (VAS, RPE, IMVC and HGT) in rest conditions (t0) and at the end of the shooting session (tf).

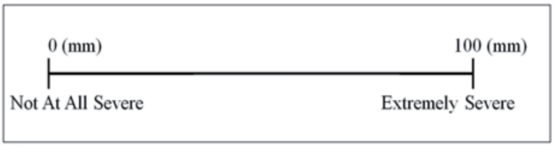
Table 1: Shotguns technical details.

Shotguns	Characterstics – shotgun adjustment					Chokes	Lenght (cm)				Weight (gr)				
	Fold Heel	Fold Comb	Pitch	Deviation Upper	Deviation Down	Tipology	LOP	Barrel	Choke external part	All Shotgun	Barrel + Rib	Choke	Rib	Carcassa + Stock	Total
Shotgun_A	56	37,5	5'	4 mm right	6 mm right	2** upper EXT 3*** down EXT	37,6	76	2 (ext) 9 (tot)	122,5	1430 (tot) 70 (Rib)	47 (2**) 45 (3***)	251	1800	3575
Shotgun_B	54	35	5'	3 mm right	8 mm right	2** upper EXT 3*** down EXT	37,3	76	2 (ext) 9 (tot)	121,5	1398 (tot) Welded Rib	34 (2**) 32 (3***)	256	1900	3621
Shotgun_C	55	36	6'	2 mm right	2 mm right	2** upper EXT 3*** down EXT	37,8	76	2 (ext) 10 (tot)	122	1466 (tot) Welded Rib	39 (2**) 37 (3***)	342	1657	3545

Two groups (G1,G2) of 4 shooters were arranged, whose subdivision was maintained until the end of all the Compak Sporting competitions.
In order to ensure repeatability of the environmental conditions, each competition started at the same time (09.00 a.m.) always in the same official shooting range for the Compak Sporting.
Before the shooting session, all shooters underwent a15' warm-up (stretching exercises for the upper trunk) to increase the body temperature and lubricate the articulations that are involved during the competition.
All shooters carried out the planned evaluation tests after the warm-up. Afterwards, G1 started shooting (the shooting series was always coordinated by two operators who had the task of checking the traps and the score), while G2 was at rest. At the end of the series, the two groups exchanged each other. This shooting sequence lasted until the end of the 3 expected series. Finally, after series 3, all shooters carried out the final evaluation tests. Table 2 shows the sequence of tests execution.

Qualitative tests
Two different instruments were used to measure the self-perceived fatigue (VAS) and effort (RPE) experienced by the shooters. VAS scale was used to quantify the perceived pain within the contact area between the shotgun and the upper body of the shooter (i.e. pectoralis major and anterior deltoid muscles). VAS scale is a validated psychometric instrument consisting in a horizontal line having length of 100 mm (0=no pain; 100=maximum pain). The shooter draws a vertical line above the reference line based on the perceived pain (Figure 1.A). RPE was used to assess the perceived effort

of the shooter in the upper trunk (upper the navel). When using this scale, the shooter writes a number between 0 (no effort) and 10 (maximum effort) to indicate the felt effort in accordance with the scale shown in Figure 1.B.



A

RATING	DESCRIPTION	
0	NOTHING ATT ALL	NIENTE DI NIENTE
0,5	VERY,VERY LIGHT	MOLTO, MOLTO LEGGERO
1	VERY LIGHT	MOLTO LEGGERO
2	FAIRLY LIGHT	ABBASTANZA LEGGERO
3	MODERATE	MODERATO
4	SOMEWHAT HARD	PIUTTOSTO DURO
5	HARD	DURO
6		
7	VERY HARD	MOLTO DURO
8		
9		
10	VERY, VERY HARD (MAXIMAL)	MOLTO, MOLTO DURO (MASSIMALE)

B

Figure 1: Reference schemes adopted for qualitative tests: (A) Visual Analog Scale, used to evaluate the pain perceived by the shooters; (B) Rate of Perceived Exertion scale, implemented as a measure of the perceived effort.

Quantitative tests

The investigation of muscle fatigue in quantitative terms was carried out through the analysis of the handgrip performance (Hand Grip Test) and the Muscular Resistance of the Upper Trapezius (Isometric Maximum Voluntary Contraction).

The execution of HGT involved the measurement of the maximal grip strength using a hand dynamometer (model: J00105, JAMAR Hydraulic Hand Dynamometer, distributed by: Patterson medical). Test was performed based on the procedure recommended by Helen C. Roberts (2011), where all the critical points of the test execution were identified. Briefly, each shooter performed the test in a sitting and comfortable position on a flat surface keeping the shoulder of tested arm adducted, the elbow flexed at 90°, whereas the forearm and wrist were set in neutral position (De Smet et al., 2001; Holm et al., 2008). Testing protocol consisted of three maximal isometric contractions with a rest period of at least 60 s between them. For each subject, maximal grip strength was determined as the highest of the three contractions (Gerodimos, V. 2012). HGT was performed on both the dominant and non-dominant hands. To demonstrate the presence of fatigue due to shooting session from the HGT results, the Strength Decrement Index (SDI) was used as an index of strength loss, where:

$$SDI = \frac{(Initial\ Strength - Final\ \ Strength)}{Initial\ Strength} \times 100$$

SDI was expressed as a percentage for each subject.

In order to study the isometric contractions of the UT, initially a three-trial test of shoulder elevation was performed to evaluate the Maximum Voluntary Contraction (MVC) of each subject, who was asked to reach the peak force within 5 seconds, with 5 minutes of rest in between. Verbal encouragement was provided to help the subject reach the highest level of contraction. Force measurement was carried out by means of two load cells (Model NO. 615, Tedea huntleight, 5000 Newton) connected to a data acquisition system (Serial No. D0201D8B, DEWE Soft – 43V ISO-POWER, "measurement innovation", made in E.C.). The mean value of the force achieved during the three repetitions was selected as reference MVC. Once this reference has been defined, the subjects was asked to perform an isometric contraction at 50%MVC (target contraction level) and to maintain this force until exhaustion both at rest and at the end of the shooting session. UT was contracted until the subject's strength decreased below 90% of the target. The time during which UT strength dropped to the specified limit value was recorded as a measure of fatigue resistance, i.e. Endurance Time (ET) (Troiano, A., et al. 2008). The test was run simultaneously for both the dominant and the non-dominant part to ensure a symmetrical posture of the subject. Even in this case three repetitions were made and the mean value of the three readings was used as outcome measure. Since muscle fatigue can be defined as any decrease in the capacity of the neuromuscular system to generate force (Zwarts M.J., et al. 2008), the relative drop in ET measured before and after the shooting session can be considered an estimate of this physiological condition. The reference index is defined as:

Statistical analysis

Indices of handgrip (HGT) and maximum voluntary contraction testing (IMVC and ET) were calculated for each shooter, on each shooting session, for both the dominant and non-dominant hands. Descriptive statistics (mean and standard deviation) were used to describe the results obtained with both the qualitative and quantitative tests.

Reliability of indices was calculated as the single measures intra-class correlation coefficient (ICC) of Day 1–3 data for rest condition. This allowed to verify whether the shooters were in the same initial conditions before carrying out the competition. In general, ICC value of >0.9 is classified as 'excellent'; ⩾ 0.6 is 'acceptable'; and < 0.6 indicates the presence of possible alterations of the initial condition of the shooters or that the measurement system is inadequate.

Wilcoxon signed-rank test was used to compare the measurements of each index before and after the shooting session. Moreover, to determine any dependence on the tool used (shotgun) on the shooter's fatigue, one-way analysis of variance (ANOVA) was applied to compare results of each test using the *F* distribution. Then, in order to compare the three shotguns directly with each other, a multiple comparison test of the means of the group was performed according to Tukey's honestly significant difference procedure. Significance was set a priori at $p<0.05$ for all tests. All analysis were performed using Matlab, version 2017b (The MathWorks, Inc., 1994).

Results

Descriptive data (presented as mean ± standard deviation) for indexes of interest according to the three days of testing are shown in Table 2.

Table 2: Reliability of data obtained in rest conditions during the three competition days.

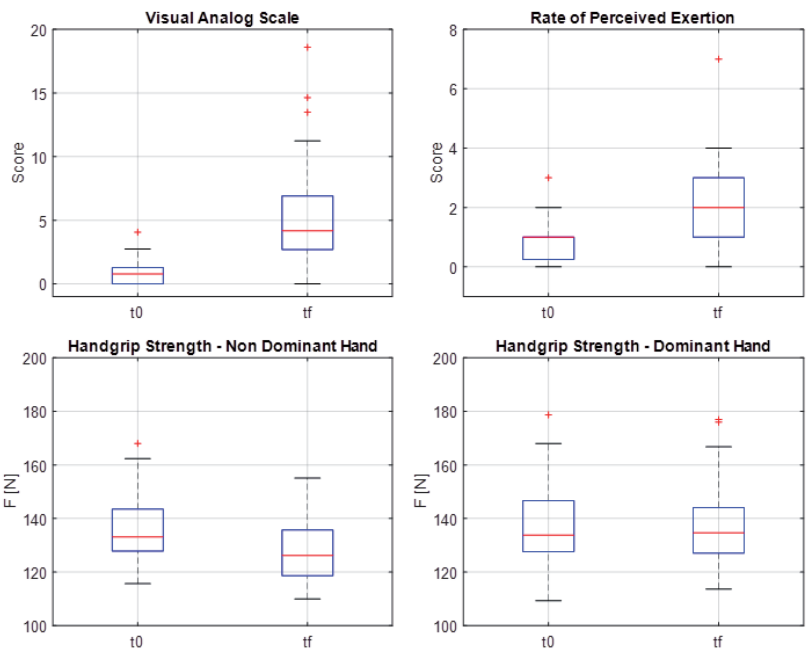
	Test	Day_1	Day_2	Day_3	ICC	p value
DOMINANT HAND	VAS	0.5±0.6	1.2±1.5	0.9±1.0	0.62	0.06
	RPE	0.9±0.8	0.9±0.6	0.8±1.0	0.85	**$1.3 \cdot 10^{-3}$**
	HGT [N]	134.9±14.8	138.3±16.5	136.9±11.7	0.96	**$5.6 \cdot 10^{-7}$**
	IMVC [N]	839.1±33.2	811.9±23.2	840.5±23.3	0.60	0.07
	ET [s]	22.1±3.6	28.0±5.6	22.8±6.8	0.59	0.08

NON DOMINANT HAND	VAS	0.5±0.6	1.2±1.5	0.9±1.0	0.62	0.06
	RPE	0.9±0.8	0.9±0.6	0.8±1.0	0.85	**$1.3 \cdot 10^{-3}$**
	HGT [N]	129.7±18.4	126.6±18.8	127.5±16.2	0.93	**$1.8 \cdot 10^{-5}$**
	IMVC [N]	781.1±28.2	751.7±32.4	783.7±34.6	0.64	0.06
	ET [s]	23.4±4.2	27.1±5.6	24.4±6.1	0.58	0.08

According to the results, the measurement of the hand grip strength and the perceived effort proved reliable (ICC>0.8, $p<0.05$) while the results obtained during the maximal voluntary contraction and the felt pain show ICC values that are lower but still acceptable. This allowed to carry out the subsequent analysis by grouping together the data obtained in the three days into two groups (t0 and tf) regardless of the used shotgun.
Figure 2 and Table 3 show the results obtained from the direct measurements carried out with both qualitative and quantitative tests divided into the two reference groups. The onset of muscle fatigue and pain perception were investigated by comparing the data thus obtained through Wilcoxon signed-rank test, whose results are reported in Table 3.

Table 3: Relationship between rest condition (t0) and after Compak Sporting competitions (tf) in Self-Perceived Fatigue (VAS) and Effort (RPE), Handgrip Performance (HGT) and Muscular Resistance (ET).

	VAS	RPE	HGT [N]		ET [s]	
			Dominant	Non Dominant	Dominant	Non Dominant
t0	0.89±1.09	0.88±0.77	137.9±17.1	136.7±13.9	24.3±5.5	25.0±4.9
tf	5.73±4.78	2.10±1.59	137.2±16.9	128.4±12.7	20.0±4.9	20.5±4.9
p value	**$2.7 \cdot 10^{-5}$**	**$6.1 \cdot 10^{-4}$**	**0.06**	**$1.8 \cdot 10^{-5}$**	**$7.1 \cdot 10^{-3}$**	**$2.6 \cdot 10^{-3}$**



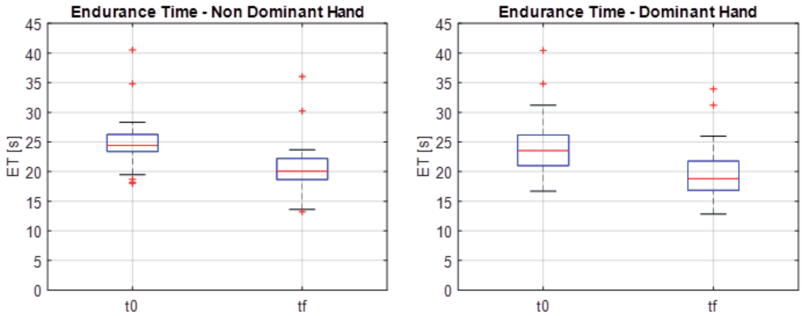
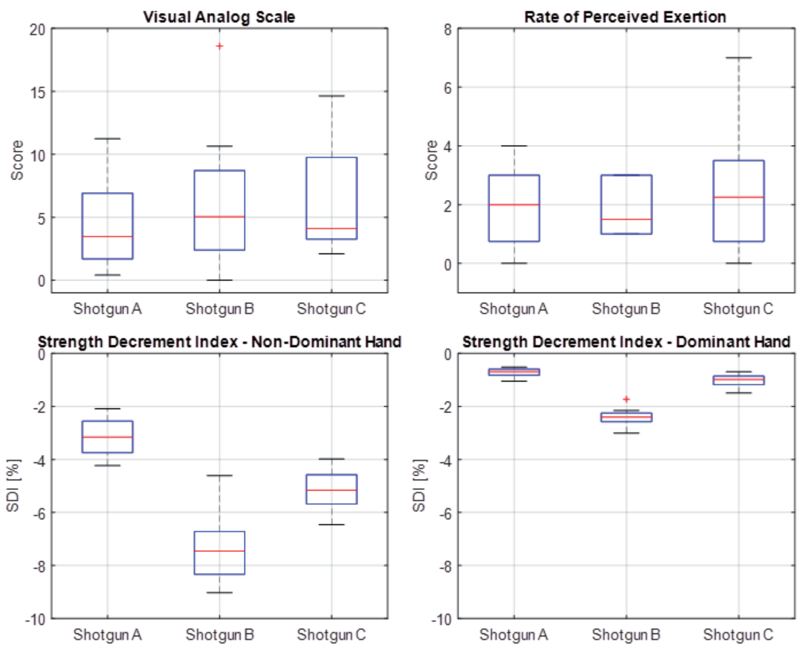


Figure2: Box plot to the data obtained from all shotguns before (t0) and after (tf) competitions.

The statistical analysis of the data reveals that both types of performed tests allow to detect significant differences between rest condition (t0) and after Compak Sporting competition (tf). It appears that, because of the participation in the competition, shooters perceived a greater sense of effort and pain (VAS, $p=1.5{\cdot}10^{-5}$, and RPE, $p=1.4{\cdot}10^{-3}$). In addition, they underwent a reduction in muscle force generated by the upper trapezius (ET of both dominant and non-dominant hand, $p=7.1{\cdot}10^{-3}$) and in handgrip strength (HGT of non-dominant hand, $p<1.8{\cdot}10^{-5}$).
In order to evaluate the effect of the recoil of different shotguns, the one-way ANOVA analysis was applied to the results divided by the three types of weapon (Shotgun A, B, C). Figure 3 shows the scores given by the shooters at the end of the competition regarding VAS and RPE.
As for quantitative tests, in this case the variations of the handgrip strength (SDI) and the reduction of the endurance time (ΔET) were analyzed. The results are reported as a percentage variation (Δ%) between rest condition and after shooting session.



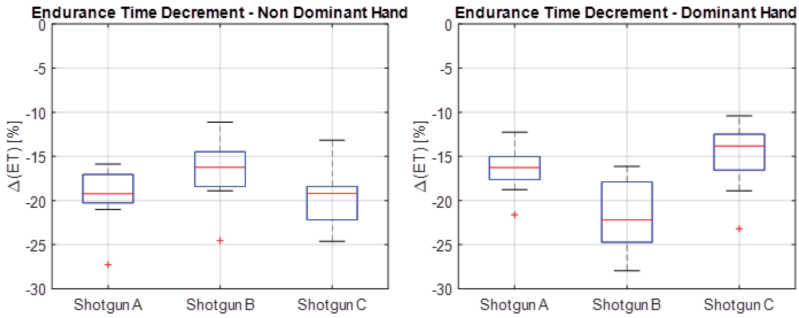


Figure 3: Box plot to the data obtained after (tf) to compare the qualitative and quantitative tests data between the different sportive shotguns used.

As reported in Table 4, the use of shotguns having different technical characteristics determined a reduction of the muscular resistance of the shooters (SDI ΔET, and $p<0.05$). On the other hand, the comparison between the effort and the pain perceived by the shooter in relation to the shotgun used during the competition was non-significant.
Post hoc tests using Tukey's honest significant difference criterion were performed for each of the quantitative parameters in order to determine which pairs of data sets related to different shotguns were significantly different. Table 5 shows the results of the multiple comparison analysis. Shotgun A was characterized by significantly lower average value of strength decrement index compared to the other two shotguns, as regards both the dominant and the non-dominant hand. With regard to this index, Shotgun B turned out to be the weapon that determines a greater reduction of the handgrip strength regardless of the hand ($p<0.05$). In contrast, Shotgun B proved to be the firearm which resulted in a lower reduction in muscular resistance of the upper trapezius; this difference was significant in the case of the dominant hand ($p<0.05$).

Table 4: F statistics obtained from ANOVA analysis. Significant differences ($p<0.05$) were observed for ΔET (dominant hand) and SDI (both dominant and non-dominant hand), as shown by (*).

VAS	RPE	SDI		ΔET	
		Dominant	Non Dominant	Dominant	Non Dominant
0.4	0.35	78.68 (*)	32.55 (*)	7.14 (*)	1.57

Table 5: Multiple comparison test on the effect of shotgun factor in SDI and ΔET.

Value		Shotgun Lower Bound		Mean Difference Upper Bound	95% CI		p value
SDI [%]	Dominant	A	B	1.7	1.3	2.0	**$1.3 \cdot 10^{-9}$**
		A	C	0.3	-0.1	0.7	0.11
		B	C	-1.4	-1.7	-1.0	**$1.2 \cdot 10^{-8}$**
	Non Dominant	A	B	4.2	2.8	5.5	**$2.1 \cdot 10^{-7}$**
		A	C	2.0	0.7	3.3	**$2.4 \cdot 10^{-3}$**
		B	C	-2.2	-3.5	-0.9	**$1.1 \cdot 10^{-3}$**

ΔET [%]	Dominant	A	B	5.3	0.5	10.0	**0.03**
		A	C	-1.5	-6.3	3.2	0.69
		B	C	-6.8	-11.6	-2.1	**$4.5 \cdot 10^{-3}$**
	Non Dominant	A	B	-2.8	-7.5	1.9	0.31
		A	C	0.1	-4.6	4.8	0.99
		B	C	2.9	-1.8	7.6	0.28

Discussions

The aims of this study were to investigate the effects of the recoil of a shotgun on the shooter during a Compak Sporting competition, and later assessing the sensitivity of these effects from the shotgun used. Indeed, three different over/under shotguns with similar configurations but different technical characteristics (balance and ergonomics) were selected for this research. The recoil's effects that were analyzed are the effort and pain perceived by the shooter and his muscular force variation between rest condition and after the competition.

As already observed in other studies (Wanamaker W.M., 1974; Shyu W.C. et al, 1993; Harper W. et al, 1996; Blankenship K. et al, 2004), a cutback in strength and an increase in the perception of pain and fatigue are expected on all shooters after the conclusion of the competition.

As predicted, results revealed a significant growth of pain and perceived effort, a reduction of the maximum peak force measured using the hand dynamometer and a decrement of the endurance time during isometric maximum voluntary contraction of the upper trapezius in all groups (shotgun_1, shotgun_2, shotgun_3). This result is verified regardless of the shotgun. In general, this evidence supports the theorizing that clay shooting competitions entail the strength decrease in the muscles of interest and a pain and effort perceived increase.

With regard to the weapon, it is possible to observe that the three shotguns reveal similar results in terms of self-perceived effort and pain. Conversely, the quantitative analysis of muscle fatigue, shotgun_A and shotgun_B shows statistically significant differences compared to shotgun_C both in HGT test (dominant and non-dominant hand) and in IMVC test (only dominant hand).

The present study is aligned with other few studies which analyzed the effects of the recoil in shooting activity (Harper W. et al, 1996; Blankenship K. et al, 2004). Indeed, the analysis of the effects of the shotgun recoil in the sportive activity is a relatively novel perspective. Many studies have analyzed the shooting technique (Hrybovskyy R. et al, 2015; Causer J. et al, 2010) but not the effects of the recoil on the performance of the shooter nor even the physiological aspects related to it. Up to date this is the first study that quantifies the strength reduction related to muscle fatigue and measures effort and pain perceived by the shooter.

Self-reported fatigue and pain ratings were low-moderate and increased marginally in all groups over the course of the competition in contrast to the muscular strength, which decreases faster. However, this result is consistent with recent findings by Vohs (Vohs K.D. et al, 2011), where muscle fatigue or depletion effects occurred independently of subjective fatigue.

The proposed protocol was effective in achieving consistent and reliable results. However, future studies require a greater number of shooters and the use of direct tests for assessing muscle fatigue.

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Body composition changes during eight weeks of aerobic, strength or combined aerobic-strength training

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ABSTRACT
Purpose of this study was to track changes in body composition for the whole body and for the particular body regions in young women during eight weeks of practicing strength, aerobic or combined aerobic-strength training. Effects of different training protocols were compared and dynamic of change in body composition examined for different exercise types. Thirty-one female aged 18-24 years were assigned to one of three groups that performed strength, aerobic or aerobic-strength exercise in one-hour sessions three times per week, for eight weeks. Body composition was assessed using bioelectric impedance method after every sixth session. Soft lean mass of lower limbs changed with strength training and fat mass with aerobic exercise, with the overall reduction of percent of body fat. Combined training showed improvements in soft lean mass and influenced body fat in all of the measured regions, except in upper limbs. Results showed that change dynamic in body composition was very different for different types of training. In conclusion, body composition changes vary with different types of exercise. The most effective in fat mass reduction and improvement in soft lean mass was combined training. Fat mass and soft lean mass changed differently when aerobic or strength exercise applied.

Key words: weight, mass of body fat, soft lean mass, bioelectrical impedance

Introduction
One of the most important goals of presence is maintenance of healthy body weight. It usually includes changes in body composition and body fat percentage lowering in order to improve health and minimize risks of diseases connected to body fat excess. Regulation of body weight is usually achieved through changes in diet (Larson-Meyer et al, 2010), introduction of physical activity in everyday life or improvement in physical activity level (Lee et al, 2012; Stensvold et al, 2010; Willis et al, 2012) or combination of those two (Ahmadi et al, 2011; Foster-Schubert et al, 2012; Ryan et al, 2012). Reports on the impact of physical activity on body composition vary a lot in types of training and results. Some studies point out the success of aerobic training in reduction of overweight and obesity (Boutcher, 2010; Heijden et al, 2010; Heydari et al, 2010). Others recommend strength training in regulation of body weight (Velez et al, 2010; Avila et al, 2010; Kwon et al, 2010; Strasser & Schobersberger, 2010) because of its positive effects and prevention of muscle mass loss at the same time (Garrow, Summerbell, 1995). Published studies that involved both types of exercises are very heterogeneous in training protocols. Among them, some describe circular training protocols that involve both types of exercise in each session (Paoli et al, 2010), while other practice sessions of aerobic and strength exercise intermittently, with different types of exercise in different sessions (Park et al, 2003). There are many studies investigating body weight changes with exercise and

most of them compare effects at the end of exercise protocol. We spotted a lack of studies considering the course of change in body weight and body composition during the implementation of exercise protocols. The aim of this study was to compare effects of different training protocols implemented during 8 weeks on body composition of sedentary women in their twenties. The main goal was to establish how aerobic training, strength training and combination of those two will affect the composition of the whole body mass, as well as composition in different body regions (upper and lower limbs and trunk). The main hypothesis, based on similar published studies is that combined training consisting of strength + aerobic exercise will be most beneficial in the sense of restructuring body composition, lowering body fat and improving lean body mass, and that changes will be the largest and the fastest for this type of exercise.

Methods and materials

1. General study design

The study took place at College of Applied Sciences Lavoslav Ruzicka in Vukovar and included 54 female students who volunteered for the study and gave written informed consent. The study protocol and procedures conformed to the standards set by the latest revision of the *Declaration of Helsinki* and national legislation. Only non-athletes were involved. We randomly assigned them to one of three groups that performed different training protocols: aerobic training (AT), strength training (ST) and combined aerobic-strength training protocol (AST) during eight weeks. Only 31 female completed the exercise protocol as follows: in AT-group 10 participants, in ST-group 10 participants, and in AST-group11 participants.

2. Morphological characteristics

We measured weight and height according to standard protocols. Analysis of body composition was made by bioelectric impedance analysis (BIA) method using body composition analyser GAIA 359 (Jawon Medical, Korea). All participants were informed regarding measuring standards: no food or drinks 4 hours prior to the measurement, no exercise 12 hours before the measurement, no alcohol consumption 48 hours before the measurement, and empty bladder 30 minutes prior to the measurement. Results included: body mass index (BMI), soft lean mass (SLM), mass of body fat (MBF), percent of body fat (PBF), upper limbs soft lean mass (ULSLM), upper limbs mass of body fat (ULMBF), lower limbs soft lean mass (LLSLM), lower limbs mass of body fat (LLMBF), soft lean mass in trunk area (TRSLM) and mass of body fat in trunk area (TRMBF). Each group was measured 5 times: initial, transitive measurements after every sixth training, and final at the end of the training protocol. All measurements were performed in the morning hours (7-9am), with unchanged conditions of measurements by the same trained technician. Subjects stood barefoot on electrodes in the pedestal of the instrument and held electrodes in the hands. Body composition was calculated based on the size of impedance.

3, Physical fitness assessment

In groups AT and AST, physical fitness was assessed at the beginning and at the end of the study using Cooper test. Cooper test was performed on the treadmill (Precor 966i, USA) during 12 minutes, while VO_2max was calculated from distance subject ran during this period of time (Ward et al, 1995)(expressed as $ml\cdot kg^{-1}\cdot min^{-1)}$. Based on the results subjects were then assigned to one of 5 categories of physical fitness: very poor (VO_2max <23.6), poor (VO_2max 23.6-28.9), fair (VO_2max 29.0-32.9), good (VO_2max 33.0-36.9), excellent (VO_2max 37.0-41.0) and superior (VO_2max >41.0).

Motor skills assessment
For groups ST and AST motor skills were assessed at the beginning and at the end of the study. Measurements included the absolute power of lower limbs (1RM - one maximum repetition both feet thrusted against the horizontal press), the absolute power of arms and shoulders (1RM chest press) and trunk flexor repetitive strength (number of trunk flexion from lying position in one minute).

4. Exercise protocols
Subjects who exercised in AT group had a three one-hour sessions per week. Aerobic exercise consisted of running outside on the asphalt road. Maximum heart rate was calculated according to the Tanak et al (Tanak et al, 2001) as HR max = 208-0.7 x years of age.
First two weeks: lower-intensity trainings at 60% HR max during 45-60 minutes. *Next two weeks:* intensity changed; interval training in duration three minutes at 75% HR max followed by rest for 6 minutes. Each session began running at 60% HR max for five minutes followed by interchanging intervals (five intervals per session). Next six sessions consisted of five minutes intervals at 75% HR max followed by low-intensity rest intervals at 60% HR max (five interval changes per session). *Last two weeks:* first session at continuous intensity at 75% HR max 40-45 minutes, second session lower intensity at 60% HR max, and every third session at 80-85% HR max. Sessions with maximum load start as 15 minutes running at 60% HR max, followed by four intervals of interchange load with one-minute working interval and three minutes rest. End of intervals followed by 15 minutes running at 60% HR max. Every running session ended with stretching exercise.
Strength training group had also three one-hour sessions per week in the gym. *First two weeks:* 12 exercises, two sets 15-20 repetitions, resting period one minute between sets. *Next two weeks:* 12 exercises, three sets 15-20 repetitions, resting period 30 seconds between sets. Training was performed as station method, load 60% of 1RM. The exercises involved muscles of arms and shoulders, torso and legs. *Final four weeks:* every session was designed for the particular muscle group load 80-85% of 1RM. The session consisted of seven to nine exercises performed in three sets 8-12 repetitions, resting period up to three minutes.
Combined aerobic-strength training group had three one-hour sessions per week consisted of aerobic part and the strength training part. Aerobic part was at the beginning and at the end of each session consisted of running outside on the asphalt road for 3.8-6 km depending on the intensity and load of strength training part of the session. Strength training was designed to employ entire body musculature using different methods of training. Exercises included various forms (push-ups, pull-ups, jumps, squats).

5. Statistical analysis
Statistical analysis was performed using MedCalc 10.2.0.0 (MedCalc Software, Belgium) and IBM SPSS Statistics 20 (IBM Corp., USA). One-way ANOVA was used for differences between groups and Repeated Measures ANOVA with grouping variable (between-subjects factor) training type, and LSD post-hoc analysis to determine influence of type of exercise on measured variables change. Statistical significance was set at $p=0.05$.

Results
Thirty-one female aged 18-24 years completed the protocol. There were no differences in morphological characteristics between groups that performed different training protocols (Table 1).

Table 1. Baseline morphological characteristics for each training group (AST aerobic strength training group, AT aerobic training group, ST strength training group) and for the whole sample (Total), with results of ANOVA test for differences between groups

	AT (N=11)		ST (N=10)		AST (N=10)		Total (N=31)				Difference between groups	
	x̄	SD	x̄	SD	x̄	SD	x̄	SD	Minimum	Maximum	F	p
BMI	21.5	2.8	23.2	1.5	21.0	2.2	21.9	2.4	17.9	26.0	2.6	0.089
PBF	26.0	4.1	27.6	3.0	24.8	3.6	26.2	3.7	19.2	34.0	1.5	0.243
MBF	15.9	5.5	18.3	3.2	14.9	3.8	16.4	4.4	9.1	26.7	1.6	0.226
SLM	40.1	5.3	43.9	3.3	41.1	4.6	41.7	4.6	33.0	49.5	1.9	0.175
ULMBF	1.9	0.7	2.1	0.4	1.8	0.5	2.0	0.6	1.1	3.4	0.6	0.568
ULSLM	5.4	0.6	6.0	0.8	5.4	0.6	5.6	0.7	4.3	8.0	2.4	0.105
LLMBF	5.7	2.0	6.5	1.2	5.2	1.7	5.8	1.7	2.8	9.6	1.6	0.221
LLSLM	14.4	2.1	16.1	1.4	14.6	1.9	15.0	1.9	11.6	18.9	2.3	0.119
TRMBF	8.2	2.8	9.2	1.9	7.7	2.0	8.4	2.3	4.7	13.7	1.0	0.366
TRSLM	20.4	2.6	21.5	1.7	20.9	2.2	20.9	2.2	16.9	24.8	0.7	0.499

Abbreviations: BMI body mass index, PBF percent of body fat, MBF mass of body fat, SLM soft lean mass, UL upper limbs, LL lower limbs, TR trunk

Initial value of VO2max among females was 27.7 $ml \cdot kg^{-1} \cdot min^{-1}$ indicating poor physical fitness level. Different exercise protocols effectiveness was measured according to the type of exercise. For AT, VO_2max was measured and values improved significantly (Table 2). For ST, changes in the motor skill tests proved that the training was regularly conducted (Table 2). For AST, all measured variables significantly changed indicating successful training (Table 2).

Table 2. Effectiveness of exercise protocols conducted (AT aerobic training, AST aerobic strength training, ST strength training) measured by functional tests improvement (mean difference)

	AT (N=10)		AST (N=11)		ST (N=10)	
	Δx̄	p	Δx̄	p	Δx̄	p
VO2max	7.69	0.00*	6.87	0.00*		
1RM CP			2.27	0.02*	6.00	0.00*
1RM LL			20.36	0.00*	12.80	0.00*
TFRS			5.36	0.00*	5.70	0.01*

Abbreviations: CP chest press, LL lower limb, TFRS trunk flexors repetitive strength (trunk flexion from lying position per minute).
*statistically significant

Body weight did not change significantly during the study in any of the three groups. However, changes in body composition were statistically significant.
The overall SLM change was not statistically significant (F=1.53, p=0.188). Significant change was obtained for LLSLM (F=4.56, p=0.001) in ST and in AT groups, but not in AST group. In ST group, improvement in LLSLM was visible after 2 weeks of exercise. Measurement value point 2 was significantly higher compared to baseline measurement (mean difference 0.91, p=0.013). After that rise, it started to decline but it was still higher in the last measurement than at the baseline, although with no statistically significant

difference (mean difference=0.172, p=0.401). In AT group, LLSLM abated first two weeks but without significant difference from baseline (p=0.927). After that, it rose for 4 weeks. LLSLM was significantly higher in points 3 and 4 compared to point 2 in AT group (p=0.01, and p=0.016, respectively). This followed the fall in the last two weeks so that the value measured at the end of the protocol (measurement point 5) was lower compared to point 4 (p=0.015), but not significantly lower compared to baseline (mean difference= 0.2, p=0.27). Changes for ULSLM and TRSLM did not significantly change between the measurement points in any group or between the groups (time x training p(ULSLM)=0.111; time x training p(TRSLM)=0.297).

MBF for the whole body showed the significant difference for time x training type (F=2.603, p=0.017). All of the MBF values (total and measured by regions) changed the same way. At the beginning of AT protocol it decreased for 6 weeks (until measurement point 4) and then started to rise, but the value measured at the end was still lower than the value at the point 3 (4 weeks after the beginning of the protocol). In AST group values of MBF for the whole body and measured by regions increased for 4 weeks and decreased after that below the baseline value. MBF changes were significant in AT and AST groups and not significant in ST group. ULMBF changed only in the AST group, while LLMBF changed in AT and AST. TRMBF changed in AT and in AST.

PBF changed similar to MBF significantly in AT and AST groups, and did not change significantly in ST group. In the first half of exercise protocol in AT group PBF was increasing, and from that point, it started to decrease so that value at the end of the protocol was lower compared to baseline (mean difference 0.609, p=0.234). Although the difference between the first and the last measurement in AST group was not statistically significant, the decrease of 1.18% between points 3 and 5 was statistically significant (p<0.0001), as well as the decrease 0.491% (p=0.032) between point 4 and point 5. In AT group, after the value of PBF decreased for 1.1% during first 6 weeks it started to increase, resulting in lowest value being the value of the fourth measurement of 26.5%, which significantly differed from baseline (p=0.004) and from the second measurement (p=0.036). When compared to the groups at the same points of measurement PBF differed only in measurement point 2 between groups AST and ST (mean difference 4.01%, p=0.028).

Discussion

Our main finding is that different types of exercises influence body composition differently in body regions. SLM did not improve equally, more in limbs than in trunk region, while the influence of exercise on MBF was more in the trunk than in the limbs.

This study design was to show how different exercise types influence body composition during eight weeks of exercise. Although there was no weight change after completing exercise protocols compared to the baseline values, influence of exercise on body composition was not lacking. Aerobic exercise protocol affected SLM of lower limbs during the eight weeks and reduced total MBF in the body, TRMBF and MBF of the limbs, both LLMBF and ULMBF. These results correspond with those of Park et al (2003), and support conclusion of Slentz et al (2011) that aerobic exercise leads to reduction in total MBF and represents a very good approach in managing obesity. It is also interesting how MBF change dynamic was different in AT and AST training protocols. Reduction of MBF in AT was faster in the beginning, while in AST, MBF first increased, followed by a decrease.

ST protocol prompted only improvement in LLSLM although it was designed to actuate the whole body. Enhancement was significant after 2 weeks of practicing strength exercise while other studies reported increase in muscle size after 3 weeks (Seyness et al, 2007).

Combined training protocol (AST) affected both, MBF and SLM. Results show decrease in the LLMBF and simultaneously improvement in LLSLM. In other words, this protocol reduced fat - aerobic part of protocol, and at the same time enhanced muscle mass - strength training of protocol. However, only in lower limbs. This may be due to running as aerobic part of the protocol where participants used leg muscles more than the rest of the body musculature. In AST, there was a significant change in MBF in all of the body regions, while in AT, MBF change was not significant for upper limbs. Some studies recommend inclusion of resistance exercise into aerobic training in weight loss programs to help reduce fat mass (Sanal et al, 2013) or prevent loss of fat-free mass (Bryner et al, 1999). Therefore, strength exercise obviously plays some role in reducing fat combined with aerobic exercise, although we did not notice any significant MBF change in ST group.

This study is one of the rare ones that sees into changes in body composition during different exercise protocols; follow the changes during exercises, and not just final effects of eight weeks practicing different protocols. Although overall initial and final changes are not statistically significant, there are some significant differences between the exercise protocols and their influence on body mass and body composition. We also compared effects of different exercise types on body composition in different body regions. An advantage of this kind of study is the ability to observe changes in body composition among body regions.

One of the limitations is no eating habits data together with info on motivation level in the groups. We asked the participants not to change their usual diet, but there is always a possibility that some of them did not follow the advice that could influence the results. Another limitation could be the sample size. Although there were only 10 or 11 participants that completed each exercise protocol, attendance was 100%, they completed all of the sessions. The sample was homogenous in all the measured variables, participants randomly distributed into three groups, which were equal in size, at the beginning and at the end of the study.

To conclude, ST changed only LLSLM, AT changed FM with an overall reduction of MBF, while AST led to improvement in SLM and influenced body fat in all of the measured regions except in upper limbs. Differences in effects of different types of exercise were as expected, considering differences in physiological processes involved. Nevertheless, we need further studies in finding the optimal approach in dealing with body fat excess.

Authors' contributions

NN designed the study, oversaw the data collection, and wrote up the initial manuscript. VŠ assisted with data analysis and writing of the manuscript. EDC analysed the data. All authors played a part in the preparation of the manuscript at each stage of its development. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

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Body mass index (BMI) vs body fat percentage (BFP) as a relation to estimate players' physiological soccer adaptation profile

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Purpose: In a soccer game, a VO2max of 60 ml/kg/min has been suggested as the minimum fitness requirement for male soccer players to play at elite level. While the average maximal oxygen intake for elite adult players are reported to be in the range of 55 to 69 ml/kg/min. Although to predict the effective endurance training to improve maximal oxygen uptake, recent research confirmed obesity in terms of Fat percentage is a better parameter than BMI for the prediction of low VO2max. On its scientific basis, our aims are to test BMI VS BFP as a relation to estimate players' physiological soccer adaptation profile.

Methods: to archive this objective, 148 well-trained first division soccer players under 18 years, at the end of the preparatory phase before the start of the Algerian championship 2016-2017, took part in the study. Split into two groups based on their V02max under or superior to 56 ml/kg/min. As a protocol, based on the validity of Test Cooper to predict VO2max in the field. Acceptable by cooper institute as an index of physiological training response or as indicators of current training status.

Results: our results show in general that VO2max is acceptable indicators of current training status. In the benefits of up to ≥ 56 ml/kg/min then it's less. Claim in the present through physiological soccer adaptation profile more related to obesity in terms of Fat percentage as a better parameter than BMI for the prediction of low VO2max among players under 18years.

Conclusions: our protocol admits that training response in soccer game requests the use of more accurate systems, such as body fat percentage (BFP) as a relation with VO2max to estimate adaptations of soccer program training correlated with its aerobics performance. Inspect in this study via VO2max up to ≥ 56 ml/kg/min as the minimum fitness requirement to improve players' aerobic capacity relative to its body fat adjustments.

Key words: BFP, BMI, VO2max, physiological, soccer player

Introduction

In professional soccer, Aerobic capacity is an important factor that affects the final league ranking, the quality of the game and the covered distances (Evangelos, Bekris; Lefteris, Mylonis; Aristotelis, Gioldasis; Ioannis, Gissis; Natalia, Kombodieta, 2016). Estimate in the case of performance among competitive soccer players through the average VO2max score between 55 and 60 ml/kg/min. Admitted by (Manuel J. Coelho e Silva, António J. Figueiredo, Marije T Elferink-Gemser, Robert M. Malina, 2016) at the average to be in the range of 55 to 69 ml/kg/min. In fact, (Youlian Hong, 2014) set that level male soccer player ranges from 55-68 mL-kg- 1 -min- ‘, with individual values higher than 70 mL-kg- 1 min.
Confirmed by (Strudwick Anthony, 2016) as a significantly greater total distance covered during elite soccer match play approximate to 12 at 13 km. Interpret by (Franco Simini, Pedro Bertemes-Filho, 2018) in the benefits of players with the smallest amount of Fat Muscle.
For the above proofs and Previous studies, which advices the significant relation between Vo2max and distance covered during a match, as much as rank order in the league of the best teams (J Hoff, U Wisløff, L C Engen, O J Kemi, J Helgerud, 2002). Set by research at 60 ml/kg/min of VO2max suggested as the minimum fitness requirement for male soccer players to play at an elite level (Almeida AMd, Santos Silva PR, Pedrinelli A, Hernandez AJ, 2018).
The purpose of this study was to evaluate aerobic capacity levels as an index to estimate the disadvantages of senior soccer players’ physiological profile. Admit by similar studies as the most typical method to enhance cardiorespiratory fitness and recover more rapidly. As much as most priority areas of any fitness program helping to control body weight or stroke. Observed through the high correlation between Vo2max and distance covered supporting the adoption of training regimes that raise the Vo2max of soccer players to high levels (K McMillan, J Helgerud, R Macdonald, J Hoff, 2005). Requesting the analysis of body composition as important for any complete fitness program (Zerf Mohammed, 2018). State in the current study through the hypothesis that the relationship between Body fat percentage (BFP) is the best way to know, recommended body weight. Sustenance by Joseph G.et al to predict the value of Vo2max account should not be based solely on age, sex, weight, and height. But also the percentage of body fat (Joseph G. Murphy, Margaret A, Lloyd, 2012). The case of this study that debates in one hand the hypothesis that body mass index (BMI) is considered to be one of the most objective anthropometric indices when it permits the correction of body weight for height. Where in other, the hypothesis, which agreed on Body fat percentage as a super factor affecting VO2 max and thus the cardiovascular status of the athletes (Anjali N. Shete, Smita S Bute and P.R Deshmukh, 2014). Conclude by Mondal H, & Mishra SP (2017) via obesity in terms of Fat% attend to be a better criterion than BMI for prediction the low VO2max (Mondal H, Mishra SP, 2017). Where

Material and Methods

Approximation method

The present study compared the performance of soccer players under 18 years from Algerian elite S-League players in a 12 minutes Cooper test. Performance in this test was assessed with players VO2max estimate from its formula, as well as their body composition estimate based on BMI and BFP formulas. Support by (Arvind Sathi, 2016) as an accurate measure to keep track of weight loss goals among Sports and Fitness programs, according to (Stephen Statle, 2016). Admit by (Zerf Mohammed, 2018) via aerobic fitness as cardiovascular fitness as part of the weight control, helping the players/ human to maintain the recommended body composition. Definitely by lower body fat percentage and higher lean mass as optimal for athletes to enhance their aerobic performance. Claim by (J Hoff, U Wisløff, L C Engen, O J Kemi, J Helgerud, 2002) via the significant amount of training time used to improve players' aerobic capacity. However, it is not known whether soccer specific training fulfils the criterion of effective endurance training to improve maximal oxygen uptake. The case of this study, which base its investigation on the average maximal oxygen intake for elite adult players, is reported to be in the range of 55 to 69 ml/kg/min according to (Manuel J. Coelho e Silva, António J. Figueiredo, Marije T Elferink-Gemser, Robert M. Malina, 2016). Built on its protocol to categorise the sample set between V02max ±56 ml/kg/min.

Participants

A total of 148 male adult elite players, representing some teams from the league Oran year 2016-2017. Were examined by the Research Team 5 Laboratory OPAPS in parameters (anthropometric and physiological) during the transition phase of the championship listed in Table 1.

Table 1. Descriptive characteristics of the soccer players participating in the study based on V02max ≤56 ml/kg/min ≥ as protocol.

Variables				Levene		Independent T-test	
	Protocol	N	Mean±SD	F	P≤0.05	T	P≤0.05
Height (cm)	VO2max < 56 ml/kg/min	74	173 .74±5.34	0.88	0.83	1.53	0.13
	VO2max > 56 ml/kg/min	74	175.16±5.91				
Weight (kg)	VO2max < 56 ml/kg/min	74	65.25±7.78	0.91	0.43	2.36	0.02
	VO2max > 56 ml/kg/min	74	62.37±7.07				
BMI(kg/cm^2)	VO2max < 56 ml/kg/min	74	21.61±2.33	0.59	0.44	3.34	0.01
	VO2max > 56 ml/kg/min	74	20.34±2.26				
BFP%	VO2max < 56 ml/kg/min	74	24.67±2.79	0.61	0.46	3.45	0.00
	VO2max > 56 ml/kg/min	74	23.15±2.72				
VO2MAX	VO2max < 56 ml/kg/min	74	53.35±2.07	1.91	0.18	2.40	0.02
	VO2max > 56 ml/kg/min	74	58.56±1.93				

Tests and protocol

- Cooper 12-minute Run Test:
  Is a popular maximal running test of aerobic fitness, in which participants try to cover as much distance as they can in 12 minutes. To estimate VO2max (in ml/kg/min) from the distance scored. We use the formula VO2max = (22.35 x kilometres) - 11.29. Admit by (Thomas Reilly, 2003) as a better indication of an individual's state of aerobic, directly related to the physical demands and physiological cardiovascular function.
- Body Mass Index (BMI):
  BMI was calculated from body mass (W) and height (H). BMI = W / (H^2), where W = body mass in kilograms and H = height in meters.
- Body fat percentage:
  For adults (Deurenberg P, Weststrate JA, Seidell JC, 1991) set that the prediction formula was BF% = 1.20 x BMI + 0.23 x age - 10.8 x sex (males = 1, females = 0) - 5.4. Its validity is comparable to the prediction error obtained with other methods of estimating BF%, such as skinfold thickness measurements or bioelectrical impedance.

Statistical analysis
Data analysis was performed using SPSS 22.0 for Windows (32- bit) (IBM, Armonk, NY, USA). Data obtained from the tests showed the homogeneity of the sample, presented as mean ± standard deviation, Levene's test. The independent T-test was used to determine the differences between players based on V02max ≤55 ml/kg/min ≥ as protocol integrates into this study. Regression analyses were conducted to analyse the combined of the variables chosen to study. While the relationship between the variables was analysed by Pearson correlations (r). All statistical significance set at p0.05.

Results
Based on the protocol used. Our results in Table 1. Shows by the significance of the independent T-test that upper VO2max is directly related to the physical performance allied to aerobic capacity as physiological demands correlate to fewer anthropometrics fat index. Admit in Table 2 based on the inverse correlation in the benefits of the players with the highest Vo2max and less body weight, fat or fatness. Our finds advance the finds of (James Jay Dawes, Robin Marc Orr , Claire Louise Siekaniec, Andrea Annie Vanderwoude and Rodney Pope, 2016) via the evidence that increasing %BF is associated with decreasing performance. Suggests as a targeted approach applied in efforts to achieve optimal improvement in physical fitness performance. Record in the present through regression Table 3. Support by previous prevalence studies, due to overweight AS difficulties in performing everyday activities after intense physical exertion (Eliane Cristina de Andrade Gonçalves, Diego Augusto Santos Silva, 2016). Establish in this study via VO2 max > 56 ml/kg/min as an exercise intensity consistent with exercise maximum and energy requirements (Zerf MOHAMMED, 2017). Limited by soccer studies among the male elite adult players through the mean values of VO2 max between 56 and 69 ml-kg-min (Warwick Spinks, Thomas Reilly, Aron Murphy, 2002).

Table 2: Presents the correlations between the variables tested in the current study.

Pearson of the total sample		BMI	BFP	Height	Weight
VO2MAX	P≤0.05	-0.34**	-0.36**	0. 32**	-0.30**

Where mode1 method forward showed a strong and significant positive association between Vo2max and %Fat as the only predictors of training response relative to VO2max values among our players under 18years. Record via BMI as independent variables excluded from the regression. Support by this study through the hypothesis, which approves Body fat percentage as a factor affecting VO2 max and thus the cardiovascular status of the athletes (Anjali N. Shete, Smita S Bute and P.R Deshmukh, 2014).

Table 3: Presents the Results of regression analyses relating VO2max and anthropometrics fat index

Dependent Y	VO2MAX
Method	Forward
Enter variable if P<	0,05
Remove variable if P>	0,1
Sample size	148
Coefficient of determination R2	0,1207
R2-adjusted	0,1147
Multiple correlation coefficient	0,3475

Residual standard deviation			3,1009			
Independent variables	Coefficient		Std. Error	rpartial	t	P
(Constant)	66,0645					
BFP	-0,4816		0,1076	-0,3475	-4,478	<0,0001
Variables not included in the model						
BMIa						
F-ratio		20,0486				
Significance level		P<0,0001				
Pearson test for Normal distribution			accept Normality (P=0,1248)			

Discussion

Based on the study design and statistical applied. Our results confirm:

1) VO2max up to ≥ 56 ml/kg/min is an advantage of physiological training response than less among soccer players. Admit by (TRISHA D. SCRIBBANS, STEPHAN VECSEY, PAUL B. HANKINSON, WILLIAM S. FOSTER, and BRENDON J. GURD, 2016) that training at any intensity above ~60% of VO2max is likely to improve maximal oxygen uptake in healthy adults. Suggest in the present through training at or greater than ~ 56% of VO2max improves maximal oxygen uptake as well as the decreases body weight or stroke. Confirmed by (Hassane Zouhal,G Emmeran LeMoal,G Del P. Wong,G Omar BenOunis,G Carlo Castagna,G Corentin Duluc,G Adam L. Owen and Barry Drust, 2013) that in training-related studies, increased VO2max of the well-trained subject are generally observed after training at high intensity. Indicate by (Thevenet D, Tardieu M, Zouhal H, et al, 2007) via the amount of oxygen consumed during exercise could serve as a good criterion to judge the effectiveness of this exercise on the development of physiological soccer game recruitment. Declare in the present study through the inverse correlation between VO2max and the fat index used in this study. In their upper reduce the levels of aerobic fitness capacity. Indicate in similar, as the basis for a good form of sports players' formation. Support by a number of tests confirming that increase the level of maximum oxygen uptake (VO2max), improves the sports performance of the game. Inspected by (Fortuna Małgorzata, Szczurowski Jacek, Zabłocki Tomasz, Pałasz Dagmara, Demczyszak Iwona, 2018) above the player lengthens the distance run during the match, the intensity of the globally performed work increases, the number of sprints increases and the number of actions with the ball increases.
2) BFP is a superior better anthropometrical tool than BMI to predict the low VO2max as the detriment of physiological training response relative to aerobic fitness among our players under 18years. Our results table 2 and 3 lines with N Koutlianos, which confirm percent body fat equation as slightly more accurate than the BMI equation (N Koutlianos, E Dimitros, T Metaxas, M Cansiz, AS Deligiannis, E Kouidi, 2013) in predicting the impact of body fat composition in term overweight. Support by (Mondal H, Mishra SP, 2017) to predict obesity in terms of Fat, BFP is a better parameter than BMI for prediction the low VO2max. Confirmed by Laxmi CC (Laxmi CC, Udaya IB, Vinutha Shankar S, 2014) trendy the effects of increasing BFP on Cardiorespiratory Fitness case sports studies and distribution adiposity case the medical studies, according to Tauseef Nab, et al (Tauseef Nabi, Nadeema Rafiq, Ouber Qayoom, 2015). Although based on the strong negative correlation between VO2max, BFP and BMI, we agree that increase in BM of 1 kg can increase the aerobic demand of exercise by 1 to 14%. Disclose in similar as a significant negative correlation between BMI and

VO2max (ml/kg/min) signifying the possibility of body fat effect on cardiorespiratory function (Radovanović S, Kocić S, Gajović G, Radević S, Milosavljević M, Nićiforović J., 2014).

From the above, we reach agreement that high aerobic capacity request from the players and their coaches to detect the excess body weight in the form of a fat percentage. Report by Anita Bean, et al (Anita Bean, Carol Vorderman, 2000) as a distinct disadvantage in almost every sport.

Record in the case of our study through the advantage players up to56% of VO2max that allows many adaptive changes concerns bodily functions related to oxygen consumption. Set by similar as an advantage in the benefits of top team compared with those in the lowest placed among the Norwegian elite league, according to (J Hoff, U Wisløff, L C Engen, O J Kemi, J Helgerud, 2002). Interpret by (Hassane Zouhal,G Emmeran LeMoal,G Del P. Wong,G Omar BenOunis,G Carlo Castagna,G Corentin Duluc,G Adam L. Owen and Barry Drust, 2013) as a training body adaptation, allied to body composition management (Paul Insel, Don Ross, Kimberley McMahon, et al, 2016). Admit in this study via the levels of aerobic capacity relative to changes in body fat percent (Mohammed Z, Abelatif H, Mokhtar M, Ali B, 2016) as effective endurance training to improve maximal oxygen uptake allied to physiological soccer demand. Conclude via this study, based on V02max ≤56 ml/kg/min ≥ used in this study as a protocol in the benefit of percentage body fat as the most important body weight management (Draper N,Marshall H, 2014) more associated with the prediction of lesser Vo2max.

Recommended through this study as the most typical method to control body weight or stroke. Observed through the high Vo2max as adopt soccer training (K McMillan, J Helgerud, R Macdonald, J Hoff, 2005). Requesting for our coaches the use of our protocol to estimate players' physiological soccer adaptation profile built on the analysis of body composition allied to VO2max levels (Zerf Mohammed, 2018). State in the current study through the hypothesis that the relationship between Body fat percentage (BFP) and VO2max is the best way to know, physiological profiles of soccer players and the physiological adaptations its training interventions.

Conclusion

Since the aerobic capacity of athletes is a vital element of success in soccer achievements. It reflects physical fitness of player to transport and utilize oxygen during exercise done at increasing intensity. However, its absolute value is strongly affected by body weight; body composition, body fat percentage, body mass index and muscle mass. Where the decrease in body fat or fatness increases aerobic capacity. Our finding confirmed that the levels of VO2mas below 56 ml/kg/min reflect the impact of body fat in term of BFP on the capacity of athletes to transport and utilize oxygen during exercise, due to its cardiovascular fitness developments. Admit in the case of this study via the significant negative correlation between BMI and VO2max (ml/kg/min) suggesting the possibility of effect or body fat percent on cardiorespiratory function. Report at present through the effect of BFP associate to decrease of aerobic soccer game demand (Paul Barash, Bruce F. Cullen, Robert K. Stoelting, 2013).

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Comparison of swimmers' performances in the 98th Korea national sports festival

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Purpose: This study was to compare the swimming styles (such as numbers of strokes, breath, and timing) between superior and inferior players in Korea national swimming competition. Also, this study was to gather the Korean elite swimmer's performance and to prepare the feedback of analysed data to the swimmer.

Methods: The subjects of this study were 100m and 200m advanced final player about all type of strokes (butterfly, back-stroke, breast-stroke and free style). All data gathered were divided by 2 groups (superior and inferior) and determined by independent t-test as statistical comparisons.

Results: Firstly, there were no significant differences on the records of all swimming styles (butterfly, back-stroke, breast-stroke and free style) in 100m. However, there was a significant difference between 2 groups on the records of all swimming styles in 200m, especially after 100m. Secondly, there were no significant differences on the numbers of strokes of all swimming styles, but the numbers of strokes were fewer in the superior group than in the inferior group. Thirdly, there were significant differences between 2 groups on the number of breaths, both 100m and 200m swimming.

Conclusion: There were differences of performances between superior and inferior group on the different distance such as 100m and 200m within Korea national competition. However, for the considering of statistical comparison, there were no significant differences on the records of all swimming styles. Thus, those sorts of the analysis of swimming needs to be considered within the approaches of methods on the performance analysis rather than the consideration of simple records from the competition.

The characteristics and predictors of performance in trap shooting tournaments

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Purpose: To describe the characteristics of the performance of athletes in elite trap shooting tournaments and to identify factors that are associated with successful outcomes (i.e. qualification for finals and winning a medal). In addition, we sought to determine whether these characteristics differed over time and between tournaments.

Methods: A database was compiled that describes the shot by shot outcomes of 2868 male and 1530 female performances, from 36 tournaments (Olympic, World Cup & World Championships) between 2011 and 2016. Descriptive statistics were used to represent the typical scores and ranking of athletes and non-parametric tests were used to make comparisons.

Results: The qualifying score required to contest the finals did not change between 2011 and 2016 for males (120 ±2, p=0.08) or females (69 ± 2, p=0.12), nor is it different between tournament types (p=0.30). The strength of the relationship between each qualifying round score and the final qualifying score, qualitatively increases from the early to late rounds (r = 0.72 increasing to 0.83). There is no relationship between the qualifying score of finalists and their final tournament rank (r = 0.22-0.24), however a 1st-3rd qualifier has a 60% chance of being a medalist compared to 40% for a 4th to 6th qualifier.

Conclusions: The characteristics of the qualifying performances of finalists has been relatively stable in the period of 2011 – 2016 and they did not vary between tournament types. Trap shooters must achieve a qualification score of 122 ± 1 (males) or 71 ± 2 (females) to be ranked in the top 3 qualifiers, to obtain a better than average likelihood of winning a medal.

The variation in teams' match performance profiles according to league ranking in the Chinese football association super league

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Purpose: The professional football competitions can be regarded as a highly dynamic and complex systems in which working groups try to keep the stability of their team performance (Vilar, Araújo et al. 2012, Liu, Gómez et al. 2016). In order to explore the team performance trends and styles of play, this study aims to identify the team's performance variation according to teams' ranking in the Chinese Football Association Super League.

Methods: A total number of 1440 matches of season 2012-2017 from the Chinese Football Association Super League were analysed. The statistics were collected by a multiple camera semi-automatic computerised player tracking system (AMISCO, Nice, France). All the teams were divided into four tiers according to their rankings: tier 1 (1-4), tier 2 (5-8), tier3 (9-12), tier 4 (13-16). Also, match location (home and away) was considered within the analysis. The team performance variation was expressed by the coefficient of variation (CV). Meanwhile, general linear model and MANOVA were adapted to investigate the difference between groups.

Results: The results showed that the CV of several attacking-related actions changed significantly according to match location for Possession in opponent half (0.138 vs. 0.151), Passes (0.207 vs. 0.224) and Opponent penalty area entries (0.457 vs. 0.505). Regarding physical performance in relation to match location, SDIP (Sprinting distance in ball possession) (0.239 vs. 0.261) and HSD (High-speed running distance)(0.151 vs. 0.168) were observed having variability. It also showed that the main variations of pass accuracy were tier-1 vs. tier-4 (0.059 vs. 0.07), tier-2 vs. tier-4(0.058 vs. 0.07). The discrepancy of Offside was significant between tier-1 and tier-4 (0.667 vs. 0.784). The results of multivariate tests within 4 tiers of team performance between home and away showed that the observed differences in variation were trivial.

Conclusions: The results showed that possession in opponent half, passes, opponent penalty area entries, SDIP and HSD had high variability under the influence of match location. Moreover, the variation trends among tiers mainly come from the discrepancies between tier-1, tier-2 and tier-4. The findings may contribute to the further investigation into the variation in teams' performance, considering more contextual variables.

Prediction of performance by heart rate-derived parameters in recreational runners

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Purpose: Heart Rate- (HR) and lactate- related parameters are both predictors of endurance performance and are also used for prescribing and monitoring training intensities (Lamberts et al., 2010; Vesterinen et al., 2016). Despite this evidence, few studies have analyzed the predictive capacity of these variables measured in a treadmill test in an official running competition. In the present work, we investigated whether HR-derived parameters or lactate-derived parameters are more accurate performance predictors in a validated 10 km race,

Methods: An incremental running test with a 1 minute recovery period between stages (4 minutes) was completed by 41 participants. At the end of each stage, HR, % of maximum HR (%HRmax), and blood lactate were recorded. We also assessed HR at the end of the recovery period (HRR), and calculated the speed at lactate and HRR thresholds and the HR deflection point (HRDP) using the Dmax method. We tested these parameters for their associations with running performance, as measured by the time in a 10 km validated road race, using Pearson´s (r) correlations.

Results: The %HRmax at submaximal running speeds (13.5, 14.5 and 15.5 km/h) significantly correlated with time in the race ($r = 0.63$ to 0.64), However, weaker correlations were found for HR and HRR at the same speeds (absolute value of $r = 0.26$ to 0.56). Of all the HR-related parameters, the speed at the HRR threshold was the strongest predictor of running performance ($r= -0.690$). The magnitudes of the correlations of lactate-related parameters were lower. Thus, blood lactate concentrations at 13.5, 14.5 and 15.5 km/h running speeds had r values from 0.49 to 0.56 and the correlation coefficient between the speed at lactate threshold and the time in the 10 km race was 0.65.

Conclusion: These results suggest to us that HR-related parameters are better predictors of the time spent in a 10 km race than those related to lactate. Concretely, the speed at the HRR threshold and % HRmax at submaximal given speed could be useful, economical and non-invasive tools to predict the performance of recreational runners.

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Intra and inter-reliability of an affordable South African developed computerised notational system to assess rugby performance

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Purpose: The purpose of the study is to firstly, determine the inter- and intra-coder reliability of a South African developed CNS and secondly, to compare the coding proficiency of amateur club rugby coaches versus an experienced coder.

Methods: Five amateur club coaches coaching in the Western Province Super League with no prior experience of CNS or coding and one experienced coder participated in the study. The participants (n=6) each coded five international rugby matches and re-coded two of these matches to determine the intra-coder reliability.

Results: The reliability between the different coding agreements were measured using Cohen's kappa statistic (K). The study revealed a good inter-coder agreement for all the performance indicators (K=0.79) with the strongest agreement being for the set-pieces (K=0.93). Very good intra-coder reliability was also revealed for all the coders; there was a mean of K=0.82. Comparing the amateur club coach coding to the experienced coder showed a good mean agreement of K=0.77.

Conclusion: There was a good agreement across the various PIs measured (mean of K=.79). Compared to studies with data generated from external companies, the agreement is not as strong (generally K≥.90) (Bradley, 2007; Larkin et al., 2016; Liu et al., 2017). The set-pieces, namely scrum and lineout PIs, had the strongest agreement across all coders. The nature of set-pieces allows for strong agreement due to the stoppage in play which can draw the attention of the coder and therefore increase their focus (Franks & Miller, 1986).The study concluded that the EncodeProRX is a reliable CNS that can be accurately and consistently used in amateur club rugby set-up.

Motivation and personality traits of students in kinesiology and rowers: similarities and differences

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Purpose: The strength of motivation, as well as personality traits, are an essential determinant of people's behaviour. The level of motivation will only point to the strength of focus in achieving the projected activity. Personality represents those characteristics of the person that account for consistent patterns of behavior. Four factors influence how we respond to any given situation: our genetic make-up, our past experience, the nature of the situation in which we find ourselves and our free will. Eysenck et al (1982) proposed that people high in extroversion and psychoticism tend to have pro-sport attitudes. This is because personality is primarily determined by genetics. The research was conducted with the aim of establishing the characteristics of motivation and the personality traits of male students of kinesiology and senior rowers, and possible differences in the appearance of the same.

Methods: Three tests were conducted: general achievement motivation (Havelka & Lazarević, 1980), sports achievement motivation (Havelka & Lazarevic, 1984) and Eysenck's EPQ. The study included a sample of 63 male students and 86 rowers of seniors' kategory. Data processing, descriptive statistics as well as variance analysis were performed using statistical statistics package Statistica 13 (TIBCO Software Inc. (2017). Statistica (data analysis software system), version 13. http://statistica.io.).

Results: The obtained data present seniors' rowers (M=16.91; SD=3.61 (M=mean; SD= standard deviation)) scoring significantly higher on the sport achievement motivation (p<.00) than students ones (M=13.72; SD=4.55). Rowers were presented as an emotionally more stable sample in situation of sport achievement. Rowers projected statistically significantly more strongly on scale of positive emotional responses (M=8.50; SD=2.45) than students (M= 7.19; SD=2.36) (p<.00). At the same time, rowers were lower on scale of negative emotional responses (M=2.09; SD=1.59) than students (M= 3.09; SD=2.3) (p<.00). Students were presented as statistically significantly stronger projected on the dissimulation scale (M=10.54; SD=4.15) than rowers (M=9.09; SD=3.89) (p=.03).

Conclusion: The investigated sample points to similar relationships between male students and rowers population involved in physical activity in the personality traits. The only specific feature found among rowers in the examined sample is a significantly higher level of sport achievement motivation than male students, as well as higher emotional stability in motivation for sport achievement.

Multifactorial benchmarking of longitudinal player performance in the Australian football league

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Purpose: This study aimed to determine a method to objectively benchmark Australian Football League (AFL) player performance based on age, experience, positional role and both draft type and round in which they were selected. The secondary aim was to identify whether a breakpoint in player performance exists within levels of both age and experience.

Methods: AFL Player Ratings data were obtained for each player from 1034 matches played during the 2013-2017 seasons, along with data pertaining to player characteristics (age, experience, positional role and draft round and type). Two separate linear mixed models were created (Bates et al., 2015), each incorporating either age or experience, with all other factors included in both. A post-hoc Tukey test (Lenth, 2016) was performed for age and experience to determine whether performance differed within each level of these factors.

Results: Results from both models revealed that all factors affected player performance, with age and experience the strongest influencers, followed by positional role. Figure 1 displays the benchmark levels of performance for age and experience based on fixed effects estimates. A post hoc Tukey test indicated that performance was affected by age at each age level up until the age of 21 (effect ranging from 0.96 - 3.70 rating points), and by experience at the levels 1-25 matches and 26-50 matches in comparison to all higher levels of experience (effect ranging from 1.14 - 3.52 rating points). No performance differences were seen between any levels above these levels of age and experience.

Conclusion: Player performance in the AFL can be benchmarked based on a player's age, experience, positional role and both draft type and round in which they were selected. The models created in this study indicate that a breakpoint in player performance exists along the distribution of both age and experience.

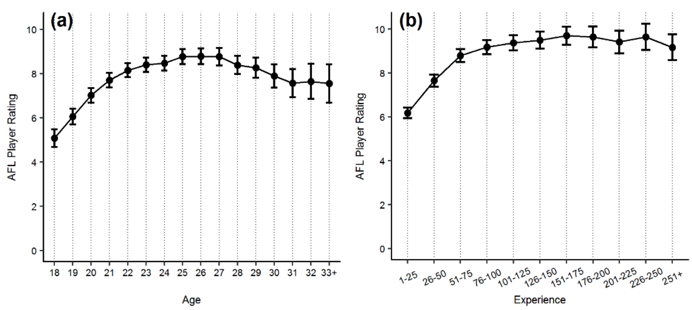

Figure 1. Benchmark levels of AFL Player Ratings by (a) Age, and (b) Experience.

Elite coaches engagement with performance analysis within olympic sport

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Purpose: Performance analysis is a key tool within the coaching process used to provide purposeful information to enhance performance. Coaches have been making use of various PA techniques for years within practice, however, what remains unclear is the extent to which coaches utilise these tools/techniques and the precise nature of coaches' interactions with PA. The coach is often the link between practitioner and athlete; therefore it is important to further understand their views regarding PA practice within elite sport. However, despite their critical role in the feedback process, the views of elite coaches have been rarely reported within academic writing. Many of the studies investigating coach/analyst/athlete perceptions have primarily focused on larger-team based sports. To enhance feedback, we must identify what information, processes, and techniques the coaches' desire within their practice. Therefore, the aims of this study are to outline; what coaches' value from the PA/feedback service, understand how coaches utilise PA, and what affects their ability to feedback.

Methods: Eighteen coaches (Experience; 16.1 ± 7.4 years) working within Olympic/Paralympic sport completed an online questionnaire including, 1) demographics, 2) feedback structure, and 3) analysis provision and the influencing factors. Likert scales were used for answers to closed questions to facilitate cross-sport comparison. Open question aspects (e.g. Why?) were included to enable expanded participant responses and allow individual reflections/experiences to be provided.

Results: A wide spectrum of PA and feedback techniques were utilised; however, consistent themes emerged throughout. Namely, the majority of coaches stated training goals, interaction and philosophy/experience influenced analysis direction. Time was the most significant constraint impacting feedback provision. Coaches with greater experience (> 8 years) delivered significantly more feedback sessions within 1-hour post performance. Balanced and mostly positive feedback sessions (< 20-minutes) were generally employed, however, athlete emotional state was a key factor within session design.

Conclusion: The findings identify key areas coaches' value from the PA service and would aid practitioners/educators' within the target/design of appropriate support to more effectively prepare their practice for the demands associated with applied PA support.

Kinematic analysis of swimming relay starts with the omega OSB11 starting-block

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Purpose: In competitive elite swimming, we can observe different types of relay starts like starts with parallel feet, starts with separated feet and starts with steps. It is unknown what of these starts is the fastest for a better performance. Therefore, the purpose of the present study was to examine the effect of a previous step in the different variables (kinematics, performance, temporal, spatial and angular) of the relay starts using the dispositive Omega OSB11.

Methods: The swimmers performed 3 types of relay starts (non step start with parallel feet, separated start and one step start) randomly, with maximum effort, to 25m with rest between each. Three fixed cameras were used to tape all the videos, at 100 Hz. In each of the swimmers footage, twenty-one body landmarks were manually digitized to define fourteen segments according to the Zatsiorsky-Seluyanov model, modified by De Leva. The real coordinates were reconstructed from the screen coordinated by 2D direct linear transformation (2D-DLT) based algorithms. Magnitude-based inference was used to evaluate the reliability of the digitalization and to verify the differences in the lineal and angular kinematic variables of the three relay starts.

Results: The time at 5m with separated start was faster than other two types starts (2.55±0.44). And the time of underwater was better with parallel feet (83.05±3.20) while separated start was the greatest at the change time (4.68±3.68). The take-off height, entry height, immersion velocity at *Y axis* and take-off angle were greater with separated start (1.25±0.07, 0.62±0.07, -2.05±0.49, 186.06±5.71). There were better performances in the entry velocity at *X axis* and immersion angle with parallel feet (3.99±0.65, 331.42±5.16), and in the initial distance with one step start (0.34±0.04).

Conclusion: There have been a few studies on relay starts. The previous studies reported the non step start is better for achieving consistent and superior performance and the horizontal velocity generated by legs driving was significantly greater than that in step start. Our study identified that many variables of the separated start were greater than that behaved by non step start with parallel feet and one step start. Therefore, the separated start may help swimmers perform better in relay events.

Examination of relationship between simple analysis data of rugby and victory / defeat - focusing on super rugby 2018

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Purpose: This research was to investigate the relationship between official data of Super Rugby in 2018 season and victory / defeat.
In recent research on rugby, we examined characteristics of the game, the degree of fatigue during game using GPS.
In this research, we investigated the cause related to victory or defeat.

Methods: In this study, we analysed 127 matches of the 2018 season's Super Rugby.
Analysis items were qualitative analyses on attack, defence, kick, set play, and the number of foul play.
For the analysis method, use official data of Super Rugby.
(https://sanzarrugby.com/superrugby/)

Results: It is currently being analysed, but the following can be suggested.
1) Success or failure of set play is related to victory or defeat
2) It seems that defence is more involved than defence against victory or defeat
3) The penalty number is related to the score
4) It is possible to extract data related to victory or defeat from official data

Conclusion: Super rugby is currently in the season, but results are given at the time in presentation. According to the current results of analysis, the success of set play, the success of defence, and the small number of offenses were important in the winning team of Super Rugby. It is likely that clarifying the items related to victory and defeat and the characteristics of the team advanced to the finals tournament will be revealed.

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Global positioning system analysis of external loads during international women's field hockey matches

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Purpose: Several rule changes have been implemented by the Fédération Internationale de Hockey (FIH) with the most significant ones being unlimited substitutions and a change in the format from two 35min halves to four 15min quarters. Limited literature is currently available to confirm whether these changes were effective in increasing the intensity. Therefore the purpose of this study was to investigate the external loads international female hockey players experience during matches. Furthermore, fluctuations in intensity during matches were also investigated.

Methods: The match activity profiles (n=142) of 24 female hockey players were recorded during nine official international test matches using 10Hz GPS units. Relative distance covered (m/min), relative player load (PL/min), high speed running (HSR) (4.18–5.19 m/s), sprinting (>5.20 m/s) and high intensity running (HIR) (>4.18 m/s) were compared across these periods. To investigate variations in intensity the matches were divided into 2:30 min periods in addition to the four 15 min quarters. A linear mixed model was used to determine differences ($p < 0.05$) between variables, with effect sizes and 90% confidence intervals used to determine the magnitude of the effects.

Results: The players covered a total relative distance of 117.9 m/min of which 14.9% consisted of HIR. An average PL for the total match was at 11.4 with the fourth quarter significantly ($p < 0.05$) lower than the first quarter. The last 2:30 min period of the third and the fourth quarters were significantly ($p < 0.05$) lower that the first 2:30 min period of the first quarter. A similar trend was found for relative distance covered with a significant decline in the final quarter compared to the first quarter. However, HIR showed small (ES < 0.2) insignificant variations during the matches, with the last quarter revealing higher values than the first quarter (15.5 vs 14.9%).

Conclusion: Although it seems that a certain amount of fatigue occurred during matches when looking at relative player load and distance covered, it seems that players were able to maintain their intensity throughout the matches.

Netball – happy landings?

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Purpose: Netball New Zealand has become increasingly concerned at the susceptibility of youth players to high level of lower limb injuries with the mechanism of injury being attributed to the landing strategy in matches. Player positions have specific contextual demands (Di Salvo et al., 2007) that may influence landing strategies away from the Netball Smart (NNZ, 2017) exemplar strategy. The problem addressed in this paper is to determine the extent to which these positional demands result in different demands being asked of the youth netballers in high level National Competition. The purpose of this study was to (1) investigate the experiences in the distribution of landing strategies of youth netballers, (2) identify differences in landing strategy that best predict performance level for the sampled players.

Methods: Eighty-four female netballers (age; 16 ± 1years, height; 173 ± 7cm, mass; 68.5 ±10.3 kg) from the National Secondary Schools tournament were analysed during 12 competitive games in which teams competed by grade. Landing strategies were investigated by independent variable of playing position (n = 7) throughout the duration of the tournament. The dependent variables coded were zone, pressure, height of pass, jump type, landing platform, stability and balance using Sportscode Elite (Hudl, USA). Intra-observer reliability found a substantial level of agreement (Κ = 0.776, $p < .001$.
Due to the non-normal distribution, descriptive data were presented using medians and inter-quartile ranges (IQR).). A Kruskal-Wallis test was used to determine differences in landing strategy between positions. Subsequently, pairwise comparisons were performed using Dunn's (1964) procedure, with a Bonferroni correction for multiple comparisons. In the second stage of analysis binary logistic regression was used to identify the variables that best predict *better* player grade.

Results: The results of the univariate analyses indicated that across the tournament duration the variables of zone, pressure, height of pass, jump type, landing platform, stability and balance were significantly differentiated by position ($p < 0.001$). The results of the logistic regression highlighted that the variables 'catch both hands', 'Jump-turn in air-land', 'balance step' and 'land neutral feet outside shoulder width' were significant factors ($p < 0.05$). The model explained 60% (Nagelkerke R^2) of the variance in grade and correctly predicted 88.1% of the grade representation. Sensitivity was 95%, specificity was 67%, positive predictive value was 90% and negative predictive value was 52%.

Conclusion: Player position significantly effects the distribution of landing strategy in youth netball and this variation is influenced by grade of player. Application of this knowledge on the distribution of these landing strategies is beneficial to both netball coaches and strength and conditioning professionals. To aid the design of more relevant training sessions and to develop conditioning strategies for injury reduction and performance improvement from a position-specific perspective.

An analysis of soccer tournament goal attempts

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Purpose: In soccer, key performance indicators have been established, these consist of shots on target, goals and total shots (Castellano *et al.*, 2012; Lago-Penas *et al.*, 2011; Lago-Balesteros and Lago-Penas, 2010; Luhtanen *et al.*, 2001). Subsequently, how goals are scored or attempted and which zone the goals originate from will be analysed. Navarro *et al.* (2016) suggests, research should aim to establish the efficiency and effectiveness of team possession styles, when analysing performance and subsequent outcomes (i.e. scoring probability of offensive possessions). Therefore, the aim of the study is to analyse the team possession style and its effectiveness, in tournament soccer.

Methods: UEFA Champions League matches 2017-18 (n=111) and UEFA European Championships 2016 matches (n=51) will be analysed using JMP version 14 discovery software (SAS Institute, JMP Statistical Discovery, NC, USA). Data using 10 attacking variables, for the type of assist and 13 attacking variables, for the type of attempt and outcome, whilst including 18 zones of the soccer pitch (Horn *et al.*, 2002; Grant *et al.*, 1998; Williams *et al.*, 2003), have been analysed. These were analysed in accordance to the team possession styles and transition location (Wright *et al.*, 2011), team possession styles include elaborate attack (Tenga *et al.*, 2010; Lago-Penas *et al.*, 2012), counter attack (Tenga *et al.*, 2010; Liu *et al.*, 2015; Lago-Penas *et al.*, 2012), direct play (Sgro *et al.*, 2016; Lago-Penas *et al.*, 2012), secondary goal attempt and set piece (Liu *et al.*, 2015; Hewitt *et al.*, 2016). To test for changes in chance creation and goals scored for each possession style in each zone, a repeated measures design linear mixed model using Restricted Maximum Likelihood (REML) method will be used. Estimates based on the least square means will be reported alongside the standard error (SE).

Results: Data is currently being collected and processed, this will be completed before 22nd July 2018. Initial exploratory findings, for location of attempt in the UEFA European Championships 2016, show significant differences between winning and losing teams, for zone 14 ($p>0.05$) and 17 ($p>0.05$). Furthermore, when analysing assist location in the UEFA Champions league 2017-18, zone 14 to zone 17 ($p<0.05$), zone 16 to zone 17 ($p<0.05$), and zone 17 to zone 17 ($p<0.01$), significantly differed when comparing winning to losing teams.

Conclusion: Other research has shown an advantage in recovering ball possession as close to goal as possible to increase goal scoring opportunities (Garganta et al., 1997; Larson, 2001). Shots from a counter attack, have been shown to improve the probability of winning (Liu *et al.*, 2015; Tenga *et al.*, 2010). In summary, using tactical modelling will provide information on performance, to enhance the understanding of coaches and performance analysts (Liu *et al.*, 2015).

Kinematic analysis of transition phase from underwater to surface swimming in national level swimmers

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Purpose: The main aim of this study was to describe the kinematical parameters of the transition phase from underwater to surface swimming in national level competitors.

Methods: Seventy-four swimmers (33 males and 41 females), all participants in national level championships and at least nine years of training experience (>20 hours per week) were recorded (50 Hz) with two cameras JVC GY-DV500E (from a lateral view) while performing 25 m maximal effort from a push start. Swimmers footage were manually digitized by an experimented observer and calibrated by mean of 2D-DLT algorithms (Abdel-Aziz and Karara, 1971). Some key events (hand(s) separation to hand(s) entry in freestyle, backstroke and butterfly strokes and leg fully flexed to leg fully flexed in breaststroke) from underwater to surface swimming were identified to define the transition phase and the following variables were calculated: transition stroke length (TSL) in meters as the horizontal hip to hip distance, transition stroke rate (TSR) in hertz as the inverse of transition stroke time, and transition velocity (TV) in m/s as TSL divided by transition stroke time. SPSS 20.0 (IBM Corporation, New York, NY, USA) was used to obtain descriptive statistics (mean and standard deviation).

Results: Table 1 shows the transition phase kinematical parameters in national-level male swimmers. The freestyle TV was different than from the study by Allnutt (2014) where freestyle TV was 1.62±0.13 m/s (both genders). Similarly, differences were observed with two backstroke TV (1.55; 1.32 m/s) possibly because group data in the study by Allnutt (2014). Freestyle TSL was lower than from study by Vantorre et al. (2010) who measured surface SL between 10 and 12.5 m (i.e. 2.24 ± 0.16 m). Very long TSL in backstroke may be due to supine position of swimmers where resistance to movement is higher (Pease 2013). Freestyle TSR (55.8 stroke/min) was similar as from the study by Vantorre (2010) (i.e. 53.3 ± 4.5 stroke/min).

Conclusions: Transition phase cyclic parameters allow evaluating the swimmer's performance during transition from underwater to surface swimming. Velocity and stroke length values were lower than in surface swimming in previous study, indicating technical modifications due to task constraints from underwater to surface position.

Table 1. Transition velocity (TV), transition stroke length (TSL) and rate (TSR) of males in all strokes (mean ± standard deviation) during transition phase

Transition	Freestyle	Backstroke	Butterfly	Breaststroke
TV (m/s)	1.79±0.17	1.60±0.23	1.80±0.17	1.32±0.32
TSL (m)	1.92±0.26	2.27±0.55	1.83±0.23	2.17±0.91
TSR (Hz)	0.94±0.13	0.73±0.13	0.99±0.13	0.59±0.13

Analysis of small sided football: effects on white blood cells and serum immunoglobulin

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Background: Football is a popular game which is generally played as 11 against 11, but it is also quite often played three versus three, four against four and seven against seven.[1] It is also an established fact that recreational football too has roughly similar aerobic demands when compared to training for elite footballers with periods of near to maximum heart rate values[2]. Small sided games are more effective on playing ability[3]. Exercise can cause a change in the consistency of serum immunoglobulin (IgA, IgM, and IgG) levels and secretion of the some hormones[4]. Present study analyzed small sided recreation football and its effect on serum immunoglobulin and white blood cells in untrained males.

Methods: Twenty seven male students were randomized into intervention (n = 12) and control group (n = 15). Three subjects from control group didn't report for post-test. Intervention group played recreational football for 16 weeks. For analysis purpose, small sided football sessions were organized on artificial outdoor pitches. The size of the pitch was 40x30m. Each team had 6 players with no permanent goal keeper. Enough spare balls were kept to minimize the break time during play. Training sessions were organized twice a week. Each session was divided into two halves of 15 minutes. Heart rate in intervention group was monitored during all football sessions. We used Polar FT7 for the analysis of physiological parameters during the football sessions. Control group subjects followed their regular routine. Analysis of Covariance (ANCOVA) was employed to find difference between two groups after 16 weeks of football.

Results: One way ANCOVA revealed significant increase in total white blood cell count (P = 0.001), eosinophil (P = 0.010) and Monocytes (P= .007). While no significant improvement was observed in Neutrophil (P = 0.797), lymphocytes (P = 0.241), Basophil (P=.758), IgA (P = .158), IgG (P = .077) and IgM (P= .655). Monocytes and eosinophil counts decreased significantly whereas basophil counts increased significantly post football training.

Conclusions: Sixteen weeks of supervised recreation football training was effective in increasing total WBC count in untrained males. Our training was vigorous in nature as indicated by high average heart rate during the training sessions. Further, recreation football could not affect serum immunoglobulin significantly but there was some substantive increase in IgG levels. Long and vigorous training makes the immune system weak while short and mild strengthen it.

Performance during exclusions in female handball

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Purpose: A temporal exclusion is a predicted sanction in the international handball federation regulation (IHF, 2016). This kind of situations represents a 20% of the total game time (Gutierrez, Fernández, & Borrás, 2010). Teams in superiority may performance at a lower level (Schucker, Hagemann, & Straus, 2013), explaining unexpected results of action during these “advantage” situations (Prieto, Gómez, & Sampaio, 2015). This fact can influence in final result of a game (Prieto, Gómez, & Sampaio, 2015; Trejo & Planas, 2018). Therefore, the aim of this study was to describe the offensive outcomes during exclusions (superiority and inferiority) and compare the final result (winner/loser) conditions in female handball.

Methods: Sample consisted in 14 matches from the 2015 PPGG played by those teams that finished the tournament in the four first places. A total of 107 exclusions occurred during those matches. Observational methodology was used. The research team reviewed the videos and collected the data using the software Lince 1.1. Differences between final conditions were analysed using Chi-square test.

Results: Figure 1 shows the distribution of the situations related to the type of finalization and in function of the final result of the game (win or lose). Winner teams converted more goals than the loser teams showing a statistically significant difference ($p<0.05$). Winner teams had a statistically significant lower percentage ($p<0.05$) of throws out in comparison to loser.

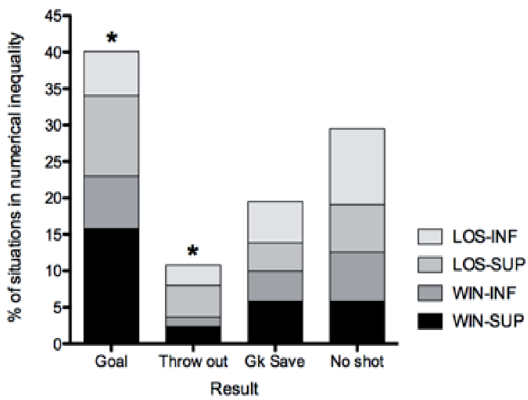

Figure 1. Percentage of situations under numerical inequality divided by team and numerical inequality condition. Gk Save: Goalkeeper save; WIN: Winner team; LOS: Loser team; SUP: Superiority; INF: Inferiority. * Statistically significant differences between winner and loser teams.

Conclusion: Performance during exclusions in female handball is better in key actions (goals and throw out) for winner than for loser teams.

Modelling of match performance indicators in Australian Football

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Purpose: There are only a few reports that have explored the relationships between player actions in matches and match outcomes in Australian Football (AF). This study extends upon this work, making use of a larger set of performance indicators (PIs), it develops models that provides an indication of the relative importance of PIs to match outcome. This work offers novel insights into AF that can assist strategic and tactical decision making.

Methods: Ninety-one (91) team performance indicators (PIs) from the 2001 to 2016 Australian Football League (AFL) seasons were used as independent variables. The categorical Win-Loss and continuous Score Margin match outcome measures were used as dependent variables. The 16-year database was partitioned into two 8-year eras. Within each era, a feature selection process was applied to the independent variables. Decision tree and Generalised Linear Models (GLMs) were created to describe the relationships between the values of the PIs and match outcome.

Results: The decision tree models achieved prediction accuracies between 83.5–88.9% using Win-Loss and 64.4–70.3% when using Score Margin. The GLMs predicted Score Margin achieving root mean squared error of 6.8–7.4 points and a Win-Loss prediction accuracy of 93.1–95.1%. Decision tree and GLMs identified the most important PIs in relation to match outcome to be Metres Gained, Time in Possession, Inside 50s, Inside 50s Per Shot, Turnovers Forced Score and Rebound 50s all in their relative form.

Conclusions: In conclusion, the methods used in this work can be implemented by other sport analysts and the findings can be used to support the decision-making process of coaches, who determine performance strategies. Further, the models created provide novel insights into AF, the most important PIs and the PI characteristics of successful match outcomes.

Analysis of technique and tactics

Differences between the winning and defeated handball teams in attack organisation – the final phase of the 2017 World women's championship in Germany

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ABSTRACT
This research was conducted to determine how different types of attack, duration of attack as well as types of their endings contribute to the differences between the winning and defeated teams at the end of the World Women's Handball Championship 2017. Out of the total of 330 attacks played in the final phase of the Championship (2 semi-final matches, bronze medal match and final match), the winning teams played a total of 162 attacks, whereas the defeated teams had four attacks more, i.e. 168 attacks. The winners played a total of 138 positional attacks (PN) and 24 transitional (TN) attacks. The defeated teams played a total of 138 positional attacks and 30 transitional, i.e. fast-breaks. The obtained results point to the great equality of the best world women's handball teams. The results of Kruskal-Wallis test and ANOVA indicate the statistically significant difference in attack duration between the winning and defeated teams where the winners performed their attacks, on average, for a longer period of time. They respected the gradual nature of attack building-up, performed fewer fast-breaks, paid full attention to the stage of attack preparation against the organized defence, used many rhythm and movement speed changes, dynamically varied their mobility with fast transfer of ball, thus creating most appropriate situations for attack realisation (attack endings).

Key words: competitive success, trends, duration of attack, top-level women's handball

Introduction
Structural analysis of sports activity is a process for determining its typical structures, performance indicators that reflect situation-related efficiency of individual players in a team, are collected by the methods of their registration in the course of a competition (real time), or during a subsequent viewing of match recordings, or by their combination (Hughes & Bartlett, 2008). However, every confrontation of the same two opponents produces only a similar, but never the same development or outcome of the game (Hughes & Franks, 2004). During a match, it is possible to record every successful and unsuccessful move each player has made. Based on some data the coach and coaching staff can competently evaluate contribution of each player to play in attack and/or defence, and to the final team result in a competition. It is a tendency for expert and scientific discussions to be based on objective, real facts recorded in handball matches. Monitoring, reviewing, registration and other methods of notational analysis generate relevant data for analysis of handball games and make objective feedback. Objectivity can be ensured by video recording observations, biomechanical systems for detailed analysis or notational analysis (Talović et al., 2011). Notational analysis is an objective way of recording performance so that key performance parts can be evaluated

in a consistent and reliable way (Talović et al., 2011). Manual notational analyses are essentially very precise, but they also have certain deficiencies, i.e. they require very much human work (Talović, et al., 2011).
Previous studies of performance in handball have been focused more on the analysis of men World and European championships and Olympic tournaments than on their female counterparts (Prieto et al., 2015). Results of some research studies indicated that performance or success in a game was substantially defined by the successful outcome of counterattacks (Bajgorić et al., 2016; Ohnjec at al., 2013, 2015) and by the successful prevention of positional attacks and counterattacks (Hianik, 2013); also, the overall efficiency in attack (shot efficiency) was significantly lower in the defeated than in the winning teams (Leuciuc & Pricop, 2016; Yamada et al., 2014). Winning teams are superior in the performance of shots on goal, the number and successful realization of counterattacks as well as in the number of goalkeeper's saves during a match (Vurgun et al., 2014). Karastergios et al. (2017) showed that the winning teams had a larger total number of throws, with more throws from 9m, and lateral side, more penetrations and more counterattacks. The defending actions (fouls), technical mistakes, and overall performance of the goalkeeper appear to be the main factors that separate the winners from the losers in women's matches between equal opponents.
The aim of this research was to establish probable differences between the winning and defeated female teams, four participants of the semi-final and final matches of the World Women's Championship in Germany in 2017 in the following variables: types of attack, finalization of attack and duration of attack. We aimed at determining which variables of game performance, i.e., which technical-tactical activities, performed by handball players, had the greatest influence on a positive game outcome – victory in a handball game.

Methods

Participants

Sample of entities in this pilot-research is comprised of 330 attacks performed by four teams, contestants in two semi-final matches and in one match for bronze medal and in one match for the gold at the World Wome's Handball Championship 2017 in Germany.

Table 1. Final games of the World Women's Handball Championship 2017 in Germany

Date and time	Competition phase	Teams	Result	1st half	2nd half
15.12.-FRI 17:30	Semi-final	NED-NOR	23-32	10-17	13-15
15.12.-FRI 20:45	Semi-final	SWE-FRA	22-24	12-11	10-13
17.12.-SUN 14:30	3rd place match	SWE-NED	21-24	8-14	13-10
17.12.-SUN 17:30	Finals	FRA-NOR	23-21	11-10	12-11

Measures

For the description of the entities (attacks), the following variables with their modalities were used:

- *type of attack* (positional, transitional)
- *the attack ending in relation to the spatial determinants of playing position* that is mainly determined by the rules of the game (left wing LK, left back LV, centre back SV, right back DV, right wing DK)
- *duration of attack* (individual fast-break IP, group fast-break PK, positional attacks of different duration PN).

Manual notational analysis was used to collect data from the observation of video-recordings of matches (the pre-defined events in the game were notated). Frequency tables are commonly used for data collection that allow simple performance analysis of athletes and teams (Talović et al., 2011).

Statistical Analysis

Descriptive analysis of nominal variables (types of attacks, organization of attacks,) was made by multi-dimensional grouping of data. The data obtained are presented by contingency tables. Basic descriptive parameters (number of entities, arithmetic mean, minimum value, maximum value, standard deviation) were calculated for a quantitative continuous variable (duration of attack). To determine the difference between the nominal variables χ^2-test for two or more independent samples was applied. Kruskal-Wallis test and univariate analysis of variance (ANOVA) were used to test the difference between the winning and defeated teams in the variable duration of attacks.

Results

Out of the total of 330 attacks executed in the four final matches of the 2017 World Women's Championship (the semi-final, final, and bronze medal matches), the winning team executed 162 attacks, whereas the defeated teams executed four attacks more, i.e. 168 attacks.

Table 2. Frequencies of different types of attack for the winning and defeated teams (perceived, standardized by columns, standardized by rows)

	Observed frequency			Columns %		Rows %	
Type of Attack	**WIN**	**DEF**	**Total**	**WIN**	**DEF**	**WIN**	**DEF**
PN	138	138	276	85.19%	82.14%	50.00%	50.00%
TN	24	30	54	14.81%	17.86%	44.44%	55.56%
Total	162	168	330	100%	100%		

PN – positional attacks, TN – transitional attacks; WIN – winning teams; DEF – defeated teams.
χ^2 =9.98, df=1, p=1;

The calculated value of χ^2-test suggests that the winning and defeated teams did not significantly differ with respect to type of attack.
In Figure 1 the overall structure of attack types is presented: the winners' structure is defined by 85.19% of positional attacks and 14.81% of transitional attacks, while the structure of the defeated teams is defined by 82.14% positional attacks and 17.86% transitional attacks.

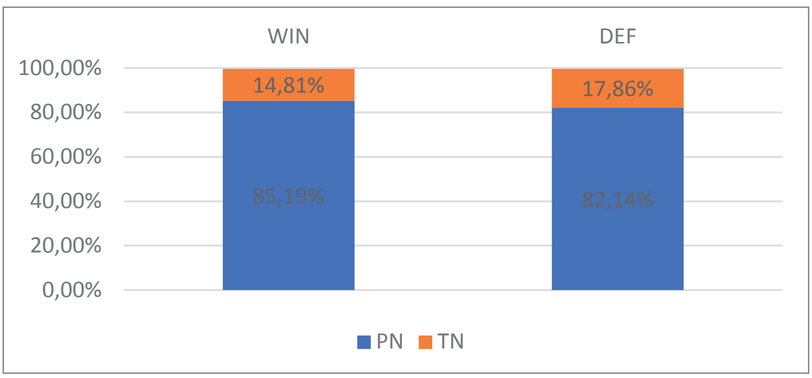


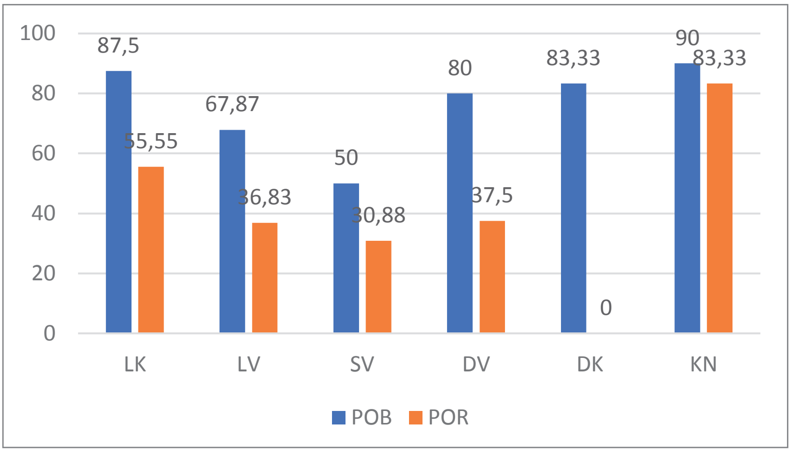
Figure 1. Types of attack for the winning and defeated teams.

Table 3. Frequency of the variable shooting from different playing positions for the winning and defeated teams (perceived, standardized by columns, standardized by rows)

	Observed frequency			Columns %		Rows %	
Playing position	WIN	DEF	Total	WIN	DEF	WIN	DEF
LW	8	9	17	8.33	10.11	47.06	52.94
LB	28	19	47	29.16	21.35	59.57	40.43
CB	34	26	60	35.42	29.21	56.67	43.33
RB	10	16	26	10.42	17.98	38.46	61.54
RW	6	1	7	6.25	1.12	85.71	14.29
P	10	18	28	10.42	20.23	35.71	64.29
Total	96	89	185	100	100		

LW – left wing; LB – left back; CB – central back; RB – right back; RW – right wing; P – pivot; WIN – winning teams; DEF – defeated teams. Note: no attack finishes with neutral result are displayed (4/9 WIN / DEF)
χ^2 =5.39, df =5, p=0.37

The calculated value of χ^2-test indicates that the winning and defeated teams did not significantly differ in the performance indicator of shots taken from different attack playing positions.
Figure 2 below shows efficiency of shots taken from different playing positions of the winning and defeated teams.



LK – left wing; LV – left back; SV – central back; DV – right back; DK – right wing; KN – pivot; POB – winning teams; POR – defeated teams.

Figure 2. Shooting efficiency from different attack playing positions – WIN/DEF.

Table 4. The results of descriptive statistics (duration of attack – winning/defeated teams)

WIN/DEF	Attack duration						
	N	Mean	Min	Max	Std.Dev.	Skew	Kurt
WIN	138	37.28	9	86	16.08	0.62	0.12
DEF	138	29.38	6	80	13.80	0.79	0.93
Total	276	33.33	6	86	15.47	0.73	0.43

Legend: N – number of entities; Mean – arithmetic mean; Min – minimum value; Max – maximum value; Std. Dev. – standard deviation; Skew , Kurt.

The results of Kruskal-Wallis test and ANOVA indicate the statistically significant difference in attack duration (H=18.14; F=19.13; p=0.00) between the winning and defeated teams at the finals of the 2017 WWCh.

Table 5. The results of Kruskal-Wallis test and univariate analysis of variance

Attack duration			
H=18.14	p=0.00	F=19.13	p=0.00

Legend: H – H-values of Kruskal-Wallis test, F – F-values, p – probability or statistical inference error.

Discussion

Differences between the winning and defeated female handball teams in type of attack

The winners performed a total of 138 positional attacks (PN) and 24 transitional (TN) attacks. The defeated teams performed a total of 138 positional attacks and 30 transitional attacks, i.e. fast-breaks. Both the winners (14.81%) and the defeated teams (17.86%) preferred to play positional attacks, which is obvious in a significantly lower frequency of transitional attacks (Figure 1). Apparently, positional attack is a predominant style of play in attack in women's contemporary handball (Foretić, 2011; Ohnjec et al., 2015; Skarbalius, 2011; Šibila et al., 2011), probably due to the advancements in retreat to defence. Equal percentage (50%) of positional attacks executed by both the winning and defeated teams maybe indicates teams' patience and tactical discipline in building-up of attacks and careful shot selection (attack finish). Importance of the semi-final and final matches, played by the four world best women's teams, was obviously immense and determined tactical solutions of attack activities. Game trends from 10 years ago were characterised by the application of short-lasting faster attack solutions, mostly based on the cooperation of two to three players (Seco, 2008); contemporary trends in attack finishing apparently tend towards longer-lasting, more patient attacks; ultimately, the result is a smaller total number of attacks executed per match. Improved performance in defence as well as a more pronounced role, performance of goalkeepers (Karastergios et al., 2017) compel top-level attackers to create their attacks more carefully with a greater responsibility in shot selection.

A considerably smaller contribution of fast-breaks and prolonged fast-breaks to the attack activities of the winning teams differs from previous research (Bilge, 2014 according Yang, 2006; Hianik, 2013; Ohnjec et al., 2013) where superiority of the winning teams was explained by a greater and more efficient application of counterattacks. It is possible that, on the one hand, improved play in transitional defence (the return to defence and denied development of counterattacks) and, on the other, exhausting and demanding play in positional defence, determined the starting point for the formation of organized positional attacks on the organized defence. A slightly larger number of transitional attacks performed by the defeated teams probably is a result of their tactical attempts to catch up with the team in lead.

Performance efficiency of attack endings is undoubtedly the key classification criterion of the winning and defeated teams. In continuation, it will be demonstrated that, apart from the well-known and clear numerical advantage in the goals scored, the structure of predominant types of positional attacks and other performance indicators also determined the winning ad defeated teams.

Differences between the winning and defeated female handball teams in attack finishes from different attack playing positions

Most of shots on goal were taken from the central part of the court (middle lane of the court, slightly wider than the goalposts) by both the winning and defeated teams (out of the total shots attempted on goal: winners 35.42% vs. the defeated 29.21%), followed by shots taken from the position of left back, which for both the winners and the defeated were more frequent than those from the right back position (Table 3). Almost identical representation of the left wing's shots was noticed in the overall shot frequency structure for both teams. The right wing's shots had a slightly higher frequency in the winning teams, whereas the pivot's shots were more represented in play of the defeated teams.
The outcome structure for both the winning and defeated teams implies optimal distribution of shot executions across all playing positions with a somewhat higher representation of the shots taken from the right backcourt position in the defeated teams. Variations of the positioning orientation of attack finishes did not have a significant impact on the criterion variable, meaning that in modern handball it is not possible to single out one or a few playing positions having superior influence on the match outcome. All playing positions are apparently equally important in team performance as demonstrated by even distribution of shot attempts and by their even effectiveness (goals scored or missed). In other words, the resultant contribution of the backcourt positions to match outcome is conditioned by their predominant numerical representation, and the contribution of shot attempts from the 6m-line positions, although of a lower frequency, is large due to their greater efficiency (Rogulj, 2009). Numeric advantage in the goals scored generates the winner of a single match, so efficient shot performance appears to be the key factor of team performance.
Overall shot efficiency (Figure 2) for the winners in this sample was 67.70%, while for the defeated it was 46.07%. The attackers of the winning teams in all the playing positions were more successful in shot attempts, which was eventually materialized in the game as victory. Superiority of all the winning backs in shot efficiency is evident in numerical advantage (50% CB, 67.87% LB, 80% RB). Probably, backcourt players who are able to score their long-range attempts through and over the defenders are playing for the winning teams; they are able to realize by the group cooperation prepared scoring situations. Such a favourable selection of shots in the context of long-range attempts is possibly due to the quality of individual players that evidently create successful match outcomes in elite women's handball.

Differences between the winning and defeated female handball teams in positional attack duration

The positional attacks performed in four final matches of the World Women's Handball Championship 2017 lasted on average 33.33 seconds. The obtained values are higher than those of the European Championships in 2010, where the average duration of the attack was 26.99 s (Ohnjec et al., 2013). The fact that Championship's games of semi-finals and finals were studied here exclusively as well as implied development trends of contemporary handball are probably in the background of the facts registered on this sample of matches. The winning teams' positional attacks had an average duration of 37.28 seconds, while the defeated teams' positional attacks lasted 29.38 seconds on average (Table 4). The maximum values of individual attacks' duration were 80 seconds for the defeated teams and 86 seconds for the winning teams. Those results suggest a very dynamic attack play that not even the referees' subjective notion of passive game could have stopped, although some attacks lasted longer than one minute. Obviously, the teams' cooperation tactic, based on a large number of place changes

with the tendency to create situations for the undisturbed performance of the finishing shots, has been reflected in the duration of positional attacks. Play style of the top-level contemporary women's handball teams observes the principle of dynamic mobility of handball players. The same was also reported in literature, for example in Manchado et al. (2013) or Michalsik et al. (2014, 2015): short-term, high-intense technical playing actions consisting of numerous piston movements, waving piston movements and constant changes of places are the key part of handball performance. Handball players consume a considerable amount of energy in actions involving accelerations and decelerations, which underlines the intermittent nature of the game (Luteberget & Spencer, 2017).
In general terms, the team play in positional attacks of the 2017 WWCh finals can be described as a tactically disciplined play based on the principles of cooperation in the recurrent application of the elements of group tactics (piston movements, waving, crosses, leading away). So tactically designed imply a gradual and purposeful construction of attacks with the aim to ensure the finishing shot on goal taken from the most suitable game situation, preferably with no contact game in this last step. The winning teams of the analysed matches applied consistent and persistent tactics of building-up and performing positional attacks with a statistically significant difference in the time necessary for such actions. They were more successful in maximal exploitation of the individual attack time allowed by the referees. It can be concluded that the winning teams were cautious and disciplined in building-up their attacks gradually (no-risk tactics), thus avoiding exposure to the unnecessary risks of losing ball possession due to half-cocked short-term solutions. Therefore, they implemented fast-breaks to a far lesser extent; even when the winners managed to steal the ball, they did not hurry into attack, but slowed down the pace of play to build up attack, through the application of variable rhythm and pace of play and varied dynamical mobility of attackers as well as fast ball circulation, to finish them from the secure, the so-called "100% scoring opportunity" game situations.

Conclusion

The research was conducted on the four final matches – 2 semi-finals and matches for gold (1) and bronze (1) of the Women's Handball Championship held in Germany at the end of 2017. Performance in attack was presented by performance indicators in the variables of technical-tactical actions: types of attacks, attack finishes with respect to the defensive players and the attack playing position, and duration of attack. To determine the difference between the winning and defeated teams χ^2-test, Kruskal -Wallis test and univariate analysis of variance (ANOVA) were used. The calculated value of χ^2-test suggests that the winning and defeated teams did not significantly differ with respect to type of attack, and shots taken from different attack playing positions. The results of Kruskal-Wallis test and ANOVA indicate the statistically significant difference in attack duration ($H=14.07$; $F=10.04$; $p=0.00$) between the winning and defeated teams at the finals of the 2017 WWCh.
The recognizable characteristics of top women's handball teams' play are obvious in the context of tactics both in attack ad defence. Style of play in attack in contemporary handball at the highest standard/competition levels is characterised by the constructive, planned and elaborated attack build-up that is manifested in a high frequency of team cooperation through piston movements, numerous changes of places with the ball and without it ball, and unobstructed finishing shots on goal. Most of the mentioned characteristics are recognizable in individual attacks of the winning teams.

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Comparative kinematic analysis of softball swing in female and male players

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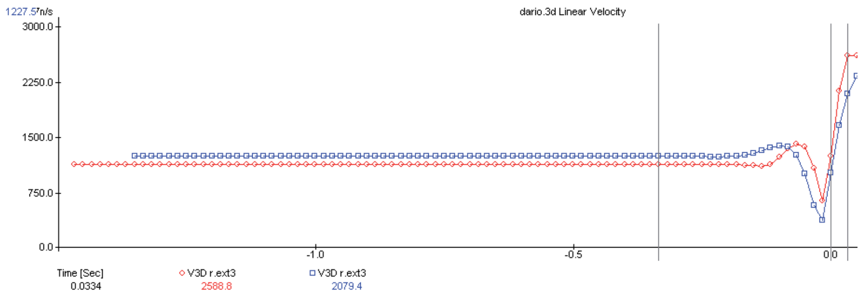
ABSTRACT
The purpose of this study was to compare softball swing performance of two athletes, male and female, and comparison of the achieved results with results from previous similar researches. Both players were members of the Croatian national senior team, and hade been playing softball for a long time. Each player hit 24 balls (two sets of 12 balls) after a standard warm-up. Three video cameras, operating at 60 frames per second, were positioned to provide 3D analysis and used for recording the performances. The best hit of each player, chosen by the expert team of coaches, players and umpires, was subjected to further analysis. Although the functioning of kinetic chain was efficient in both analyzed hits, significant differences occurred in the variables of elbow angles. In the female swing a much larger angle was registered than in the male one, which led to a slower elbow extension speed. The female player opened her shoulder prematurely, and pushed the knob too much off, instead of staying inside the ball trajectory and keeping the knob close to her body. Players often mistakenly go around the ball, instead staying in and then push properly through the extension phase. Speed of elbow extension is very important for the ball trajectory, as much as the knob path.

Introduction
Softball is one of the most competitive amateur sports played in USA. In Europe, it has not yet reached the USA popularity level. The European Softball Federation was established in 1976 with only six memeber countries. Its membership has been enlarged over the years to 33 countries. Nowadays, softball is mostly played, and at a high level, in the Netherlands, the Czech Republic, Italy and Germany. Outside of Europe, it is popular in Japan, where there is also a professional league.
It has developed from baseball, on which much research has been done focusing mainly on hitting and kinematics of swinging (Adiar, 2002), whereas few scientific investigations were done on softball and especially on female players.
Hitting the ball in softball takes a lot of time to be learned since a high level of coordination is needed. Rubinoff (2016) states that balance and consistency are the crucial factors in achieving success.
Milanovich and Nesbit (2014) demonstrated that since the research by Messier and Owen (1984) most research works were about the bat and its mechanical performance as on all the effects of its speed.
The purpose of this study was to compare softball swings of two athletes – one male and one female, and to compare the obtained results with previous ones.

Methods
One female (age 23 years, body height 160.5 cm, body weight 53 kg) and one male (age 20 years, body height 180 cm, body weight 77 kg) were the subjects of this study. The analyzed hitters were members of the Croatian senior national team and had been

playing softball for a long time. After a standard pre-competition warm-up, each player hit 24 balls, i.e. 2 sets of 12 balls each.
The videometric data were acquired by three video cameras operating at 60 frames per second and positioned in such a way to provide 3D analysis. The best hit of each player, chosen by the expert team of coaches, players and umpires, was subjected to further analysis. The data were processed according to the standards of the APAS procedure (3D analysis, DLT, Cubic Spline), considering specifics of the analyzed movements.

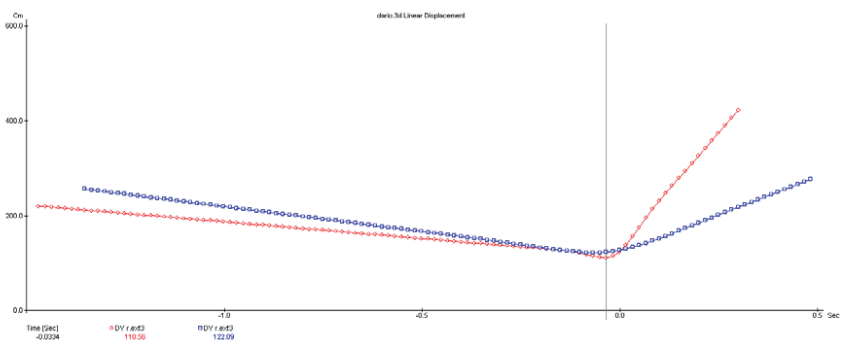
Results and discussion
The focus of the softball hitting analysis was mostly on speed of the ball after the impact with the bat and on the height at which the ball was hit.



Male RED; Female BLUE

Graph 1. Ball speed after the impact with the bat

The measured ball speed in the present study was lower than in other studies – the average speed was reported to be between 31 m/s and 22 m/s (Koenig, et al., 2004), whereas in our study ball speed after the collision with the bat was 25.92 m/s and 21.73 m/s for the male and female subject, respectively (Graph 1).
Apart from the obvious anthropometric differences between our two subjects, as well as between their physical abilities, there was also a difference between their performance techniques and the resulting ball trajectory. The first and most obvious difference was the height at which the ball was hit (Graph 2).

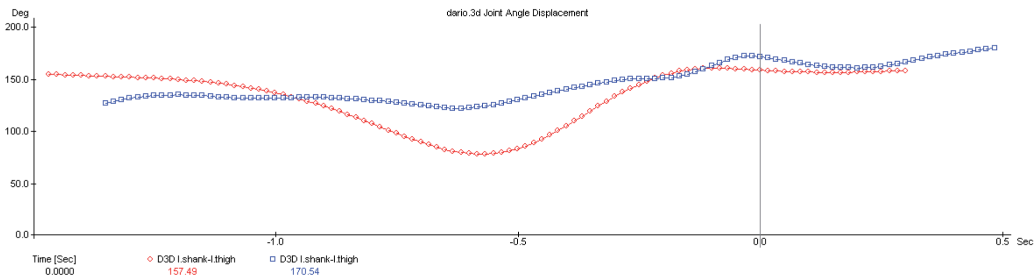


Male RED; Female BLUE

Graph 2. Height at which the ball was hit

The female subject hit the ball at the height of 122.09 cm, which was significantly higher than in the case of the male subject (110.56 cm). The ball hit by the female subject was at the top of the strike zone and therefore her ball trajectory was more vertical than the male's. The male subject hit the ball in the middle of the strike zone, thus demonstrating a more efficient timing of hitting the ball.

Also, the knees of the female subject were much more extended than the male's, especially the left (leading) knee, 170.54° comparing to 157.49° (Graph 3).

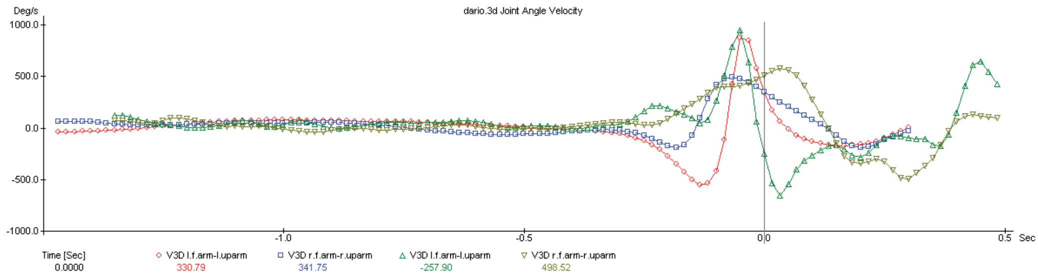


Male RED; Female BLUE

Graph 3. Angles in the left knee

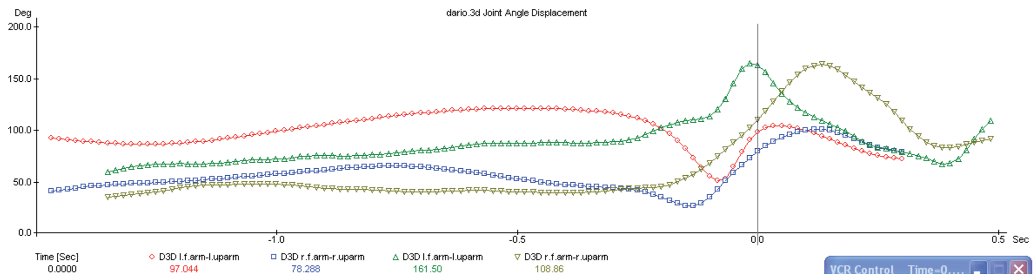
During the softball swing analysis, it is common to divide the movement in five performance phases: stance, load (negative phase/movement), contact with the ball, extension and finishing phase (Bahill, 2004). Stance is individual for every player; commonly, their feet are parallel, static, and can be shoulder width or more apart. Feet apartness depends on the player's sense of comfortability (Escamilla et al., 2009b; Flyger, Button, & Rishiraj, 2006; Welch et al.,1995). The eyes are focused on the pitcher (Monteleone & Chrisfield, 1999). In the second phase, it is important to produce a negative momentum – the body weight shifts on the rare leg, preparing to transfer all the body energy to the ball. The batter lifts the front leg off the ground to make more force while he/she is landing it on the ground again. We can compare two ways of negative momentum generation in the current study – the male participant lifted his front leg way much more and made the angle in knees of 77° while the smallest female angle was 120.7°. So far in the recent research works both techniques have been proven as successful ones. The third phase – the ball and bat collision, is the most important phase; its performance depends on the angles at which the ball is being approached, on the way the knob is travelling to the ball and, of course, on the bat speed. After the contact, the elbows are extending through the ball.

The female subject demonstrated a bigger angle at the contact with the ball; her arms/ elbows were more extended than they should have been, which led to a poorer hit. Because of a greater angular velocity (Graph 4.) of the extending elbows – 940,11 °/s at the left elbow and 562 °/s at the right elbow, compared to 861,7 °/s and 482,1 °/s measured in the male participant, at the end of the swing performance she had a bigger angle (Graph 5.), caused by the mentioned higher angular velocities in the elbows. The maximum speed was reached 0.03 seconds after the contact, which is corresponding to some previous studies.



Male left RED and right BLUE; Female left GREEN and right OLIVE GREEN

Graph 4. Angular velocities in elbows

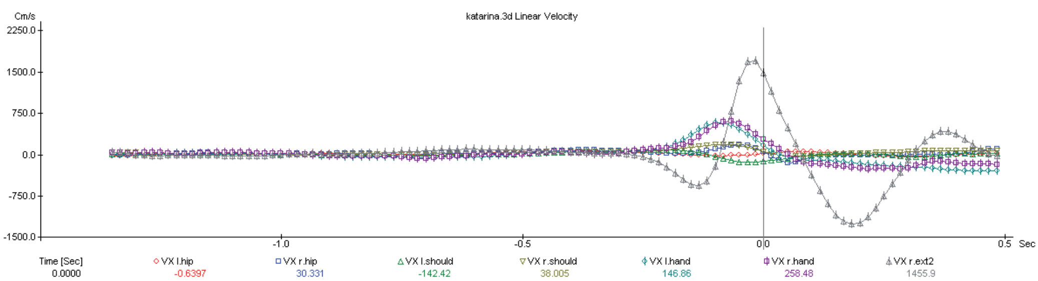


Male RED; Female BLUE

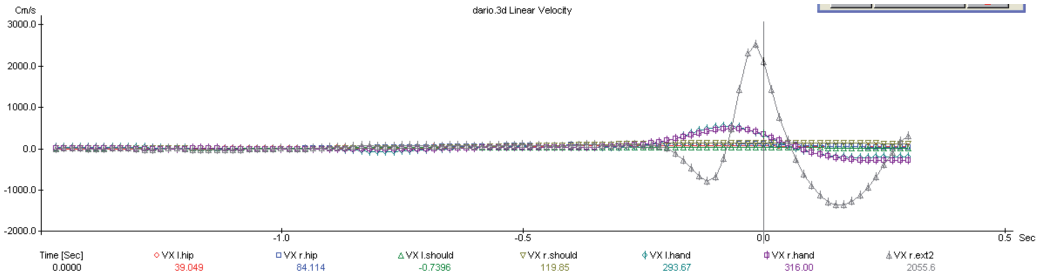
Graph 5. Angles in the elbows

During a swing, the kinetic chain makes all the energy needed to transfer it to the ball. Starting from the feet through the legs, hips, abdominal muscles, arms, wrists to the – bat (Race,1961; Welch et al., 1995).

In previous studies, researchers concluded that the hips were the ones leading the swing and giving the starting acceleration and then came the shoulders and arms. Timing is crucial for the success of a hit – the right body parts should start moving at the right moment. In case of the current study, in both participants the functioning of the kinetic chain was efficient (Graph 6. and 7.).



Graph 6. Kinetic chain of the female model



Graph 7. Kinetic chain of the male model

Conclusion

The comparison between the male and female models has shown significant differences in their softball swings. One of the variables in which they significantly differ were angles in the elbows. In the female model we can see a bigger angle than in the male one, which leads to a lower speed of elbow extension. The female player opens her shoulders too early and pushes the knob too much off, instead of staying inside the ball lane and keeping the knob close to her body. Players often make such a mistake that they go around the ball, instead staying in and then pushing properly through the extension phase. Speed of elbow extension is very important for the following ball trajectory, as much as the knob path.

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The relationships between cycling economy, pedalling effectiveness and cyclist's musculoskeletal state

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ABSTRACT
The purpose of the study was to examine the relationships between road cyclists' musculoskeletal state, pedalling technique and metabolic economy (*Gross Efficiency-GE*) measured during incremental cycling exercise. The strength of knee extensor (KnEX) and flexor (KnFL) muscles of 30 competitive cyclists (19.0±2.1 y.; 1.82±0.06 m; 74.6±6.8 kg) were tested with a *Humac NORM isokinetic dynamometer* at angular speeds 60^0/s (Maximal strength) and 180^0/s (strength endurance and Fatigue Index (FI)). The core stability and for the fundamental movement abilities of cyclists were evaluated with *Functional Movement Screen (FMS)* test battery. After that cyclists performed *incremental cycling exercise* on *Cyclus2 ergometer* using their own racing bike equipped with *Garmin Vector* pedals. The ventilator, pedalling Torque Effectiveness (TE) and Smoothness (PS) parameters were captured continuously during the test. The *GE* was computed as ratio between mechanical cycling power and energy expenditure rate. The FMS score, thigh muscles strength characteristics, as well averaged GE, TE and PS values between aerobic (AeL) and anaerobic (AnL) work levels were registered for analysis in a later stage. Correlation and regression analysis were used to assess the relationships between the registered parameters. Tests revealed a moderate relationship between the GE and cyclists' ability to perform fundamental movements, evaluated by FMS test, as well as with KnEX FI and biomechanically effective pedalling technique. Multiple regression analysis of in-between subjects variation in GE the KnEX FI (Adj. R^2 = 0.36) revealed common explanatory power with TE (Adj. R^2 = 0.19), but adding the FMS score to the both parameters separately will increase the adjusted explanatory power of the model with 4% (Adj. R^2 = 0.40) and 12% (Adj. R^2 = 0.31) for KnEX FI and TE models respectively.

Key words: Gross Efficiency, Isokinetic Dynamometry, FMS test, Incremental Cycling Exercise, Garmin Vector, Cyclus2

Introduction

For a forward movement cyclist must overcome the environmental and rolling resistance and also the force of gravity in uphill cycling (Faria et al., 2005b). This requires from a cyclist to transfer the energy received from the food or stored in the body to the mechanical work (Ettema & Lorås, 2009). When pedalling, the cyclist will do both internal and external mechanical work. The internal mechanical work is done by moving the body segments relative to the body's centre of gravity and to overcome the resistance of different passive tissue and antagonistic muscles within the body, the external work is needed to move the body's centre of gravity, in cycling, mainly to generate forces that move the bicycle forward (Ettema & Lorås, 2009; Minetti, 2011).

Road cycling is considered one of the most energy-demanding sports where high metabolic efficiency is required for the conservation of energy resources (Faria et al., 2015a; Jeukendrup et al., 2000), that is, how much energy can be transformed into external mechanical work and how much energy leaves the body as a heat (Ettema & Lorås, 2009) generated by the result of biochemical and physiological processes (Mady, 2013; Spanghero et al., 2018) and also as a product of internal mechanical work (Minetti, 2011). In the light of the latest knowledge, the most valid and stable feature of the cycling performance assessment is the ratio of the total cost of metabolic energy to the mechanical external work (Gross Efficiency - GE) (Castronovo et al., 2013; Ettema ja Loras, 2009; Moseley & Jeukendrup, 2001) and the GE can explain up to 30% of the variation of the aerobic cycling performance (Jobson et al., 2012). The GE may, according to theoretical calculations, be at least 30% (Ettema & Lorås, 2009; Spanghero et al., 2018), but in experimental studies the GE of competitive cyclists are found to be on average between 18,5-23,5% (De Koning et al., 2012; Hopker et al., 2010; Luhtanen et al., 1987; Moseley et al., 2004). For the world class professional riders, values up to 28% have been measured and in that population the GE is inversely related with VO2max values (Lucia et al., 2002). It is not completely clear what mechanisms and training adaptions describe differences in the metabolic economy but from a morphological point of view, it has been found that more than half of the difference in metabolic economy variations between elite level cyclists can be explained by the proportion of type I muscle fibres in the Vastus Lateralis muscle (Coyle et al., 1992). Also it is found that exercises affecting local muscle performance properties, like maximal strength trainings (Sunde et al., 2010) and endurance training at higher training intensities (Hopker et al., 2009) are beneficial to improve GE. But a question remains if the local strength properties of main muscles involved in the pedalling action can also describe the differences in metabolic economy between cyclists?

The Metabolic economy depends on the intensity of the work to be performed - up to 40% of the VO2max power the GE improves significantly with increasing workload (Ettema & Lorås, 2009), after which improvement rate lessens (Chavarren & Calbet, 1999; Ettema & Lorås, 2009) or discontinues (Moseley et al., 2004), but after respiratory compensation (onset of blood lactate accumulation) threshold the GE starts to decline (Luhtanen et al., 1987). In addition to the workload intensity, the GE level is affected by a number of pedalling technique characteristics like cadence (Chavarren & Calbet, 1999; Hansen et al., 2002; Lucía et al., 2004), bike handlebar height (Gnehm et al., 1997; Grappe et al., 1998) and saddle setup (Price & Donne, 1997; Ferrer et al., 2014). The relationship between biomechanical rationality, determined as force transfer effectiveness from legs to the pedals (Bini et al., 2013; Fonda & Sarabon, 2010), and GE is still not clear. There are studies where cyclists with higher pedalling efficiency have also shown to have better metabolic economy (Zameziati et al., 2006; Leirdal & Ettema, 2011) and for both indicators, higher values have been found among professional riders compared with lower level cyclists (García-López et al., 2016; Lucia et al., 2002). But the existence of a causal relationship is not clear because when the pedalling efficiency is improved by feedback training, the metabolic economy tends to significantly decrease (Korff et al., 2007).

Most of the studies that explore relationships between cyclists' movement technique and cycling metabolic economy have focused on the distribution of pedal forces in the pedalling cycle, while there is evidences that stabilization or destabilization of the cyclist's position have an effect on metabolic cost in cycling (McDaniel et al., 2005; Miller et al., 2013). Also if the cycling workload increases, the weight of the cyclists' upper body is less supported by the saddle and more force is applied to the handlebar (Costes et al., 2015), this will cause larger isometric contraction of upper body muscle to stabilize the position, which can significantly increase energy consumption (Pedersen et al.,

2002). The weakness or tiredness of the trunk muscles may lead to irrational changes in the kinematics of the rider movements (Abt et al., 2007) and this in turn can lead also to additional metabolic costs. However, little is known about the role of the rider's upper body musculoskeletal status and the stability of the riding position in context of metabolic economy.
Therefore, the purpose of the present study was to examine the relationships between road cyclists' musculoskeletal state, pedalling technique and metabolic economy measured during incremental cycling exercise.

Methods
Participants of the current study were 30 competitive junior and U23 male road cyclists (age 19.0±2.1 yrs., height 1.82±0.06 m, body mass 74.6±6.8 kg, VO2max 65.9±4.4 ml/min/kg). All athletes had at least 4 years of focused endurance cycling training and competition experience, and had annual cycling distance above 12000 km during the last season and above 3000 km during preparation period before experiment. The participants were free of injuries and signed an informed consent term in accordance with the principles of the Declaration of Helsinki.
The procedures of the study were conducted during the second half of preparation period and less than 1 month before first cycling competitions. All experimental procedures for one person were made on the same day and protocol consisted of 3 separate tests in the following order: Functional Movement Screen (FMS) tests, incremental cycling exercise and thigh muscles strength tests on isokinetic dynamometer. All cyclists were familiar with test procedures and had performed all tests at least once in the past.
The musculoskeletal status of cyclists was evaluated in two aspects. The *overall functionality of upper body and pelvis region muscles* to stabilize body position and to perform controlled movements was evaluated with the FMS test package (Cook et al., 2014). All 7 FMS test sub-tests were performed after 15 minutes warm up and at least 3 attempts for all exercises were captured by two computer controlled HD web-cameras (frame rate 30 Hz). Recordings were analysed with video analysis software Kinovea 0.8.25 by an experienced (22 years of practice) physical therapist with 7 years of experience with the FMS. The movement quality of all 7 sub-test were evaluated in four point ranking system (0-3) and all sub-tests scores were summed to a total FMS score (Cook et al., 2014) and saved for impending analysis.
The local muscle strength properties of thigh muscle, as main pedalling force producers in submaximal cycling, were evaluated on the Humac Norm isokinetic dynamometer. The test procedure consisted of 2 tests for knee extensors (KnEX) and flexors (KnFL): the maximum strength (Peak Torque- PT [Nm/kg]) of muscle groups (3 trial and 5 testing repetitions) was evaluated at an angular velocity of 60 °/s and at velocity of 180 °/s (3 trial and 20 testing repetitions) were evaluated the strength endurance (Average Torque of 20 repetitions between knee flexion angle of 30 and 70 degree- AvT [Nm/kg]) and resistance to fatigue measured by Fatigue Index (FI= 100*Average Torque of last 5 reps./ Average Torque of first 5 reps. [%]). The subjects were instructed to start strength endurance test with maximum effort. For both tests left and right leg were tested in a randomised order between subjects and the average values of both sides of each parameter were saved for analysis.
Experimental cycling exercise was performed using the cyclist's personal racing bike mounted on the Cyclus 2 ergometer and bicycle was equipped with pair of Garmin Vector™ power meter pedals. Exercise protocol consisted of a 10 minutes warm-up of steady ride at the power level of 100 W and was followed by the incremental cycling exercise conducted in sitting position hands on the drops: target cadence 90±5 revolution/min (rpm), initial workload of 100 W and the workload increased by 25 W after every 2 minute until exhaustion. During and after 3 minute of the cycling exercise the heart rate and

breath by breath pulmonary O2 (Vo2), CO2 production ($\dot{V}co2$), and expired minute ventilation ($\dot{V}E$) were measured continuously with the Cosmed Quark CPET metabolic analyser (Rome, Italy). The maximal aerobic peak power (PP) and ventilatory threshold levels assessments were performed using Cosmed PFT Ergo software independently by two experienced researchers. The first (aerobic level – AeL) and second ventilatory thresholds level (Anaerobic level – AnL) were estimated by methods described and validated by Weston and Gabbett (2001). The maximal aerobic oxygen uptake ($VO2_{max}$ [ml/min/kg]) was determined as the highest 30 s average values during the exercise. Furthermore, for the future analysis power data at the AeL, and AnL were registered. When the certain intensity level was achieved during first 30 sec of the incremental step the previous increment was chosen as a true value. The values of oxygen uptake (VO2 [ml/min/kg]) and power (P [W/kg]) were normalized with body mass. For the last minute of every step between AeL and AnL the GE (%) value was computed as ratio between cycling power and metabolic energy expenditure rate (Emet). The metabolic energy expenditure rate was computed according to the formula: Emet=[(3.869*VO2)+(1.195*VCO2)]*69.77 (Moseley & Jeukendrup, 2001). To reduce the effect of slow component of VO2, the average value of GE of all steps between AeL and AnL was computed and saved for the future analysis.
The biomechanical effectiveness of force delivery during pedalling was described by Torque Effectiveness (TE=100*(Positive Torque in pedalling cycle)/(Positive + Negative Torque in pedalling cycle) [%]) and Pedalling Smoothness (PS=100*Average Torque in pedalling cycle/Maximal Torque in pedalling cycle [%]), that were registered with Garmin Vector™ pedals. Similarly with GE characteristic, the TE and PS values of second minute of every step between AeL and AnL were averaged and the average values of the right and left pedal were taken into further analysis.
Statistical data analysis was performed with software SPSS version 23.0 (IBM Company, New York). Descriptive statistics were computed for all variables and for every test phase and expressed mainly as a mean ± SD. To describe the intra cyclists' homogeneity in measured parameters the Variability Coefficient was computed as ratio between SD and mean in percent (%). All the data was tested for their normal distribution (Kolmogorov-Smirnov test). Pearson product-moment (for normally distributed variables) or Spearman rank correlation (for non-normally distributed variables) and simple and multiple stepwise regression analysis were performed to examine the relationship between measured parameters. Significance level for correlation analyses was set at $p<0.05$ ($r>|0.36|$). In multiple stepwise regression analysis the significance level for parameter entering was set at $p<0.05$ and removal level at $p<0.1$.

Results
The average values of cycling specific abilities of study subjects were: P_{AeL} - 3.31±0.30 W/kg, P_{AnL}- 4.42±0.35 W/kg, PP - 5.07±0.39 W/kg, $VO2_{AeL}$ – 49.6±4.3 ml/min/kg, $VO2_{AnL}$ - 60.7±4.8 ml/min/kg, $VO2_{max}$ 65.9±4.4 ml/min/kg, GE - 20.6±1.0 % (18.9-22.3%). The descriptive statistics of the musculoskeletal functional abilities and pedalling technique characteristics among the participated cyclists and correlation with GE of those parameters are given in Table 1 below. For FMS test the median value was 15 points and 9 cyclists performed the test under that critical 15 point level. The parameters with highest variability among cyclists were KnEX and KnFL strength and local strength endurance characteristics, while the smallest variation was found in pedalling technique and FI parameters. Said less varying characteristics were correlated with GE. The more fatigue resistant were the KnEx muscles and the better was cyclists' ability to perform fundamental movements as measured by FMS score as well as higher pedalling effectiveness and smoothness were all related with better metabolic economy in cycling

(GE) (Table 1). The more detailed and illustrated information about relationships between named parameters and GE is presented in regression models in Figure 1. No significant correlations were found between GE and thigh muscles strength values (Table 1).

Table 1. The descriptive statistics and correlation with GE of FMS test, tigh muscles strength tests and pedalling technique characteristics

N=30	Minimum	Maximum	Mean	SD	Var. Coef. (%)	Correl. with GE
FMS score (points)	11	18	14.8	1.5	10.4	0.49*
KnFL PT (Nm/kg)	1.40	2.50	1.91	0.26	13.4	-0.19
KnEX PT (Nm/kg)	2.30	4.00	3.10	0.44	14.2	0.00
KnFL AvT (Nm/kg)	0.70	1.20	0.97	0.15	15.1	-0.06
KnEX AvT (Nm/kg)	1.30	2.10	1.66	0.20	12.1	0.19
KnFL FI (%)	58.2	76.7	68.6	5.0	7.3	0.34
KnEX FI (%)	72.1	84.4	77.2	3.5	4.6	0.62*
PE (%)	77.6	94.6	85.7	4.4	5.2	0.47*
PS (%)	22.2	32.2	25.5	2.2	8.4	0.36*

*. Correlation is significant at the 0.05 level (2-tailed).

The correlation matrix (Table 2) describes relationships between musculoskeletal state and pedalling effectiveness parameters. Test revealed a moderate positive correlation between pedalling TE and PS and thigh muscles AvT and FI characteristics. Also there is a moderate inter-correlation between most of those parameters that correlate with GE, except between FMS score and pedalling variables. To test the communality of explanatory power for GE inter subjects' variation of those parameters the multiple regression analysis was performed.

Table 2. Correlations between FMS test score, tight muscles performance values and pedalling technique characteristics

FMS score (points)	1								
KnFL PT (Nm/kg)	-0.34	1							
KnEX PT (Nm/kg)	-0.19	0.68**	1						
KnFL AvT (Nm/kg)	-0.11	0.69**	0.36*	1					
KnEX AvT (Nm/kg)	0.02	0.59**	0.69**	0.62**	1				
KnFL FI (%)	0.25	0.11	-0.11	0.46*	0.20	1			
KnEX FI (%)	0.44*	-0.02	0.02	0.12	0.49**	0.42*	1		
TE (%)	0.29	0.24	0.36*	0.21	0.49**	0.46*	0.57**	1	
PS (%)	0.07	0.38*	0.36	0.23	0.50**	0.44*	0.54**	0.77**	1

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).

By adding pedalling TE and PS variables separately to the regression model of KnEX FI to explain between subjects variation in GE, both model components did not reveal statistically significant relationship and adjusted R^2 of initial model reduced from 0.36 to less than 0.33. It means that those independent variables share common explanatory power to GE. When combining FMS score with KnEX FI into the same model the explanatory power for GE increases from 36% to 40% and the model is:

$$GE=0.14*KnEX\ FI+0.18*FMS+6.90; (R^2 = 0.44; adj.\ R^2 = 0.40; p<0.001).$$

By combining FMS score into TE model the explanatory power increased from 19% (TE alone) or 21% (FMS score alone) to 31% and the model is:

$$GE=0.08*TE+0.26*FMS+9.85; (R^2 = 0.36; adj. R^2 = 0.31; p=0.003).$$

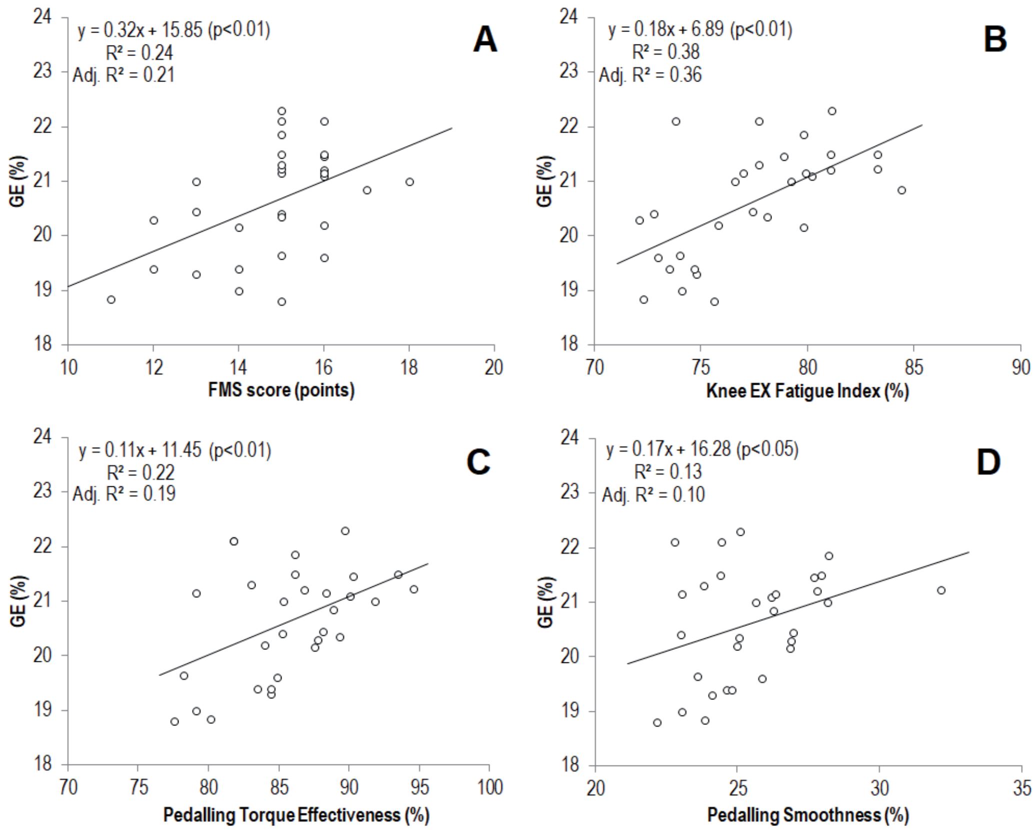

Figure 1. Simple regression between GE and FMS score (A), Knee EX FI (B), Pedalling TE (C) and PS (D)

Discussion

The one aim of present study was to evaluate the musculoskeletal state and cycling specific aerobic performance of young competitive road cyclists. The FMS score, that reflects cyclist's core stability and ability to perform fundamental movements, indicated that almost one third of study subjects achieved scores below 15 points, indicating raised injury risk level (Kiesel et al., 2007; Hotta et al., 2015). The average values found in current study were a bit higher (14.8±1.5) than a results of our previous research conducted in the transition period after the competitive cycling season (14.1±1.8) (Rannama et al., 2016) and results of same aged competitive male runners (14.1±2.3) (Hotta et al., 2015).

The GE values of cyclists in present study were between 18.9-22.3% (average 20.6±1.0%) and this fits well with previous findings (18.5-23.5%) measured in competitive road cyclists (De Koning et al., 2012; Hopker et al., 2010; Moseley et al., 2004), but is significantly lower than is reported amog top level professional riders (Lucia et al., 2002). Also the pedalling TE values (77.6±94.6) at the intensive aerobic cycling workload are similar with previously reported results of trained cyclists (García-López et al., 2015).

The second and main aim of present study was to examine the relationships between cyclists' musculoskeletal state, pedalling technique and metabolic economy during

intensive aerobic work, measured during the incremental cycling exercise. Some of the previous studies have shown that cyclists with higher pedalling efficiency have better metabolic economy (Zameziati et al., 2006; Leirdal & Ettema, 2011). Our findings were in agreement with the same trend. However, GE was more strongly related with cyclists' state of the musculoskeletal characteristics. The KnEX FI had largest descriptive power (40%) describing in-between subjects variability in metabolic economy. The earlier studies have not directly shown a link between GE and thigh muscles strength and endurance properties, but the significant morphological factor that seem to describe about a half of the GE variation is the proportion of the Type-I (slow-twitch) muscle fibres in the *Vastus Lateralis* muscle (Coyle et al., 1992). The topic is not settled as an earlier study of Thorstensson & Karlsson (1976) demonstrated that proportional distribution of Type-I and Type-II muscle fibres in the *Vastus Lateralis* correlates strongly (r=0.86) with decline in force during a multi-repetition knee extensors isokinetic exercise at velocity 180°/s. Therefore the causal relationship between KnEX FI and GE in application for cyclists' performance evaluation needs further investigation with intra subjects study design.
The KnEX FI and some other thigh muscles strength characteristics in current study correlated positively with pedalling efficiency and multiple regression analysis revealed that pedalling characteristics do not add any additional descriptive power to KnEX FI. This may indicate that the link between metabolic and biomechanical rationality relationship is buried in some common morpho-physiological properties of KnEX, as themost exploited and trained muscle in pedalling motion (Elmer et al., 2011). This may also explain the tendency among higher level professional cyclists who demonstrate higher values in both metabolic and biomechanical rationality compared to lower tier riders (García-López et al., 2016; Lucia et al., 2002). One interesting findings of our study was that the maximal strength and strength endurance values of thigh muscles were not related to GE. The finding deviates from findings of positive effect of strength training on GE (Sunde et al., 2010). The inter-subjects design of the present study and the local muscle testing (ignoring the inter-muscular coordination) may be not enough sensitive and adequate test to expose the effect of maximal strength on GE.
One of the main findings of this study was that the state of cyclist's core stability and the ability to perform fundamental movements is related to GE and to the states of stabilizing muscles of trunk and pelvis region while the lack of hip and trunk mobility can negatively affect cycling performance. Earlier studies have shown that lower FMS score is related to larger postural swaying during cycling effort (Rannama et al., 2017) whereas a more stable upper body position is related to savings in the metabolic cost (McDaniel et al., 2005). Also less developed muscles fatigue sooner and tiredness of trunk muscles leads to altered upper body kinematics (Abt et al., 2007). All this adds to extra internal mechanical work, that is further related with longer motion paths of the body segments and excessive external mechanical work that is performed by moving body COG against bicycle (Minetti, 2011). To the best of our knowledge, relationship between the general functional movement abilities and the cycling economy has not been previously presented.

Conclusion

The results of the current study demonstrated that during intense aerobic part of the incremental cycling exercise the strongest predictors of metabolic economy were cyclists' ability to perform fundamental movements, evaluated by FMS test and knee extensors resistance to fatigue. The smoother and effective pedalling technique was also positively related with higher metabolic economy, but those pedalling measures are sharing common explanatory power with KnEX strength and fatigue resistance properties.

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Central ellipsoid of inertia in analyzing snowboard trick flight - single and double “wildcat” - case study

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Purpose: Here we present the potential of central ellipsoid of inertia model which provides dimensionally reduced description of complex human motion.

Methods: The subject of this study was a single 26 years old male competitor who has been training snowboard since 2002 (body high 174 cm, body mass 65 kg). He performed 10 snowboard “wildcat” backflip tricks (4 single and 2 double) in a controlled environment. The ramp used was 5.6m high and 16.6m long; the 2.3 drop was angled at 30 degrees. We used Motion Capture Vicon system consisting of 10 cameras (4MP resolution, acquisition speed 100Hz). We used human body model based on Vicon Nexus software and Plug-in Gait model. The cameras were mounted on special crate placed 2m above the ramp drop. The measured space was an elliptical cylinder of height 3m and base axis of lengths 6.47m and 4.20m.

Results: Mean height of center of mass (CoM) was similar in single (1.92 m SD 0.2 m) and double backflips (2.06 m SD 0.05 m). Likewise, CoM velocities 1m above the ramp were also similar for vertical (single 3.57 m/s SD 0,61 m/s and double backflips 3.75 m/s SD 0,35 m/s) and horizontal component (single 4.95 m/s SD 0.35 m/s and double backflips 5,00 SD 0,28 m/s). However, cumulative moment of inertia as well as flight time were different in the two types of backflips.

Conclusion: Central ellipsoid of inertia model can be useful in analysing sport techniques, particularly for complex aerial movements, where CoM describe only resultant body motion.

Longitudinal reviews on research topics between South Korea and China based on the text-mining techniques

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Purpose: This research was to focus on understanding the flow and the future direction of the studies relevant to the physical education in Korea and China that it was able to identify the characteristics of the research environment in both countries.

Methods: The subjects were the papers published in the field of physical education and sport sciences in Korea and China from 2010 to 2016. Additionally, the study was concluded from the following analysis of words that were emerging every year: absolute frequency and relative frequency (TF-IDF index and Word Cloud) disparities, similarity disparities (the result of hierarchical cluster analysis), in-text similarity disparities (K-mean cluster analysis), trend analysis (TF-DI index) and social network analysis.

Results: Firstly, there is a yearly disparity in the word frequency that are emerging from the academic papers between Korea and China. As time flows, the frequency of certain words had increased: in the case of Korea, 'exercise', 'group', 'sports', 'education', but in case of China, 'sports', 'training', 'education', and 'exercise'. Secondly, there is a yearly disparity in word similarity in the study of physical education in Korea and China. As time flows, Korean studies has been attributed to the main three words of 'exercise', 'sports', 'education', whereas Chinese has been subject to two major words: 'sports' and 'education'. Thirdly, in terms of study trends, there is a yearly disparity of the words that are emerging from the academic paper between Korea and China. In Korea, the word 'analysis' showed a upward tendency, but in China, 'sports'. Fourthly, in terms of correlation, no significant differences were found between academic study of physical education in Korea and China. It was found that words closely related to research methods, such as 'method', 'literature', 'results' are correlative.

Conclusion: in point of the physical education academic study in Korea and China, subdivision of the study field showed the trend which has a diversity and an attribution of the words used in the study, Korean studies are approaching to a multi-disciplined research, Chinese studies appears to be developing through a detailed and specialized approach.

What tactical and technical comments do coaches make during sports matches? A qualitative analysis in netball

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Purpose: In sport an 'explosion' of information (Mayer-Schönberger and Cukier, 2013) has meant that coaches may not have the time or cognitive resources to integrate it effectively into their decision-making. Due to cognitive limitations, coaches may use this information to selectively reinforce their opinions, creating a conformational bias (Hughes and Franks, 2008). This phenomena could also be explained by research which suggested disconnect exists between the information provided by the 'sport scientist to coach', and subsequent 'coach to player' (William and Kendall, 2007) possibly due to a different foci. This suggests there is a need to analyse the coach-player communications during competition to determine their relationship to effective coach decision-making. Research has successfully captured and categorised the behaviours of volleyball coaches through systematic observation (Zetou, Amprasi, Micha, Iopoulou and Aggelousis, 2011). Further investigation is required to determine the detail within the tactical and technical instruction, with the aim of creating better alignment between the performance analyst data collected and actual coach requirements during a game.

Methods: This study conducted an analysis of coach's verbal conversations with players and other coaches during competition. Using inductive content analysis (Neuendorf.,2002; Krippendorff., 2004), with an independent researcher acting as a 'critical friend', themes and dimensions were extracted from audio recordings of six coaches' (ANZ Premiership netball) conversations during competition. This methodology created a model, which demonstrates the proportion and elements of technical and tactical conversations.

Results: Analysis of the transcribed recordings found that the coaches discussed the technical and tactical elements of the game 695 times, within five general dimensions; movement (38.4%), actions (23.9%), positioning (17.3%), possession outcomes (10.6%) and strategy (9.8%). Within these 5 dimensions there were 17 higher order themes including; movement timing, movement intensity, movement spatial, opposition movements, team positioning, player positioning, opposition actions, defending actions, attacking actions, centre pass, gains/losses, scoring, attack strategy, defensive strategy, errors, vision, and niggle. Within these 17 higher order themes, there were 56 lower order themes, which the 695 raw data themes/comments were grouped into.

Conclusion: The six netball coaches analysed discussed movement more than any other technical or tactical dimension. These results will be discussed in relation to the latest performance analysis literature and recommendations will be made for future research.

Technical and tactical based teaching models efficiency in ultimate frisbee, elementary school fifth class

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Purpose: Since the 1980s some reform models in Anglo-Saxon countries have set the goal of re-thinking the teaching of sportsgames. These reform models: the British Teaching Games for Understanding – TGfU (Bunker and Thorpe, 1982), the American Tactical Games Model - TGM (Mitchell et al., 1997), and the Australian Game Sence (Brooker et al., 2000) achieved a fundamental change in the methodology of teaching invasion sportsgames from technical to tactical base. Dozens of researches speaks about the positives of these models in the childrens motivation. But the efficiency of the reform models did not cause a real break-through in Physical education (Rink, 2010).

Methods: We examined two classes of fifth in a same elementary school. One class was learning Ultimate frisbee technical fundamentals like catching and throwing the disc. Other class was learning the tactical minimums of Ultimate during 2:1 and 2:2 situated games with a ball. First class started to play complex Ultimate game after the 10th lesson. Second class met flying disc after their 10th lesson. Before and after the 20 lesson cycle member of the two classes played Ultimate frisbee games with ball in 4:4 teams (mixed, 2boys and 2girls in each team). After the 20 lessons all of the kids throwed discs with forehand technic to a target from 12 meters.
We hyphothesized first class performs better results in throwing technic. We hypothesized second class performs better results in efficiency of decision-making during the game. As indicator of decision-making all the throws, all the catched throws, all the droped throwes and all the interceptions were counted, and we calculated percentages.

Results: Both hyphothesis came down. During the throwing technic task the kids from first class performed 28% efficiency on target. Kids from second class (who were training less!) performed 28,46% efficiency on the 12 meters away target.
During the 4on4 games the first class' catched throws/all throws rate was 65% before the first lesson and 75% after the 20th lesson. The second class (which trained more tactics) showed 67% at the beginning and 61% at the end of the research. We did not measure any significant differences by the droped throws or interceptions.

Conclusion: The examination method of efficiency in invasion sportgames caused lot of disputation. We are sure that the GPAI and TSAP calculations are not really valid in Ultimate frisbee, due the special rules of Ultimate (e.g. just pass is allowed by the handler).
During the 20 lesson cycle and at the final games after the research we discovered a new point of view of the efficiency, which could be the main purpose of the next research. In the second class (tactical model) the corporation was better and better between the players during the 4on4 games. In the first class (technical model) the kids

just recognised which players are dominant and many times only 2 players performed the good result during the games and the other 2 players withdrawed theirselves from the 4on4 games in offence. If next research confirm this new perception, maybe it can cause a revolution in Ultimate frisbee teaching.

Analysis of the tactical performance factors in elite beach volleyball

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Purpose: To analyze the tactical performance factors of counterattack in the elite senior category of beach volleyball.

Methods: Data were obtained from the recording of 34 matches played from 28 July to 6 August 2017 in the city of Vienna. The observed variables were related to the counterattack in elite players of beach volleyball. The free software used to register the variables was LongoMatch (v.1.3). Subsequently, the data were processed with the SPSS statistical package (V.22).

Results: There are significant differences in the attacks of the blocker between points 15-21 of the set and in the effectiveness of the defenders and blockers depending on whether they play the ball in the natural side or not. Moreover, defenders present differences in the type of attack (hard or feint) depending on the time of the set.

Conclusions: Learning about the dynamics of the tactical aspects of the counterattack in beach volleyball is necessary to understand the development of the competition.

The analysis of technical characteristics of Chinese elite women 100m backstroke swimmers

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Introduction: The aim of the study was analyzing the technical characteristic of Chinese elite female 100m backstroke swimmers.

Methods: Recording female 100m backstroke finals of 2014, 2015, 2016 Chinese Championships by 6 cameras and analyzed the kinematics parameters of top 8 female swimmers' 4 phases (start, swim, turning, sprint) by Swim Race Microsoft and SPSS Microsoft.

Results: The average speed of dolphin-kick in start phase of the women's 100m backstroke final swimmers from 2014 to 2016 Chinese Championships was 2.50±0.22m/s and there were significant differences among them ($p=0.023,0.034,0.013<0.05$). In swim phase, the average stroke frequency of top 8 swimmers from 2014 to 2016 was 45.35±2.21 strokes within a minute, showing significant differences ($p=0.017,0.029,0.014<0.05$), and the average range of the stroke was 2.06±0.11 meters per stroke, showing significant differences ($p=0.007,0.004,0.018<0.05$). In turning phase, the average turning time (5m before the wall and 10m after the turning) of top 8 swimmers from 2014 to 2016 was 8.61±0.16m/s, showing significant differences ($p=0.034, 0.022, 0.016<0.05$). In sprint phase, the average speed of last 5m of top 8 swimmers from 2014 to 2016 was 1.62±0.07m/s, and there were no significant differences among them ($p=0.765, 0.273, 0.090>0.05$).

Conclusion: Start phase: The Chinese elite female 100m backstroke swimmer's dolphin kick have been improved. Swim phase: The data shows that Chinese elite female 100m backstroke swimmers have the technical characteristics of reducing the frequency of the stroke and increasing the range of the stroke. Swimmers' body position is higher and in the process of rotation from the hip joint, driving the body and shoulder rotation, the arm come out of the water in the end. About breathing, the breathing frequency of swimmer was about 3-4 strokes (single arm rowing) to breathe once. Turning phase: Compared to 2014 Chinese championship, the top 8 swimmers of female 100m backstroke use less time of turning in 2016.The speed of the swimmers' 5m before turning had a small increase, and the speed of the swimmers to speed up to the edge is better. When the body turns, the leg will have a small dolphin kick movement. Sprint phase: When the swimmers touch the wall, the side arm of the wall throws out of the water. At the same time, the swimmer works with the waist, and the head backs up, forming the body position of the back bow, touching the wall to the side.

Technical and tactical profile of the wrlist TOP10 judokas

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Purpose: The information obtained from the analysis of the judo competition allows a better identification of the technical and tactical preparation of the athletes, which may increase their efficiency (Adam et al., 2018). In fact, there is a large number of literature on high-level technical and tactical issues (Brito, et al., 2017; Dudeniene, et al., 2017; Villapol et al., 2017). However, despite the fact that the effect of weight category and gender on judo competition is determinant for tactical technical study (Almansba et al., 2008), no work has been found on the general technical characteristics of a particular category. Therefore, the main objective of this study is to analyze the technical profile of the 10 best judokas of the World Ranking List (WRL) of the International Judo Federation (IJF) in the category of less than 63 kilograms.

Methods: 197 sequences were analysed (taking advantage) of the TOP10 WRL at -63 kg, where the variables were extracted: (a) laterality of the tori and uke (right, left or undefined); (b) position of the foot of the tori and uke (neutral, right front or left front); (c) sequence time; (d) displacement before scoring (traction, push, circular, reaction action); (e) type of technique (legs, arms, hip or sacrifice); (f) foot or ground technique; (g) lateral entry technique (right or left); (h) direction of uke drop (front, back, right, left); (i) standing score, ground score or penalty score.

Results: The results obtained show that 16.2% of the TOP10 are right-handed and 83.8% left-handed, despite the fact that the position of the feet is 32.5% with the right foot in front and 67.5% with the left. The average time of the effective sequences is 24.3±16.04 seconds. The techniques with which they score highest are uchi-mata (16.8%), o-uchi-gari (10.7%) and ippon-seio-nage (8.6%). With a previous displacement of traction (25.4%), followed by push (19.3%) and circular (15.7%). The entry directions are 63.5% from the left and 18.3% from the right, causing falls to uke in a backward direction (28.1%) and the left (20.9%). The percentages of standing scores are: 45.7% of wazari, 40.6% of sanctions and 13.7% of ippon. The advantages of passivity were the most common (13.2%).

Conclusions: The best judokas of -63 kg have a technical and tactical profile of left-handed, are effective with leg techniques, where they generate mainly previous displacements with traction and shoot down the opponents backwards.

New modified anterior cruciate ligament and anterolateral ligament reconstruction technique

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Purpose: The anterior cruciate ligament (ACL) is one of the most significant structures that maintain knee-joint stability by limiting rotation and restricting anterior tibial translation on the femur. It is the most frequently injured knee ligament in athletes participating in contact and pivot sports. If athletes want to continue at the same level they are advised to undergo ACL reconstruction. Despite all technical improvements, some patients continue to have rotational instability postoperatively. The aim of our new technique is to achieve anatomical ACL reconstruction, rotational stability, strong graft fixation and to decrease bone removal.

Surgical technique: The patient is supine with an injured leg in a leg holder and knee flexed at 90°. Head of the fibula, the Gerdy tubercule, lateral epicondyle of femur, points for drilling ALL tunnels and the position of arthroscopic portals are marked. Two convergent tunnels on the tibia are created and connected, a guide wire is positioned proximal and posterior to lateral epicondyle. Suture is tied from tibial tunnels to guide wire to check the isometry of the ALL graft. Two hamstrings tendons are harvested to make a four strand graft (tripled ST and one strand GR). The ACL TightRope is combined with four strand graft. The femoral ACL tunnel is made with „outside in“ technique and is positioned intraarticularly at the footprint of the native ACL on lateral femoral condyle. The tibial tunnel is positioned at the tibial ACL remnant. The tibial ACL tunnel drilling is performed with a RetroDrill to decrease bone removal. The ACL remnant is always preserved. When the ACL graft placement is confirmed interference screw is put into femoral tunnel. During screw positioning knee is at the 30° of knee flexion. G tendon is passed through ALL tunnels and tied with sutures from the femoral tunnel with knee in full extension. At the end, if necessary, the ACL graft is tensioned with TightRope.

Discussion: Earlier combined ACL reconstruction and nonanatomic extra-articular lateral tenodesis had good rotational control, but limited range of motion and poor clinical results. Latest described surgical technique differentiated from previously published extra-articular lateral tenodesis and has better clinical results for now (Sonnery-Cottet et al., 2015).

Conclusion: Possible benefits from our new modified technique is decreased bone removal at the tibial side and more precise tensioning of the graft.

Analysing the process of creating unstable situations in football

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Purpose: For a complex sport where players use off-the-ball positioning to gain an advantage over their opponents it may be difficult to discern periods of stability and instability and furthermore which actions are responsible for changes in the system state. Whilst previous papers have attempted to identify perturbations, there were no operational definitions for stability, instability or perturbations with consequent subjectivity for determining these events. The main aim of this study was to identify the process of creating unstable situations in football.

Method: This study established operational definitions for 5 Perturbation chances (Midfield line break, Zone 14, Wide area, Counter attack and Set piece) when a team had an advantage and Perturbation attempts (Attempt- short pass, long pass, dribble or skill, quick movement, cross, shot and No attempt- lost possession, switch chance, out of chance, time wasting). Also, unstable situations were categorised into 5 situations, deemed unstable (Penalty box possession, Counter attack, Ratio attacking to defending player, Successful cross and Shot).

Result: A total of 81.5 perturbation chances occurred, resulting in 44.5 attempts and 23.5 successes (unstable situations) per team per match. Of 81.5 perturbation chances, 31.1% were wide area chances (M= 28.5), which was the highest, but led only to 14 attempts and 7 unstable situations whilst set piece chance had great efficiency (6 chances led to 6 attempts and 4 unstable situations). A team created more unstable situations by approaching penalty area (M= 9.5) than cross (M= 6) or counter attack (M= 5.5).

Conclusion: Analysing the whole process of perturbations takes more holistic view and dynamically considers the sequential dependency of different events. This study seeks to adopt a methodology that facilitates the discovery of perturbations, which can be more idiographic than previous nomothetic approaches.

Does shooting rhythm have an influence upon shooting accuracy in biathlon?

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Purpose: Nitzsche (1998, cited in Sattlecker *et al.*, 2007) stated that Shooting Rhythm is a key influence upon Shooting Accuracy in biathlon, with Augustín and Moravec's (2002) further support this statement. With these researchers examining shooting in a controlled environment, the influence of Shooting Rhythm has never been investigated in a competition setting. Investigating the influence of Shooting Rhythm during competition would increase the depth of knowledge within this area. Analysing shooting during competition in biathlon is also seen as the ideal method, as all influencing variables would be present (Sattlecker *et al.*, 2007). The purpose of this study was to investigate whether Shooting Rhythm have an influence upon Shooting Accuracy in elite biathlon competition.

Methods: 104 elite male biathletes competing in the Individual 20km in Oestersund during the 2015/16 Biathlon World Cup were used for the study. Hand-based notational analysis was utilised for the study. In order to assess the Shooting Rhythm of the biathletes, a system was specifically designed for this study. The influence of Shooting Rhythm upon Shooting Accuracy would be analysed using the Spearman's Correlations test. The KPIs can be seen in Table 1. The shooting is performed in two positions, prone and standing, and the correlation will also be calculated for each position.

Table 1. KPI Definitions.

Shooting Accuracy	Number of targets hit out of the 20 targets required (Lakie, 2010; IBU, nd.).
Shooting Rhythm	Time taken between each shot, i.e. 1st-2nd, 2nd-3rd etc. and the similarity of the time between shots. (Augustín & Moravec, 2002).

Results: The correlation between Shooting Rhythm and Shooting Accuracy was 0.516. For prone shooting the correlation was 0.506 and for standing shooting the correlation was 0.502. This indicates a direct moderate correlation between Shooting Rhythm and Shooting Accuracy. The correlation between Shooting Rhythm and Shooting Accuracy was statistically significant with $P<0.01$.

Conclusion: The results of this study indicate that Shooting Rhythm has a positive influence upon Shooting Accuracy in biathlon. It would therefore be beneficial for biathletes to shoot with a "good" Shooting Rhythm in order to achieve the desired shooting result. Further research should consider investigating the influence of Shooting Rhythm over a whole season and for all the various race types in biathlon. Research should also look to establish an optimal rhythm in biathlon to enhance accuracy and be as time efficient as possible across the two shooting positions.

An analysis of three-way attacks in male collegiate volleyball

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Purpose: The purpose of this research is to clarify the factors influenced the results of three-way attacks in volleyball. We focused on the relationship between the results of three-way attacks and the component skills of three-way attacks, such as receive, toss, attack and so on.

Methods: The data was collected from regular matches of Japanese regional collegiate competitions. We collected 985 attacks in 18 sets of 6 matches. We analyzed component skills of three-way attacks, opponent block patterns and attack results. Component skills of three-way Attacks were categorized as follows: 1) receive position, 2) receive quality, 3) toss position, 4) toss quality, 5) toss type, 6) attack position, 7) attack type, 8) attack strength and 9) combination. We used mathematical quantification theory class II to clarify the degree of influence between the results of three-way attacks and the opponent block pattern.

Results: As a result, attack position and opponent block pattern was the most influenced factors against the results of three-way attacks. (Fig 1).

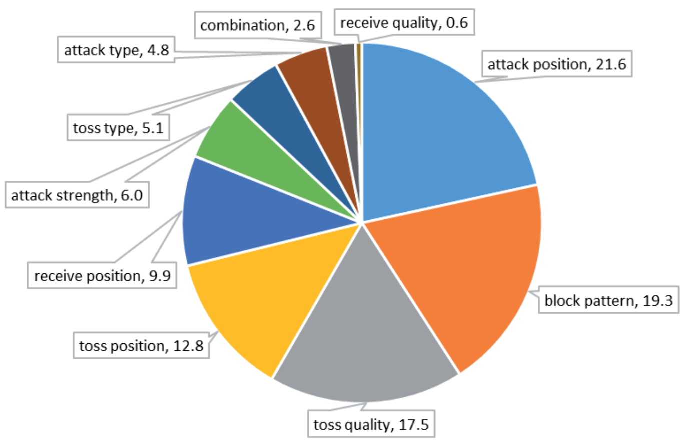

Fig 1. The ratio of items affecting success or failure of attack

Conclusion: Back attacks was most effective in the attack position. The most effective in the block pattern was the state of one person joined late and one did not participate. Those results showed that important to back attack and to make the block bad.
Attack position (21.6%) was the most influenced factors to attack results. It is considered that the diversity of back attack was affecting the score.

Different styles in the performance of technique clear hip circle to handstand on the uneven bars – a case study

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Purpose: The aim of this case study was to determine the differences in the performance technique of the Clear hip circle to handstand on the uneven bars (KOVT), based on the kinematic analysis of the reference points of female gymnasts who participated on the final of the 39th and 40th World Cup in Maribor (SLO). The differences were determined based on the value of the trajectory, the angles, and angular velocities of the selected kinematic parameters.

Methods: The experiment included a kinematic analysis as the basic method, with statistical analysis support. The sample included 13 female gymnasts. In total 15 successful KOVTs were performed. Data processing followed the standards of the Ariel Performance 3D Video System (Ariel Dynamics Inc., San Diego, CA) for kinematic analysis, with 16 reference points through several phases: frame grabbing, digitalization of the recorded videos and the reference points of the body, transforming the three-dimensional space, data filtering and the calculation of kinematic quantities. The Ethics Committee of the Faculty of Sport, University of Ljubljana approved all experimental procedures according to the revised Declaration of Helsinki. The criterion was the successful KOVT performance in the World Cup Finals. The sample of reference points was presented as the center of the shoulder joint and body center of gravity. Based on the sample of the reference points, the kinematic parameters of angle and angular velocity of the hip and shoulder joints were calculated, followed by statistical data processing.

Results: Based on the analysis of angular graphs and the angular velocity of movement of the hip and shoulder joints, three different ways of starting the first phase and entering the second phase of movement of the KOVT were noted. The kinematic analysis indicated that there are three different styles in the technique of execution of the Clear hip circle to handstand at the World Cups: 1) The first phase is carried out with the stretched body of little significance for the flexion of the hip during the entire execution (four competitors); 2) Extended body or at the very beginning of the movement of the shoulders backwards there is a short and quick extension of the hip joint - (extension in the hip joint with peripheral support - the legs stand visibly, and the hips are lowered - six competitors); 3) Hyperextension in the hip joint (three competitors).

Conclusions: These three styles of the performance do not affect the successful performance the technique. The style of a technique depends on the individual characteristics of the gymnasts.

Comparing ball speed and ball spin of tennis serve between game situation and practice in collegiate male tennis players

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Purpose: We introduced new technology system of tracking ball movement in tennis, called Trackman tennis radar (Trackman Inc., Denmark). The accuracy of Trackman data was verified about ball speed and ball spin (Murakami et al., 2016).
The purpose of this study was to investigate ball speed and ball spin of tennis serve of male collegiate players. We focused on comparing those data between game situation and practice.

Methods: Participants of this study was 14 male collegiate tennis players. They were divided into two groups: high ranked players (HRP) and low ranked players (LRP). Trackman tennis radar was used to collect data of experimental matches by participants and practice sessions.

Results: Regardless of groups, ball speed of 1st serve and 2nd serve in practice session was significantly faster than in game situation. Ball spin of 1st serve in game situation was significantly higher than in practice session. HRP showed that ball spin of 2nd serve in game situation was significantly lower than in practice session. LRP also showed no significant differences in ball spin of 2nd serve between game situation and practice session (Fig 1).

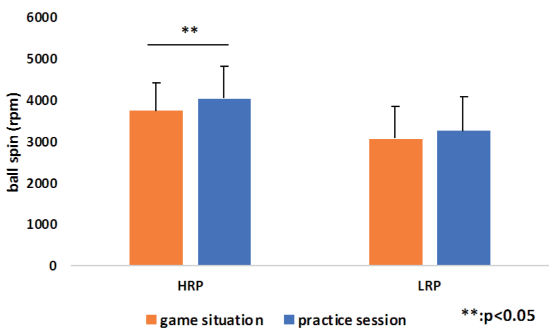

Fig 1. Comparing ball spin of 2nd serve between game situation and practice session

Conclusion

Players selected safety serve to avoid errors in game situation. It also indicated that players showed slower swing speed on 2nd serve in game situation rather than practice session. It is considered they had skill problem on 2nd serve.

Analysis of elite athletes and teams

Differences in situational efficiency of the match winners in 2015 Australian Open and Roland Garros

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ABSTRACT
The aim of this research is to determine the differences in parameters of situational efficiency in the middle and the final part of a tennis point between players who won matches at the 2015 Australian Open and Roland Garros. The study includes analysis of statistics for players who won in 103 tennis matches played in the main part of the Australian Open tournament and 126 tennis matches played at Roland Garros, for which official statistical data was available. For the purpose of this research, analysis was conducted by using the available statistical indicators for played ATP matches of tennis players in the main part of the 2015 Australian Open and Roland Garros tournaments. The data was downloaded from the official tournament websites and it exclusively refers to the game during the middle and the final part of a tennis point. The following parameters of descriptive statistics were calculated for each variable: arithmetic mean (AM), minimum value (Min), maximum value (Max) and standard deviation (SD). The above-mentioned parameters were calculated for the winners of tennis matches played at the 2015 Australian Open and Roland Garros. The differences in parameters of situational efficiency for the middle and final part of a tennis point between the players who won matches at the mentioned tournaments were determined by using the independent samples t-test.
The results of this research indicated statistical differences for groundstroke shots in the following variables: forehand winners ($p<0,00$), backhand winners ($p<0,00$), forehand forced errors ($p<0,00$) and backhand forced errors ($p<0,00$). Analysis for drop shots demonstrated statistical differences ($p<0,00$) in variables of forehand winners, backhand winners, forehand unforced errors and backhand unforced errors. Likewise, there were statistical differences in variables of forehand forced errors and backhand forced errors for passing shots. Overhead shots also indicated statistical differences in forehand winners ($p<0,01$), while volley shots demonstrated statistical differences in variables of forehand winners ($p<0,01$) and backhand winners ($p<0,03$).
The obtained results allow the conclusion that tennis players who won matches at the mentioned tournaments statistically differ in a substantial number of variables. The main reason for such differences are different tennis court surfaces on which the two compared tournaments are played, which therefore implies different tactical variants of playing points for the players. The strongest differences are represented in groundstroke shots, which results in the conclusion that clay court surfaces require players to use an aggressive game tactics from the baseline, including powerful topspin shots and drop shots, whereas hard court surfaces require tennis players to base their game primarily from the baseline, however, with somewhat straighter shots due to less friction of the tennis court surface. The results of this research can be very valuable in terms of better

understanding the diversity of the game on different court surfaces, as well as for assisting in preparing tennis players for competing on hard or clay court surfaces.

Key words: tennis, analysis, situational efficiency, men tennis singles

Introduction

Aside from the opening shots, the middle and the final part of a tennis point can be described as playing the main role in relation to the end result of a tennis match. As much attention has been dedicated to precisely these segments of the game, it is for that reason that studying differences in parameters of situational efficiency in the middle and the final part of a tennis point was chosen as the aim of this research. When playing on clay court surfaces, the tennis ball is in the game for much longer during points, gems and in the entire set, there are substantially more points played in gems, as well as points and gems are of longer duration. As playing on hard court surfaces demonstrates quite the opposite, clay court surfaces include a significantly higher number of played gems during one hour of playing (Barbaros Tudor, Matković and Novak, 2007). Hence, due to different court surfaces on which a tennis match is played, players evidently apply various tactical variants in their game. Considering the dynamic and complexity of tennis, which is characterized by a large number of movements and shots, it is necessary to compare the differences between those segments of the game. This paper also includes prior research that assisted this study, as well as it might be of help in future research of the efficiency of individual game elements or shots in tennis.

Barbaros Tudor, Zečić and Matković (2014) published a research that aimed at determining the differences in parameters of competitive efficiency in tennis between identical Grand Slam tournaments played in 2010 and 2011. The mentioned research included three Grand Slam competitions: Roland Garros, Wimbledon and US Open. The smallest differences were determined for the Roland Garros Grand Slam tournament. In general, all three tennis competitions showed a reduction in the speed of the first and second service in 2011, which most likely indicates that the players' game philosophy started focusing on other segments of the service besides its strength of performance in order to actively start the point. The Roland Garros Grand Slam in 2011 showed an increase in the number of unforced errors, while the grass court surface in Wimbledon and the hard court surface in US Open indicated a statistically significant reduction in the number of unforced errors and winners. Their results in a certain manner imply that tennis on fast tennis court surfaces started changing towards a somewhat safer way of playing, with less risk in the starting and middle part of the point, whereas tennis on slow court surfaces started evolving towards a more aggressive game philosophy in the middle part of the point.

Reid, McMurtrie and Crespo (2010) state in their research the importance of winners after the second service, as well as winners after second service returns as the most relevant variables affecting the rank position of male tennis players on the ATP list.

Barbaros Tudor, Matković and Novak (2007) state in their paper that tennis court surfaces also affect doubles games and cause changes in the space-time parameters of their game. Likewise, they indicate that the hard court surface allows for a somewhat quicker and lower bounce, which results in the player having been put faster in a unfavourable position, i.e. due to a greater time pressure, points end faster (therefore winners and errors are more common). Consequently, it can be concluded that tennis can somewhat vary with regard to the court surface. On clay court surfaces, players mostly perform powerful shots with a lot of rotation, in order to remove the opposing player away from the baseline as far as possible, as well as to be as precise as possible in opening up space for playing during diagonal shots. Whereas on hard court surfaces, players mostly

use shots with less rotation as the court surface itself is sliding and does not accept ball rotation.
As top-level tennis players are always oriented on winning their service gem and attempt at possibly winning their opponent's service gem, the opening shots in tennis (service and return) are of extreme importance and are very well trained in top tennis players. In case a player succeeds in neutralizing his opponent's service, the point is then decided by a quality played middle and final part of the point. For that reason, the aim of this research is to determine the differences in parameters of situational efficiency in the middle and the final part of a tennis point, and namely between players who won matches at the 2015 Australian Open and Roland Garros.

Methods
For the purpose of this research, analysis was conducted by using the available statistical indicators for played ATP matches of tennis players in the main part of the 2015 Australian Open and Roland Garros tournaments. The data was downloaded from the official tournament websites and it exclusively refers to the game during the middle and the final part of a tennis point. The following parameters of descriptive statistics were calculated for each variable: arithmetic mean (AM), minimum value (Min), maximum value (Max) and standard deviation (SD). The above-mentioned parameters were calculated for players who won tennis matches played at the 2015 Australian Open and Roland Garros. The differences in parameters of situational efficiency for the middle and final part of a tennis point between the players who won the matches at the mentioned tournaments were determined by using the independent samples t-test.

Sample of examinees
The sample used in this research includes statistical data for players who won in 103 tennis matches played at the Australian Open and 126 tennis matches played at Roland Garros. For each match, statistical analysis was conducted for the first three played sets during the first, second, third and fourth round, as well as in the quarterfinals, semi-finals and the final.

Sample of variables
The sample of variables that were observed in this research includes a total of 30 statistical parameters which are officially recorded by the International Tennis Federation in both Grand Slam tournaments. These parameters are divided into five categories of shots (drop shots, groundstroke shots, passing shots, overhead shots and volley shots), that are further divided into the following variables: forehand winners, backhand winners, forehand forced errors, backhand forced errors, forehand unforced errors and backhand unforced errors.

Results
Statistical analysis of the obtained data provided results that are represented in Table 1. The mentioned results demonstrate the differences in parameters of situational efficiency in the middle and the final part of a tennis point between players who won matches at the 2015 Australian Open and Roland Garros. The demonstrated table indicates results with regard to different types of shots – groundstroke shots, drop shots, passing shots, overhead shots and volley shots.

Table 1. Descriptive statistical parameters (AS, SD) and statistically significant differences between players who won and lost in variables for evaluating the middle and final part of a point

VARIABLES	GROUNDSTROKE SHOTS		DROP SHOTS		PASSING SHOTS		OVERHEAD SHOTS		VOLLEY SHOTS	
	AS± SD	AS± SD	AS± SD	AS± SD	AS± SD	AS± SD	AS± SD	**AS± SD**	**AS± SD**	**AS± SD**
	RG	**AO**	**RG**	**AO**	**RG**	**AO**	**RG**	**AO**	**RG**	**AO**
FOREHAND WINNERS	4,225* ±2,555	3,350* ±2,243	0,256* ±0,568	0,101* ±0,350	0,503 ±0,825	0,515 ±0,769	0,532* ±0,772	0,403* ±0,662	0,660* ±0,844	0,812* ±1,007
BACKHAND WINNERS	1,582* ±1,431	1,074* ±1,155	0,344* ±0,677	0,074* ±0,291	0,516 ±0,825	0,488 ±0,799	0,002 ±0,047	0,013 ±0,115	0,548* ±0,873	0,427* ±0,744
FOREHAND FORCED ERRORS	2,234* ±1,761	1,385* ±1,340	0,015 ±0,123	0,005 ±0,073	0,409* ±0,670	0,610* ±0,853	0,018 ±0,131	0,011 ±0,103	0,127 ±0,359	0,127 ±0,386
BACKHAND FORCED ERRORS	1,814* ±1,687	0,936* ±1,107	0,020 ±0,140	0,005 ±0,073	0,510* ±0,869	0,878* ±1,077	0,004 ±0,066	0,005 ±0,073	0,156 ±0,454	0,218 ±0,521
FOREHAND UNFORCED ERRORS	4,138 ±2,598	4,358 ±2,942	0,142* ±0,385	0,061* ±0,251	0,033 ±0,178	0,053 ±0,236	0,059 ±0,254	0,053 ±0,224	0,107 ±0,337	0,133 ±0,347
BACKHAND UNFORCED ERRORS	3,368 ±2,219	3,162 ±2,298	0,241* ±0,533	0,064* ±0,244	0,077 ±0,282	0,088 ±0,318	0,000 ±0,000	0,000 ±0,000	0,125 ±0,386	0,111 ±0,355

*Statistical difference (p<.01); ** Statistical difference (p<.05)

The results obtained in this research indicate that players who won matches at Roland Garros differ from the players who won matches at Australian Open in a substantial number of variables. For groundstroke shots, the most noticeable statistically significant differences were found in forehand winners (RG 4,225*±2,55, AO 3,350*±2,243), backhand winners (RG 1,582*±1,431, AO 1,074*±1,155), forehand forced errors (RG 2,234*±1,761, AO 1,385*±1,340) and backhand forced errors (RG 1,814*±1,687, AO 0,936*±1,107). In addition, this research demonstrated that drop shots also showed statistically significant differences in the following four variables: forehand winners (RG 0,256*±0,568, AO 0,101*±0,350), backhand winners (0,344*±0,677, AO 0,074*±0,291), forehand unforced errors (RG 0,142*±0,385, AO 0,061*±0,251) and backhand unforced errors (RG 0,241*±0,533, AO 0,064*±0,244). The results further showed that there were two variables with statistically significant differences for passing shots, namely in forehand forced errors and backhand forced errors. Overhead shots only demonstrated one variable with a statistically significant difference in forehand winners, while volley shots indicated statistically significant differences in forehand winners and backhand winners.

Discussion

The obtained results indicate that the players who won matches at Roland Garros differ from the players who won matches at Australian Open in four parameters for groundstroke shots. Players who won matches at Roland Garros had an average of 4,225 forehand winners, while at Australian Open players showed an average of 3,350 forehand winners. Likewise, players at Roland Garros had slightly more backhand winners (1,582) than those at Australian Open (1,074), however, it can also be noticed that there were substantially more backhand forced errors at Roland Garros when compared to Australian Open (1,814/0,936).
As for drop shots, there is a statistically significant difference in the variables of forehand and backhand winners. Thus at Roland Garros, the players who won matches averagely won more both forehand (0,256) and backhand winners (0,344) than it was the case with

players at Australian Open, where forehand shots resulted in 0,101 winners, while there were 0,074 backhand winners. It can be observed that players had different tactical approaches for playing at the two mentioned Grand Slam tournaments. At Roland Garros, the players who won matches more often used drop shots, as they base their game on the baseline, or even quite far away behind it, in order to return topspin shots that are dominant on that type of court surface. Winners at Roland Garros committed more forehand and backhand unforced errors when compared with the players who won matches at Australian Open, which is reasonable, as at Roland Garros drops shots were more often used, which also increases the possibility of making an error. In terms of passing shots, players who won matches at Roland Garros committed 0,409 forehand forced errors and 0,510 backhand forced errors, whereas at Australian Open there were 0,610 forehand forced errors and 0,878 backhand forced errors. The above-mentioned data indicates that players were making more unforced errors during passing shots at Australian Open, which once again confirms the effect of the tennis court surface on the game in tennis. As the slowest among different court surfaces, the clay court surface leaves some more time for players to prepare for performing a shot, which consequently results in making less unforced errors. On the other hand, the hard court surface puts the players in a much more defensive and unfavourable position during the performance of passing shots, as it does not allow much time for quality performance of a passing shot due to the speed and lower bounce of the oncoming tennis ball. In addition, it is noticeable that players in both tournaments committed more forced errors with their backhand, which once again reaffirms that players more often attack on the backhand side of their opponent, which is usually the weaker playing side for most tennis players. The statistics for overhead shots showed that the only statistically significant difference referred to the variable of forehand winners. At Roland Garros there were 0,532 successful forehand winners, while at Australian Open there were 0,403 such points. The remaining variables for overhead shots indicated no statistically significant differences, however, it should be stated that players demonstrated a much higher number of winners than errors during overhead shots in both tournaments. The final two statistically significant differences refer to volley shots and to the variables of forehand and backhand winners. At Roland Garros there were 0,660 successful forehand winners and 0,548 backhand winners, while at Australian Open players performed 0,812 forehand winners and 0,427 backhand winners. It is evident that players demonstrate different reactions in defensive situations in these two tennis tournaments. As there were more backhand winners from volley shots performed at Roland Garros when compared to Australian Open, it can be concluded that at Roland Garros players more often attempt to win a point on the backhand side of their opponent in a situation when the opponent is at the net, which thus gives the player at the net the opportunity to win more points with the backhand volley shot. The situation is reversed at Australian Open, where players attempt to win points on the forehand side when their opponent is at the net, which then allows the possibility of scoring more winners with the forehand volley.

Conclusion

The above-mentioned results allow for the conclusion that players have a different approach to a tennis match in the two studied tournaments. This in turn implies that style and manner of playing also depend on the type of tennis court surface. It can be observed that players at Roland Garros statistically most differ in groundstroke shots when compared to Australian Open. At Roland Garros, players perform most winners with groundstroke shots, however, they also often successfully use drop shots. It is interesting that players at Australian Open demonstrated more volley forehand winners, whereas players at Roland Garros performed more winners with the backhand volley, which implies different tactical variants used by players in a defensive situation when their opponent is playing at the net. This further results in the conclusion that on clay court surfaces players should use the tactical option of an aggressive game from the baseline, with powerful topspin shots, and of using the front part of the playing court when the opponent in further away from the baseline. On the other hand, players at Australian Open should also base their game at the baseline, however, with somewhat straighter shots due to the faster court surface and lower bounce, during which they should pay attention not to increase their number of unforced errors (this could be observed as successfully implemented at the 2015 Australian Open). The obtained information can be useful for better understanding the varieties of tennis on different court surfaces, as well as for assisting in better preparation of tennis players for playing on hard or on clay court surfaces.

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Differences in motor abilities between football players of different positions

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ABSTRACT
The purpose of this study was to determine the differences between results of motor ability tests between football players of different positions. Twenty-two first-league football players participated in this study. Variables of 20 m sprint, long jump and different measures of vertical jumps on the Optojump platform were measured. Pearson's correlation coefficient showed the greatest correlation between variables Height CMJ and T flight CMJ (r= 0,91); Height SJ and Height CMJ (r= 0,92); Height SJ and T flight CMJ (r= 0,91 and; Height DJ and T flight DJ (r=1). Significant differences between players of different positions occurred in these variables: sprint 20m and T flight CMJ. Differences also occurred between wingers and strikers in variables Height CMJ and T flight CMJ. For further research it is necessary to expand the sample with players from different clubs.

Key words: optojump, speed, positions, vertical jump

Introduction
Football is one of the high-performances games in which players perform numerous actions and are in need of abilities like strength, power, speed, agility, balance, flexibility and endurance. One of the main goals of the soccer game is to minimize unknown variables to the smallest possible number (Jovanovic et al., 2011). The capability of football players to produce varied high speed actions is known to have an impact upon soccer match performance (Luhtanen et al., 2001). The football game itself has changed through time in terms of different demands of football game. Today, speed actions are necessary to be successful. High speed actions only contribute to 11% of total distance covered; high- speed movements constitute the more crucial moments of the game and contribute directly to winning possession of the ball and to the scoring or conceding of goals (Bangsbo, 1994). Football players spend approximately 70% of total time at low speed zone, but during the game there are 150-250 high intensity actions (Bangsbo et al., 2006). It is not enough to train each football player the same, because each player's position has a variety of demands that is perceived in the morphology of the player. Goalkeepers are the tallest and the heaviest players in the team. They are also the slowest players in the team in terms of sprinting ability over 10 and 20 meters. Attackers are the quickest players in the team when looking at sprint values over 5, 10, and 20 meters. There are differences between attackers and defenders when measuring vertical jump height by squat jump (Sporiš et al., 2009). Goalkeepers are able to perform better on explosive power tests (squat jump and countermovement jump) than players in the field. Midfielders are superior in relative oxygen consumption, maximal heart rate, maximal running speed, and blood lactate than defenders and attackers. This leads to indication of the different physical demands of different playing positions in football (Bloomfield et al., 2007).

The purpose of this study was to determine differences between results of motor ability tests by different player's positions in football.

Methods

Twenty-two professional football players (aged 22,2±2,3) from Croatian League Division 1 were tested as part of their athletic training programme at the completion of their pre-season training period. The players were divided into positions in the field: 5 centre backs (1), 5 full backs (2), 3 centre midfielders (3), 5 wingers (4) and 4 strikers (5). The following motor ability variables were measured: sprint 20 m (sec) - 20m running expressed in sec, long jump (cm) - horizontal jump expressed in cm, Height CMJ (cm) - height of countermovement jump on Optojump platform expressed in cm, T flight CMJ (sec) - time spend in the air during countermovement jump on Optojump platform, Height SJ (cm) - height of squat jump on Optojump platform expressed in cm, T flight SJ (sec) - time spend in the air during squat jump on Optojump platform expressed in sec, Height DJ (cm) - height of drop jump on Optojump platform expressed in cm, T flight DJ (sec) - time spend in the air during drop jump on Optojump platform expressed in sec.
The results obtained were analyzed using Statistica 13. The normality of distribution was evaluated using Kolmogorov - Smirnov test (K-S). Descriptive statistics were calculated for all variables (Mean, standard deviation (SD), minimum (MIN) and maximum (MAX)). Pearson`s correlation coefficient was used to determine the correlation between all applied variables. Analysis of variance (with post – hoc Tukey test) was used to determine the differences between players' positions.

Results

Table 1. Descriptive statistic parameters for the total sample; Kolmogorov – Smirnov test for normality of distribution (K-S)

	N	Mean±SD	MIN	MAX	K-S
Sprint 20 m (sec)	22	2.93±0.10	2.81	3.21	0.18
Long jump (cm)	22	249.73±11.95	220.00	275.00	0.15
Height CMJ (cm)	22	38.91±3.93	30.20	46.70	0.08
T flight CMJ (sec)	22	0.56±0.03	0.51	0.62	0.09
Height SJ (cm)	22	38.19±3.73	30.80	44.60	0.07
T. flight SJ (sec)	22	0.53±0.12	0.00	0.60	0.37
Height DJ (cm)	22	35±5.85	22.20	49.60	0.11
T flight DJ (sec)	22	0.53±0.04	0.43	0.64	0.11
D = .0.28 for N = 22 (p<0.05)					

According to Kolmogorov-Smirnov test (Table 1) there were no differences between the observed and expected distributions (p<0.05) for all variables except for T flight SJ. Table 2 shows Pearson's correlation coefficients for the total sample between all the variables. The greatest correlation was noted between variables Height CMJ and T flight CMJ (r=0,91); Height SJ and Height CMJ (r=0,92); Height SJ and T flight CMJ (r=0,91); Height DJ and T flight DJ (r=1). Variable T flight CMJ shows correlation with three different expressions of explosive power. The correlations between CMJ variables and sprinting performance in football players were stronger for maximum speed (small to large effect sizes) than for acceleration (trivial to moderate sizes). The variable that produced the strongest correlation with acceleration was jump height and with maximum speed was peak power/weight. The squat and countermovement heights as well as squat jump relative power output were the only variables found to be significantly greater in fast players. In this study Variable T flight DJ showed correlation with almost all variables and strongest correlation was with Height DJ (r= 1).

Table 2. Pearson's correlation coefficient for the total sample between all the variables.

	Sprint 20 m (sec)	Long jump (cm)	Height CMJ (cm)	T flight CMJ (sec)	Height SJ (cm)	T flight SJ (sec)	Height DJ (cm)	T flight DJ (sec)
Sprint 20 m (sec)	1,00							
Long jump (cm)	0,02	1,00						
Height CMJ (cm)	-0,35	0,41	1,00					
T flight CMJ (sec)	-0,44	0,47	0,91	1,00				
Height SJ (cm)	-0,40	0,49	0,92	0,91	1,00			
T flight SJ (sec)	-0,10	0,15	0,14	0,11	0,20	1,00		
Height DJ (cm)	-0,15	0,53	0,59	0,51	0,67	0,17	1,00	
T flight DJ (sec)	-0,14	0,53	0,60	0,52	0,67	0,17	1,00	1,00

When observing the differences between the player's positions in the field, the differences appeared in Sprint 20m test between wingers and center backs (Figure 1). Wingers are faster than center backs and have better results in variable T flight CMJ (Figure 3). Differences are also shown between wingers and strikers in variables Height CMJ (Figure 2), T flight CMJ (Figure 3) and height SJ.

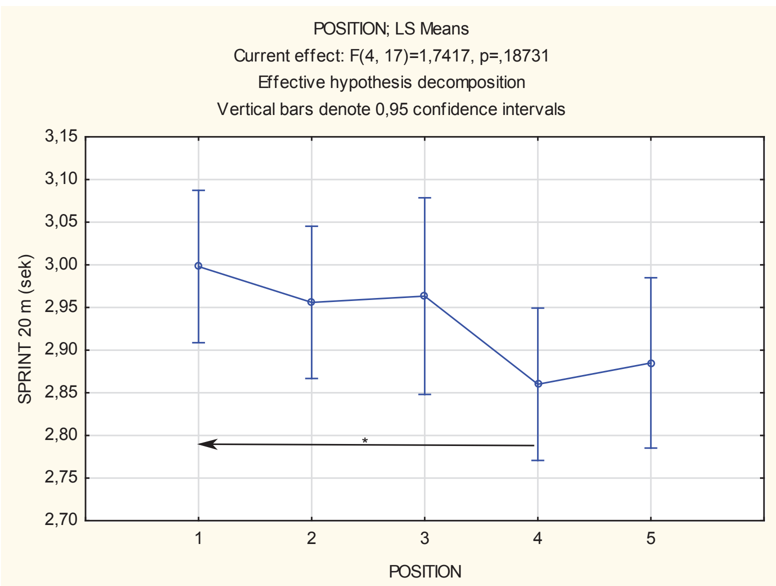

Figure 1. Differences in Sprint 20m test between player's positions (centre backs (1), full backs (2), centre midfielders (3), wingers (4) and strikers (5)). *significant difference according to post – hoc Tukey test.

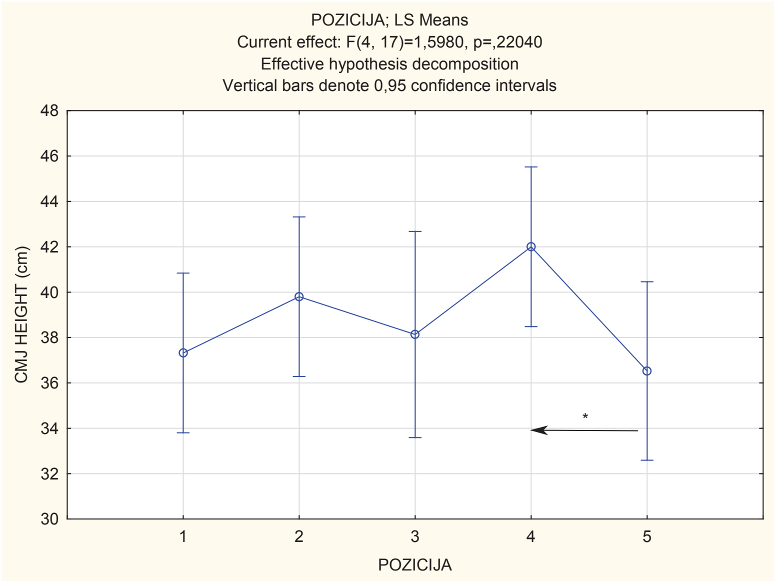

Figure 2. Differences in height CMJ test between player's positions (centre backs (1), full backs (2), centre midfielders (3), wingers (4) and strikers (5)). *significant difference according to post – hoc Tukey test.

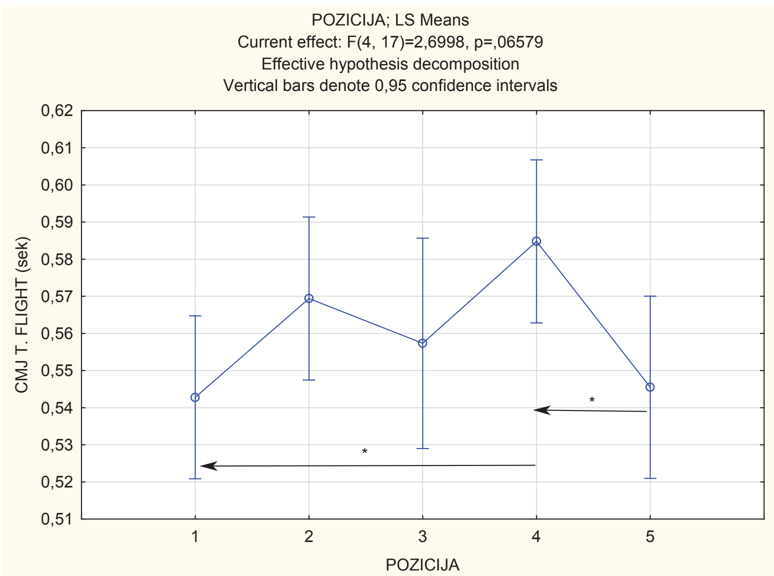

Figure 3. Differences in T flight CMJ test between player's positions (centre backs (1), full backs (2), centre midfielders (3), wingers (4) and strikers (5)). *significant difference according to post – hoc Tukey test.

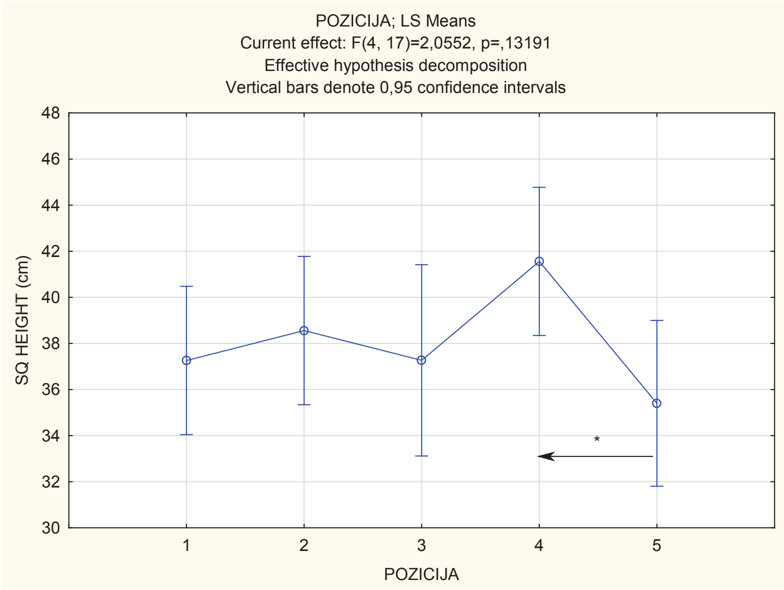

Figure 4. Differences in height SJ test between player's positions (centre backs (1), full backs (2), centre midfielders (3), wingers (4) and strikers (5)). *significant difference according to post – hoc Tukey test.

Discussion

Variable T flight CMJ showed correlation with three different expressions of explosive power. Similar results were noticed in Young et al. (2011). The variable that produced the strongest correlation with acceleration was jump height and with maximum speed was peak power/weight. Also Cronin & Hansen (2005) recommend the use of plyometric training involving countermovement and loaded jump-squat for enhancing sport speed in elite football players. The most probable reason for the differences between player's positions are the tactical demands of the football game itself.

Football progressively advances in the quest for quality and ability. In 1976 players were shorter, with less weight, higher max oxygen consumption and fat mass, approximately same values of maximal hart rate (Raven et al., 1976). Profile of successful football player was investigated (Mangine et al., 1990) and dynamic game with more speed and agility was described. These demands improved the game because in order to increase these abilities it is necessary to train them. In this study countermovement jump tests showed high correlation but also significantly correlated with two different manifests of explosive power (speed 20m and long jump) which was expected. It remains unclear why T flight CMJ correlates with other tests while the height of the same test doesn't. It was expected that height CMJ will correlate with the same variables since countermovement jump evaluates explosive force of the vertical jump. Authors state that player's position has a significant influence on the percentage of purposeful movement time spent sprinting, running, shuffling, skipping and standing still (Bloomfield et al., 2007). This is indirectly the reason of differences in motor abilities between player's positions because different game requirements form different types of players. It is known that forwards are 3–4% faster than midfielders (Haugen et al., 2012).

Conclusion

In this study wingers proved to be faster than center backs and had better results in countermovement jump. Also, wingers and strikers (forwards) have not shown statistical differences in running test. Football tactics is probably another reason of differences between player's positions. Attacking football has different demands than defensive football and future research should include tactics analysis when investigating differences between the player's positions.

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Differences in energetic capacity indicators between Croatian elite female and male sport dancers

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ABSTRACT
The aim of the paper was to examine the differences in ventilation and metabolic parameters of Croatian elite female and male Latin-American and standard sport dancers. The subject sample consisted of 19 professional Latin and standard sport dancers (8 women, average age 19.88±4.77 and 11 male, average age 20.85±4.28). All the subjects completed an incremental treadmill test (ITT). ITT is a standard test to evaluate aerobic and anaerobic capacity.

Statistically significant differences between male and female dancers were identified in as many as 11 variables (F1Brzmax, F1BrzVT, F1RVO2, F1RVO2VT, F1VEmax, F1VO2, F1VO2/HR, F1VO2VT, F1VTmax, FFEV1, FFEV1%, FFVK). The lower values of oxygen uptake between female and male dancers might be explained by some factors that influence the female endurance, and they include amount of fat, heart size, as well as estrogen and progesterone levels at different phases of a menstrual cycle, which notably influence cardio-vascular system (Šalaj, 2009). The average age of the dancing partners should be taken into account as well, since the age category of the dance couple is determined regarding the age of the older dancer (who is usually the male) and the particular ventilating parameters do not reach their maximum potential in younger dancers, due to their ongoing development.

The results show that it is extremely important to have an individual approach in defining energy components of the dance couple and to define precisely the training process parameters (intensity and volume). Similarly, one of the key factors for the success of a dance couple could also involve considering gender differences when planning endurance training. Only the above-mentioned approach in dance sport couples' training in Croatia can contribute to its development and to achieving top European and world level results.

Key words: oxygen uptake, ITT, individual approach

Introduction

Dance sport is a sport of the artistic-aesthetic direction. However, over the last few years the approach to this sporting activity has started to take shape of a serious sport performance from the aspect of diagnosing, executing and controlling a training process. The recent research in this sport have contributed as well to the more precise definition and structural analysis of the sport itself.

Functional analysis in the context of energy consumption in specific conditions of a dance competition proves dance sport a highly intensive activity containing mixed aerobic-anaerobic energetic characteristics (Bria et al., 2011). Being acquainted with the ventilation and metabolic parameters of the female and male dancers becomes the

basis of planning, programing, executing and controlling a dance sport training.
Since dance sport is a dance performed in couples and since the complexity of endurance training is clearly defined by this fact, being acquainted with differences in ventilation and metabolic parameters of male and female dancers helps a great deal to create an endurance routine. Endurance as an ability and endurance training as a process that needs to be organised and directed systematically, seems to be something many dance instructors in Croatia are not familiar with, which diminishes the possibility of achieving top European and world results. Pilch et al. (2017) determine that the oxygen uptake, heart and lactate rate parameters, measured in their study on energy consumption and lacteal concentration in a simulated final round of the standard style dance competition, clearly demonstrate that dance sport is a highly demanding activity when taking into account both energetic components, aerobic and anaerobic. Especially since the differences between the dancing partners in the given parameters are strongly emphasised. Furthermore, the paper on physiological characteristics of the elite sport dancers (Bria et al., 2011) showed significant difference in oxygen uptake between female and male partners of a dance couple. The value measured for female dancers was 38.0 ± 8.5 ml $\cdot$ min^{-1} $\cdot$ kg^{-1} and for male dancers 45.8 ± 6.0 ml $\cdot$ min^{-1} $\cdot$ kg^{-1}. Diagnosing momentary energetic state of the dance couple is necessary to optimise the endurance training in order to develop high energy efficiency of the dance couple (Adzo-Banini and Despot, 2003). On the other hand, an individual approach in creating, performing and controlling daily training process is also necessary, so the aim of this study is to determine the differences in ventilation and metabolic parameters (oxygen uptake, heart rate, respiratory rate, vital capacity) of the Croatian elite Latin-American female and male sport dancers (Despot et al. 2017).

Methods

Subjects

The subject sample consisted of 19 professional Latin and standard sport dancers (8 women, average age 19.88±4.77 and 11 males, average age 20.85±4.28). Measuring was performed at the Sports Diagnostic Centre of the Faculty of Kinesiology, University of Zagreb. The subjects were given clear instructions prior to the testing and all of them volunteered to take part in it.

Testing protocol

Measuring was performed at the Sports Diagnostic Centre at the Faculty of Kinesiology, University of Zagreb. All the subjects performed an incremental treadmill test (ITT). ITT is a standard test to evaluate aerobic and anaerobic capacity. Test consists of 4 stages: rest stage, warm-up, main stage and the recovery. After a dynamic stretching, a one-minute rest stage follows. After a minute is completed, a 2-minute warm-up stage begins that includes running on a treadmill set at speed of 3km/h and at 1% incline. The main stage of the test follows: after initial 2 minutes, the treadmill speed increases every 30 seconds by 0,5km/h. The testing is finished when the subject cannot proceed with running.
Spirometry directly measured ventilation parameters. Heart rate monitor POLAR H7 monitored and collected heart rate parameters.

The variables

Table 1. shows ventilation and metabolic parameters assessment variables used in this study.

Table 1. List of variables

No	Abbreviation	Variable description
1	F1%FSVT	anaerobic threshold heart rate percentage
2	F1%VO2VT	anaerobic threshold maximum oxygen uptake percentage
3	F1Brzmax	peak velocity attained in test
4	F1BrzVT	velocity at anaerobic threshold
5	F1HRmax	maximum heart rate attained
6	F1HRVT	heart rate at anaerobic threshold
7	F1Rfmax	maximum respiratory rate
8	F1RVO2	maximum relative oxygen uptake
9	F1RVO2VT	relative oxygen uptake at anaerobic threshold
10	F1VeEq	ventilation equivalent
11	F1VEmax	maximum minute respiration volume
12	F1VO2	maximum absolute oxygen uptake
13	F1VO2/HR	maximum oxygen uptake and heart rate ratio
14	F1VO2VT	absolute anaerobic threshold maximum oxygen uptake
15	F1VTmax	respiratory volume
16	FFEV1	first second forced vital capacity
17	FFEV1%	the Tiffeneau index
18	FFVK	forced vital capacity

Data assessment method

Analysis of the results was performed in Statistica 13 program. Descriptive statistics were used to gain basic statistic parameters for each variable. Arithmetic mean (AS), standard deviation (SD), maximum (Max) and minimum (Min) value parameters were obtained by descriptive statistics as well.

We established statistically significant differences in certain variables by using Student's t-Test for independent variables in several groups. Statistical significance was $p<0.05$.

Results

By using Student's t-Test for independent variables in several groups, we attained the results that indicate statistically significant differences between female and male sport dancers. As many as 11 variables show statistically significant differences between female and male sport dancers. Table 2 shows the results obtained by Student's t-Test.

Table 2. Results

Variable	T-tests; Grouping: Sex, Group 1: M, Group 2: Ž								
	Mean	Mean	t-value	df	P	Std. Dev.	Std. Dev.	F-ratio	p
F1%VO2VT	88,27	88,63	-0,20	17,00	0,84	4,50	2,39	3,55	0,11
F1Brzmax	16,55	13,75	5,15	17,00	**0,00**	1,21	1,10	1,21	0,82
F1BrzVT	12,77	10,31	3,56	17,00	**0,00**	1,56	1,39	1,26	0,78
F1HRmax	192,58	195,13	-0,41	17,00	0,68	16,10	7,51	4,60	0,05
F1HRVT	174,73	177,75	-0,86	17,00	0,40	7,96	6,92	1,32	0,73
F1Rfmax	57,90	56,83	0,31	17,00	0,76	5,85	9,33	2,54	0,18
F1RVO2	56,50	47,89	4,18	17,00	**0,00**	3,94	5,05	1,64	0,46
F1RVO2VT	50,11	42,47	3,96	17,00	**0,00**	3,86	4,55	1,39	0,61
F1VeEq	35,37	37,45	-0,94	17,00	0,36	4,84	4,66	1,08	0,95
F1VEmax	143,27	100,84	5,51	17,00	**0,00**	16,36	16,86	1,06	0,90
F1VO2	3,98	2,68	7,10	17,00	**0,00**	0,41	0,37	1,19	0,85
F1VO2/HR	21,13	13,99	6,31	17,00	**0,00**	2,77	1,85	2,24	0,30
F1VO2VT	3,53	2,38	6,60	17,00	**0,00**	0,41	0,33	1,49	0,62
F1VTmax	2,66	1,96	3,04	17,00	**0,01**	0,52	0,46	1,25	0,79
FFEV1	4,77	3,44	6,60	17,00	**0,00**	0,47	0,36	1,71	0,49
FFEV1%	84,84	89,05	-1,48	17,00	0,16	7,34	3,84	3,65	0,10
FFVK	5,65	3,87	6,05	17,00	**0,00**	0,73	0,47	2,43	0,25

p<0,05 = statistically significant differences

Discussion

The endurance in dance sport can be interpreted by maximum oxygen uptake, economizing movement and anaerobic threshold. The components mentioned are conditioned by the morphological characteristics as well, that, on the other hand, can be genetically caused (Mittleman and Zacher, 2000). The observed differences that is, the observed lower values of oxygen uptake parameters between the female and male dancers, could be explained through the following factors that affect the endurance difference in female dancers: fat amount, heart size and estrogen and progesterone level at different phases of a menstrual cycle. These also influence highly the cardiovascular system (Šalaj, 2009). The average age of the dancing partners should also be taken into consideration, since the older partner's age (usually male) determines the age category of the dance couple and the female partner's ventilation parameters might not yet have reached their maximum due to the ongoing development. Systematic aerobic and anaerobic training also conditions the difference between female and male dancers. It is a well-known fact in the dance world that the dancing partners change quite frequently and that this interrupts the continuity of the training and competing. The female dancers generally pay more attention to technical details and expressivity and less to endurance and speed development when training.

Conclusion

Dance sport is a highly intensive sport if we refer to its energetic analysis. If the dance couples want to achieve a top dance performance, they have to develop all energetic mechanisms since improvement of these contributes to a better performance at a competition. It is necessary to have an individual approach in defining energy components of the dance couple, different ones for a female and for a male dancer, as well as in defining precise training process parameters (intensity, volume). Taking into consideration the gender differences when planning and programing endurance training can also be one of the decisive factors of a dance sport couples' success. This kind of approach to dance sport couples' training in Croatia can contribute to its development and to accomplishing top European and world results.

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Towards machine learning on data from professional cyclists

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ABSTRACT
Professional sports are developing towards increasingly scientific training methods with increasing amounts of data being collected from laboratory tests, training sessions and competitions. In cycling, it is standard to equip bicycles with small computers recording data from sensors such as power-meters, in addition to heart-rate, speed, altitude etc. Recently, machine learning techniques have provided huge success in a wide variety of areas where large amounts of data ("big data") is available. In this paper, we perform a pilot experiment on machine learning to model physical response in elite cyclists. As a first experiment, we show that it is possible to train a LSTM machine learning algorithm to predict the heart-rate response of a cyclist during a training session. This work is a promising first step towards developing more elaborate models based on big data and machine learning to capture performance aspects of athletes.

Key words: machine learning, cycling, performance analysis systems, performance data, performance analysis software, digitalisation and sports

Introduction
Professional sports have long been developing towards increasingly scientific training methods. One of the most fundamental principles in sport science and training practices is the dose-response relationship, i.e., the physical adaption to training stimulus. At first sight, it seems simple; more training better performance; but in reality, there are several stimuli and the responses are not linear. It is a complex multi-dimensional nonlinear problem. An early system-level description of the challenge was reported in (Calvert et. al. 1976). Beside the challenge of multi-dimensional nonlinear modelling, another issue is to define accurate and valid input data.
Recently development in the ICT sector has supported athletes and coaches with vast amount of data being available from GPS sensors, heart rate monitors, power meters, and motion sensors. Collected over time it becomes a lot of data that can be used to design training programs and follow up training loads with target to peak performance with reduced risk of overreaching, which otherwise may result in injuries, sickness, and degraded performance. Still, among practitioners rather primitive methods are used to handle the large data sets. Coaches and athletes mostly rely on gut feeling or studies of single parameters, e.g., heart rate or power data. At best, the levels are normalized to maximum capacity or critical power. Coggan and Allen have defined the training stress score (TSS) (Allen & Coggan, 2010), which is a key number that is calculated from real-time work intensity related to each subject documented critical intensity, defined through either power, heart rate or speed. Despite being widely used for assessment of training, TSS still considers only one variable, e.g., the power. The nonlinear intensity relationships in the TSS formula are also ad-hoc without any clear motivation about the

nonlinear relationship used (Kuylenstierna, 2018). Recently, TSS compared to TRIMP have also been shown to differ significantly depending whether the data was collected in a training or racing session (van Erp, 2018).

One of the challenges in modelling physiological and biological systems is the large number of stimulus involved making it impossible to clearly define the governing dynamics needed for an analytical model starting from first principles. Under these constraints a black box modelling approach is more adequate (Cooper 1991).

With the rise of computing power and availability of large amounts of digital data, *machine learning* has revolutionised many fields, from machine vision (Cireşan et al, 2012) to natural language translation (Sutskever et al. 2014) and genetics (Chicco et al, 2014), just to mention a few. There exists a wide range of machine learning algorithms. Here, we are mainly concerned with supervised learning algorithms, which typically have in common that they model complex statistical relationships, implemented as adjustable weights in the model. These weights are typically gradually adjusted to fit a set of *training data*, containing labelled examples (for instance pictures of animals labelled by their species), followed by an evaluation on unseen validation data to assess how well the model generalises to novel examples.

There has been some work on machine learning methods in the context of performance analysis in sports. In (Pfeiffer & Hohmann, 2011), neural network algorithms are used to several rather different tasks: predicting talent development in young swimmers, recognising tactical patterns in handball matches and finally to analyse the effect of training on performance in one Olympic swimmer. They found that neural network-based approaches performed better than alternative models. In (Churchill, 2014) the aim was to predict fitness indicators of elite cyclists based on data from training and races, collected from bike non-laboratory setting such as bike computers and self-assessments in training diaries. The motivation was to aid athletes and coaches approximate current fitness values without having to conduct time consuming laboratory tests, which is often infeasible during racing season due to time constraints. A challenge here was that the data was relatively sparse, only coming from a few cyclists. Small datasets are a problem in machine learning. A novel algorithm specially developed to handle small datasets, the so-called hybrid artificial neural network ensemble model (HANNEM), was proposed and used for modelling field data from a few world class cyclists.

In our work, we consider data in the form of time-series collected from bike computers and associated sensors recorded during training sessions of professional cyclists. We thus had access to both a larger volume and longer time-series of data than e.g. (Churchill, 2014). Furthermore, we apply modern recent so called *deep-learning* methods, which have revolutionised many applications of machine learning. To our knowledge this is the first study on deep-learning methods applied to sports data. Specifically, we use a so called *long-short term memory (LSTM) neural network model* (Hochreiter & Schmidhuber, 1997), which is suitable for the analysis of time series data. Our pilot study is an experiment to train an LSTM model to predict the cyclists heart-rate at any given point in time. While this is not our ultimate goal from a performance analysis point of view, it is a suitable evaluator for assessing if machine learning at all can *capture and encode* the dependencies between different physiological and performance factors.

Methods

For this study we had access to a dataset collected from both male and female professional cyclists. The files in the dataset each correspond to one training session or race and was extracted from the cyclist's bike computers. These small devices record one data point per second, including information from various sensors, e.g. heart rate monitor, power meter (if the bike is equipped with one), GPS position, altitude, speed etc.

As a typical training session or race lasts between 2-6 hours, each file consists of time series of thousands or tens of thousands of data-points.

The quality of the data varied between different individuals, with some always riding with a heart rate monitor and power meter, while others rarely rode with sensors on the bike. Furthermore, the sensors are not always measuring perfectly and some sessions contained obviously spurious values. The dataset also contained more historical data for the male cyclists. Due to these variations, we ended up only using data from 15 male cyclists for the experiments described here.

In addition to the data from bike computers, we also had access to some meta-data about each cyclist. This included for instance some information about performance in laboratory test such as maximum oxygen uptake and power output and heart rate at lactate threshold etc.

As a first experiment in applying machine learning to performance data from cyclists we decided to attempt to train a machine learning algorithm to predict the heart rate at any given point in time during a training session. We first give a brief overview of the kind of machine learning algorithms we used, followed by a more detailed description of how we trained and evaluated a model for predicting heart rate.

A Brief Introduction to Recurrent Neural Networks and LSTMs

Each training session in our dataset is represented as a time series, as described above. To train a machine learning algorithm on such data, we need a suitable algorithm which can remember and utilise earlier information to solve some task at the present point. *Long short-term memory* networks (LSTMs for short) (Hochreiter & Schmidhuber, 1997), is a machine learning model in the family of *recurrent neural networks* (RNNs for short) (Lipton et al. 2015) which has been successfully applied to a variety of tasks involving data in the form of sequences or time-series, including speech recognition, translation (Sutskever et al. 2014) and image captioning. Like all recurrent neural network models, LSTMs consist of a chain of repeated processing units, taking an input each, and feeding the result of its computation to the next unit in the network. What is special about LSTMs is that they also keep track of a *state* (effectively its "memory"), which is updated by each unit and then read by the next unit in the network. This way, LSTMs can "remember" information from much earlier in the input sequence (here earlier points in time, as we are handling time series), which other types of RNNs will not do well.

Training a neural network, such as an LSTM, essentially consists of repeatedly calculating a so-called *loss function* for each data point in the training set, and then adjusting and fine-tuning the *weights* connecting the units in the network as to minimise the error between the current and expected values. The weights essentially regulate what information is passed through the network, how much importance the network should attach to it, and what is forgotten or ignored. For example, in our experiment to predict the heart rate at a given point in time, the loss function is the difference between the actual heart rate, and the heart rate computed by our network. For each training step, this error is propagated through the network and weights are updated in order to try to make this error smaller. The process is repeated many times for a large number of training examples. Typically, there are a number of parameters for training that are tweaked experimentally, and many different algorithms for training different network architectures. See (Lipton et al. 2015) for an overview.

The process of training a neural network model such as an LSTM can be computationally expensive and time consuming, but the situation has much improved in recent years with the help of specialised software libraries, for example TensorFlow (https://www.tensorflow.org), and specialised hardware called Graphical Processing Units (GPUs), which thanks to parallelism perform well for training tasks.

When using machine learning algorithms, the available data is typically divided into a larger training set and a smaller evaluation set. The training set is used to train the chosen model, often under a longer period of time, and possibly over several passes over the data, allowing the model to adjust and learn through tweaking its internal parameters. To ensure the model has learned parameters that generalise also to new data, the performance of the model is evaluated on the unseen evaluation set.

Predicting Heart Rate with an LSTM

Given the successes found in the literature, and the nature of our data as a time series we decided to attempt to implement a LSTM network and train it to predict heart rate of a cyclist. While this is not our ultimate goal, it serves as a good first indicator to evaluate if the machine learning model manages to learn some representation of physical response. A trained LSTM network cannot only be used for prediction, but also for producing compact encodings of the data, as numeric vectors called *embeddings* (Srivatava et al, 2015). Such embeddings can be useful for instance for visualisation of the data. In Figure 1, we show the intended workflow of our system.

The source code which was used to run these experiments is available online (see https://github.com/agrinh/procyclist_performance) and is based on the TensorFlow library written in Python. The target of this experiment was to predict heart rate for any time step, given input variables:

- Time (seconds)
- Speed (km/h)
- Distance (km)
- Power (Watt)
- Cadence (pedal strokes/minute)
- Power/weight (Watt/kg)
- Altitude (m)
- Heart rate 30 s. prior to current time (beats per minute)

The raw data contained one sample per second. With long training sessions lasting up to 5-6 hours, each session could be extremely long. For practical reasons, the data was therefore down-sampled with a factor of 1/0.3.

As a pre-processing step for cleaning the raw data, we removed sessions where no heart rate values were recorded, or where spurious values were recorded (e.g. heart rates way over 200, indicating faulty readings of the HR-monitor). Also, sessions with negative values for distance, speed or power (indicating faulty readings) were removed together with sessions where the power was recorded but the distance did not increase (e.g. sessions on stationary bikes). The data was also trimmed to remove leading and trailing zeros in heart rate, indicating the rider removing the heart rate monitor with the bike computer still recording. The input parameters listed above were standardised (rescaled) to mean 0 and standard deviation 1 to avoid introducing artificial bias in any variables, as units vary between the different inputs (this is standard in machine learning applications).

The final dataset used for this experiment thus consisted of 7541 sessions from 15 male professional cyclists. Finally, as is common practice in machine learning, the data was split into a training set, consisting of data from 10 cyclists (5179 sessions), and a validation set, consisting of data from 5 cyclists (2362 sessions). After training, the model was evaluated on the unseen validation set.

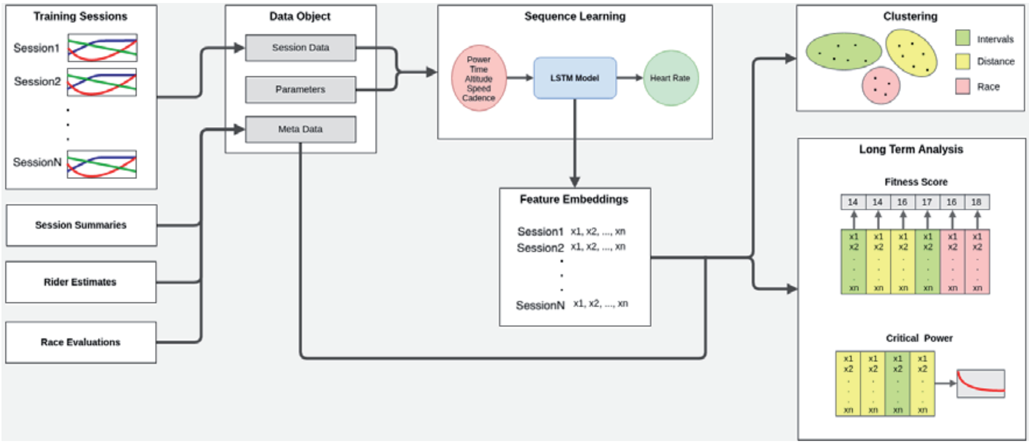

Figure 1: Overview of the workflow of our machine learning experiment. Data from training sessions are fed to a LSTM model which is trained to predict heart-rate based on modelling physical response for the given input parameters. In addition, we can extract so called feature embeddings from the model (numeric vectors), which is a compact encoding which can be computed for a training session fed to the model. In the future, we would like to investigate in more detail if these feature embeddings form clusters with any sensible meaning. We hypothesise that similar training sessions (e.g. interval sessions vs distance sessions) will have similar embeddings. Such information could then be useful for long-term analysis.

Results

The LSTM-network was trained for approximately 1 week on a Titan X Pascal GPU and obtained a final min, mean and max Root Mean Squared Error (RMSE) of 2.51, 5,62 and 25.67 on the validation set. Figure 2 and Figure 3 show our trained models predictions on two samples from the validation set, where the RMSE was less than 4. The model's predictions are very close to the actual heart rate measured both for an interval training session, where the heart rate varies quite drastically, and on a session ridden at high but rather constant velocity and power. This indicates that the LSTM-network has indeed managed to learn a representation for the cyclists' physical response. In Figure 4, we show a session where the model's prediction has a larger RMSE. Towards the end of the session there are a few short steep spikes, followed by a drop, which our model does not capture well, possibly due to the fact that it has not learnt to react to very short sprints or similar. It is also likely that the heart rate monitor has recorded some spurious values (lost contact) towards the end when it drops to near zero.

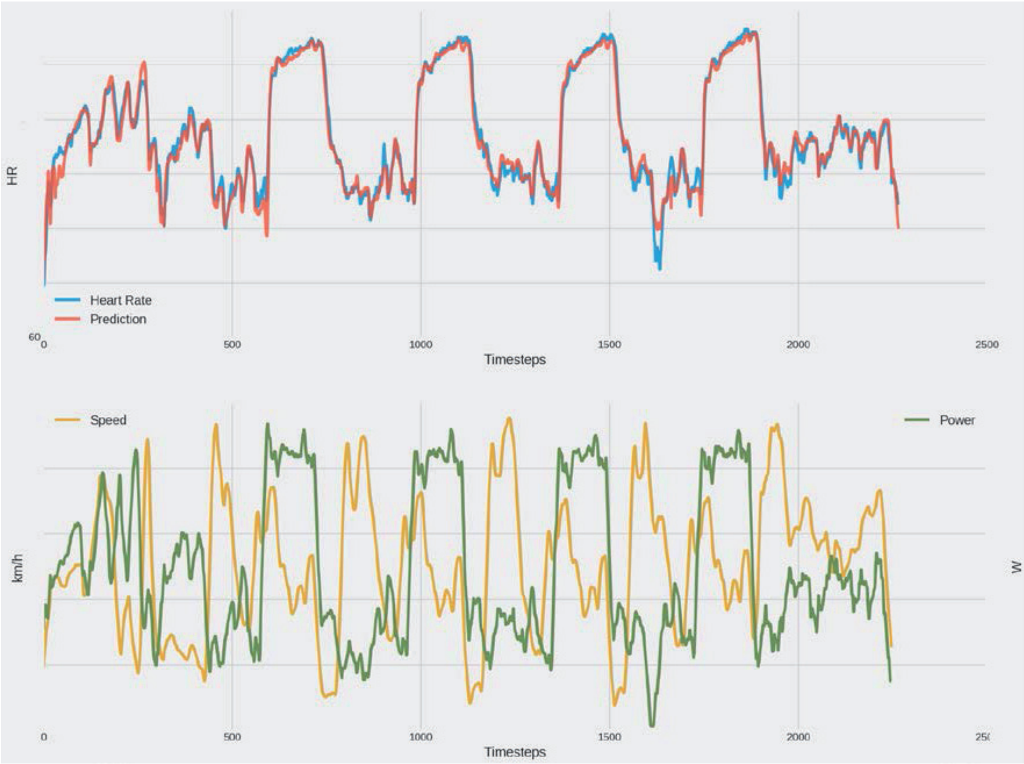

Figure 2: Prediction of heart-rate on an interval training session.

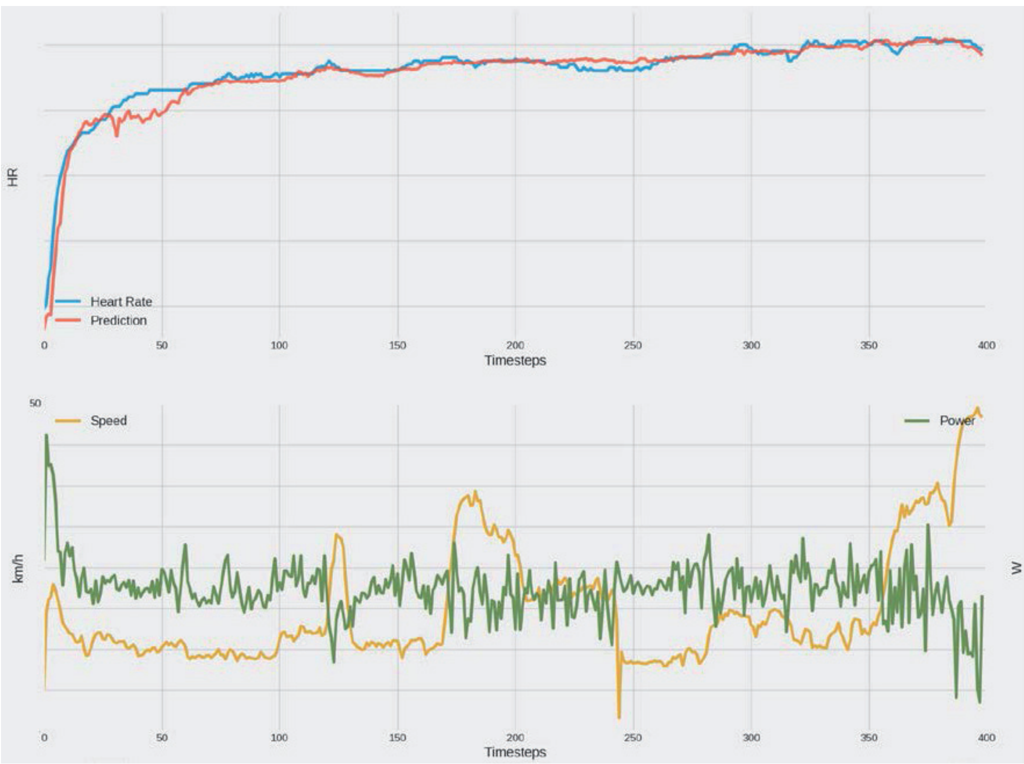

Figure 3: Prediction of heart-rate on a session at relatively even pace.

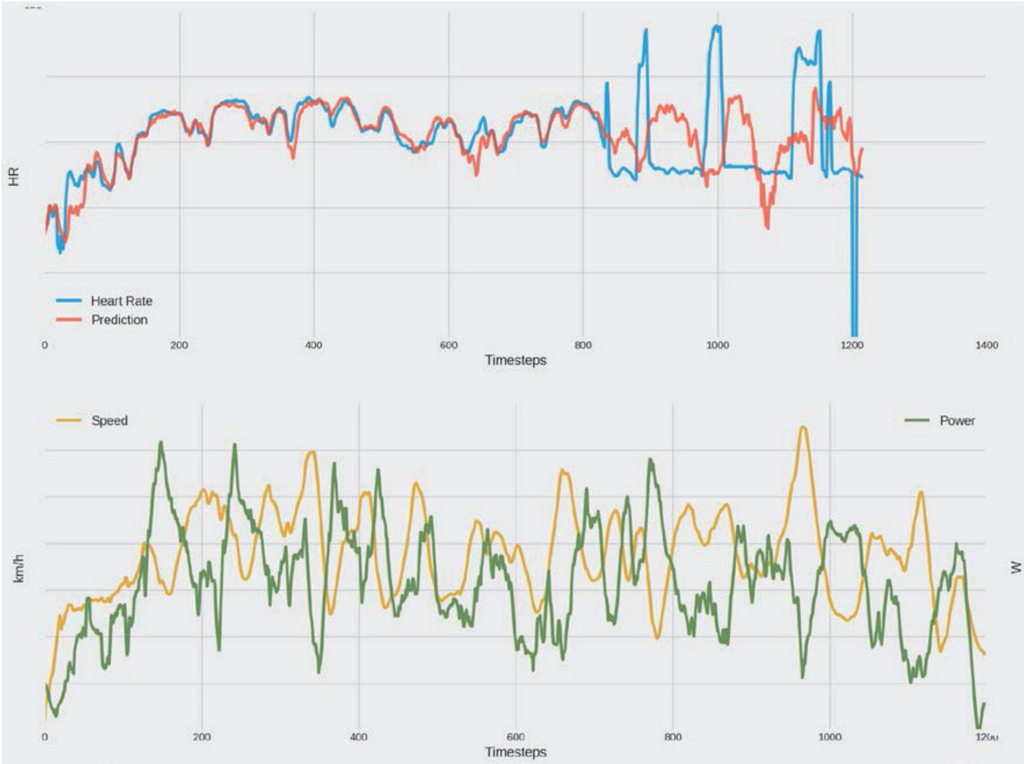

Figure 4: A session where our model's RMSE > 4, and the predicted values differ.

Recall that the trained LSTM model also can be used to extract compact encodings of its inputs as numeric vectors, which in turn can be used to visualise the data. The idea is that input data given to the model with similar features gets encoded to numeric vectors which are "closer" together in a multi-dimensional space, forming clusters, as is shown in Figure 5. We speculate that the embeddings possibly could be used to cluster and classify similar training sessions
(interval session of varying intensity, races, time-trials, distance rides etc.). As the figure shows, there are indeed clusters being formed, but a detailed analysis of the sessions in the respective clusters is further work.

Discussion
We note that the time series representing training sessions are very long (several hours) compared to for instance the time series used when training machine learning models to recognise objects in short video clips (seconds). Even after down-sampling our data, each time series is still very long. This meant that training our model was somewhat time consuming,
preventing us to explore all modifications to the learning parameters we would have liked within the project's time frame. For instance, experiments with systematically excluding different input parameters and observing the re-trained model's performance on the evaluation set would give us an indication of which of the inputs are most relevant for prediction. We would also like to swap input/output parameters and explore how this affects the model, e.g. predicating power given heart rate instead. This is further work.

Figure 5: Feature embeddings extracted from our LSTM model. Each plot represents a training session.

Finally, a difference compared to conventional applications of deep learning is that while our data was long, the training set was not particularly big compared to for instance image recognition systems which typically are trained on sets containing at least tens of thousands of training examples. In future work, we will consider techniques to compensate for the relatively few but long training samples. For instance, one approach might have been to split each training session into smaller chunks, thus getting more but shorter data. However, one would then of course loose information about length of the session, which indeed can be relevant for performance metrics.

Conclusion

This paper describes a first experiment in applying advanced machine learning methods on performance data collected from professional cyclists, using an LSTM-model. We showed that is indeed possible to train such a model to predict the heart rate of a cyclist at any given point in time. Our work on machine learning and performance data is still at an early stage. While the heart rate prediction model we use as a first case study in this paper might not be of immediate use in performance analytics, it still indicates that further investigation into similar models are worth pursuing. As a next step, we would like to train a model to recognise for instance some measure of intensity (e.g. TSS or normalised power), possibly also including data from rider's subjective experience as recorded in their training diaries. Unlike heart rate, which is mainly a local property, these measures need to capture a representation of the whole training session. The weights of the trained machine learning model would then be forced to learn a compact encoding of the whole time-series from a session. We speculate that the model then could be used to for instance automatically classify sessions and compute training intensity measures both over an individual session, as well as over a longer training period. We would also like to experiment with other machine learning architectures, not just LSTMs.

There is interest in conducting similar experiments with data from other sports. For instance, the Chalmers University spin-off company Skisens AB (http://skisens.com) are developing power meters for ski poles and are interested in analysing data collected from cross-country skiers. In summary, applying machine learning to performance data is a new promising area of research, which has the potential to provide coaches and athletes with novel software tools to help analyse, categorise and steer training. Our work is a first step in this direction, suggesting several interesting topics to explore next.

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Attack and counterattack efficiency in elite male volleyball

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ABSTRACT
Forty randomly selected volleyball sets played in the European League for Men in years 2011. and 2012. were analyzed in order to determine the differences between the efficiency of the attack phase spike and the counter-attack phase spike. Reliability analysis conducted on a sample of 6 randomly selected sets determined a high intra-rater and inter-rater reliability (R = 0.951 and 0.923 respectively). The T-test for independent samples did not determine any significant differences between the efficiency of the attack phase spike and the counter-attack phase spike. The Mann Whitney U test determined significant differences in the efficiency of the counter-attack phase spike between winning and losing teams but not in the efficiency of the attack phase spike. The obtained results indicate that considerable attention has to be devoted to the improvement of the team's play in the counter-attack phase play in the training process.

Key words: European league, notational analysis, spike, winning and losing the set, analysis of differences.

Introduction
The elite volleyball teams are valued based on their ability to win the match. To achieve this, teams must have efficient ways to win points. During the match the winning team can win over 100 points. The great majority of these points were won by the efficient attack phase and counter-attack phase spike (Eom & Schutz, 1992; Palao et al.,2004; Marcelino et al., 2008; Drikos et al., 2009). That is the reason why the efficient performance of these phases has a significant impact on the success of a volleyball set or a match (Nishijima, 2001; Hayrinen et al., 2004; Palao et al., 2004; Yiannis et al., 2004; Marcelino & Mesquita, 2006).
The conditions of performing the attack phase spike and counter-attack phase spike are significantly different (Eom & Schutz, 1992, Afonso et al., 2005; Palao et al., 2005). Counter-attack phase spike is performed in the transitional conditions after the block and the dig or after the spike coverage while the attack phase spike is performed in the transition after the serve reception. In this respect, the transition from receiving the serve to the attack phase spiking is considerably simpler, especially for the spikers that do not participate in receiving (opposite hitter and middle hitter). The spikers that do receive the serve perform the transition to spike in a forward movement. The transition to the counter-attack phase spike is considerably more complicated especially for the players who executed the block because they have to pull away from the net in a very short time and be available to perform the counter-attack phase spike. Also, due to the more demanding situation in the dig compared to the reception, the balls that the setter must play in the counter-attack phase are not precisely sent to the setting zone, which in addition complicates the setting and the spiking in that phase (Marcelino et al., 2009). Because of the above-mentioned, the frequency of strong spikes is significantly higher

in the attack phase (Palao et al., 2005; Mesquita et al., 2007; Castro & Mesquita, 2008), with the emphasis on a faster tempo of the play in the same phase (Afonso et al., 2005). Opposite from that, in the counter-attack phase, the tempo of the attack is slower, which reduces the probability of winning the points by allowing the larger number of blockers in the opponent's block (Afonso et al., 2005; Cesar & Mesquita, 2006; Mesquita et al., 2007). Obviously, the efficiency of the attack phase spike must be analyzed separately from the counter-attack phase spike.

The performance quality analysis of the attack phase spike and the counter-attack phase spike mostly used frequencies of individual variables affecting the total efficiency of volleyball players such as the number of points won or the number of errors (Joao et al., 2010; Rodriguez-Ruiz et al., 2011; Patsiaouras et al., 2011; Pena et al., 2013). However, previous research determined that the performance coefficients of the attack phase spike and the counter-attack phase were better efficiency predictors at the competition than the individual variables from which they were derived (Marcelino et al., 2008; Drikos et al., 2009). In these studies, performance coefficients were used to compare teams of different ranking, but there is a lack of research that use the performance coefficients to analyze differences in the efficiency of the attack phase spike and counter-attack phase spike between winning and losing teams.

Therefore, the aim of this research is to determine significant differences between sets with different outcome, won and lost, separately in the efficiency of the attack phase spike and in the efficiency of the counter-attack phase spike in elite men volleyball.

Methods

The sample of entities was represented by 40 volleyball sets played in years 2011 and 2012 in European League for Men. A set was randomly selected from a match. In this way, the problem of linear dependence of the sample is avoided because the team's play in a set is not linearly independent of the team's play in the remaining sets, and also the team's play depends on the opponent team's play in each set.

The sample of variables was composed of performance efficiency coefficients of two technical and tactical volleyball skills, attack phase spike and counter-attack phase spike. Performance efficiency coefficients were average values of all performed spikes, estimated on the Likert scale from 1 to 4 (Mathias & Greco, 2011). Value 4 represented the spikes that won the point, value 3 represented the spikes after which the rally continued, but obtained advantage for the team. Value 2 represented the spikes after which the rally continued, but obtained advantage for the opposite team, and value 1 represented the spikes which resulted in a winning point for the opponent.

Data was collected in pre-prepared forms from video recordings made by a camera that was placed in such a position to clearly cover the entire court and all players in the court. Reliability analysis was performed on a subsample of 6 randomly selected sets. Inter-observer reliability was analyzed on the basis of the arrangement of the first surveyor (the first author of this research) and another surveyor (an expert with years of experience in conducting notational analysis in volleyball). Intra-observer reliability was calculated in a way to determine the degree of arrangement of two different measurements from the same surveyor (the first author of this study) in two time points (test-retest method) with a time interval of 6 weeks between them.

In order to assess normality of variable distribution, the Kolmogorov-Smirnov test was used and Skewness and Kurtosis were calculated.

Basic descriptive parameters of performance efficiency coefficients of the attack phase spike and counter-attack phase spike were calculated: arithmetic mean (AM), standard deviation (SD), minimum value (MIN) and maximum value (MAX). They were calculated for the entire sample of sets and also for the winning and losing sets separately.

The t-test for independent samples was used to analyze the significance of the difference between the performance efficiency coefficients of the attack phase spike and counter-attack phase spike of the entire sample of sets. The Mann-Whitney's test was used to analyze the significance of the difference between the performance efficiency coefficients of the attack phase spike and counter-attack phase spike, separately for the winning sets and for the losing sets.

Results

The Spearman's rank correlation indicates high intra-observer (R = 0.951) and inter-observer reliability (R = 0.923).

The descriptive parameters of performance efficiency coefficients of the attack phase spike (Spike att.) and counter-attack phase spike (Spike c-att.) are presented in Table 1. The t-test for independent samples was used to analyze the difference between performance efficiency coefficients of those two skills on an entire sample of sets independently of the set's outcome (win or lose).

Table 1. Descriptive parameters and metric features of spike performance efficiency coefficients

	AS	SD	Min	Max	Skew	Kurt	KS_{maxD}
Spike att.	3.082	0.264	2.556	3.700	-0.017	-0.201	0.096
Spike c-att.	2.960	0.398	2.000	3.667	-0.765	0.510	0.104
T-test=1.85 **p**= 0.07							

KS_{crit}=0.21

LEGEND: AS – arithmetic mean; SD – standard deviation; MIN – minimum value, MAX – maximum value, SKEW – measure of distribution asymmetry; KURT – measure of distribution peakedness, KS_{maxD} – coefficient of K-S test.

By analyzing the symmetry and the tailedness measures (skewness and kurtosis) of variables' distribution, as well as comparing the Kolmogorov-Smirnov test results with a critical value, it can be concluded that the distribution of measured variables of the entire sample of sets does not significantly differ from the normal distribution. By analyzing descriptive parameters of performance efficiency coefficients, the higher values of attack phase spike are observed. However, the T-test for independent samples did not determine statistically significant differences between the attack phase spike and the counter-attack phase spike although the p value is close to the borderline of significance. In Table 2, the results of the analysis of differences in attack phase spike and counter-attack phase spike between sets won and sets lost are presented.

Table 2 Analysis of differences in spike's performance efficiency coefficients* between sets won and sets lost.

	AS	SD	Min	Max	Skew	Kurt	KS_{maxD}	P_{KS}
				Spike - attack				
Sets won (n=21)	3.131	0.260	2.583	3.700	0.087	0.538	0.184	>0.20
Sets lost (n=19)	3.028	0.266	2.556	3.529	-0.102	-0.921	0.173	>0.20
				Spike - counter-attack				
Sets won (n=21)	3.163	0.259	2.769	3.667	0.317	-0.938	0.334	<0.01
Sets lost (n=19)	2.736	0.410	2.000	3.250	-0.570	-0.792	0.243	<0.20
	Spike att.	**Spike c-att.**						
Rank Sum win	469,00	551,50					KS_{crit}=0.301	
RankSum lose	351,00	268,50					(n=19)	
U=	161,00	78,50					KS_{crit}=0.287	
Z=	1,03	3,26					(n=21)	
p=	0,30	0,00						

LEGEND: AS – arithmetic mean; SD – standard deviation; MIN – minimum value, MAX – maximum value, SKEW – measure of distribution asymmetry; KURT – measure of distribution peakedness, KS_{maxD} – coefficient of K-S test.
*Performance efficiency coefficients: Sum of attempts by cattegory, multiplied by value of category and divided by total attempts

After the sets are divided into subsamples of sets won and sets lost, skewness and kurtosis were also calculated and the Kolmogorov-Smirnov test was performed. Results show that the distributions of subsamples are quite flattened, meaning that the subsamples are very heterogeneous. Skewness shows that all four distributions are asymmetrical. Asymmetry of the spikes' distributions (attack and counter-attack both) of sets won is positive, meaning the largest frequency is below average and some sets have extremely high efficiency coefficients. In contrary, asymmetry of the spike distributions (attack and counter-attack both) of sets lost is negative, meaning the largest frequency is above average and some sets have extremely low efficiency coefficients. Results of the Kolmogorov-Smirnov test show that the efficiency coefficients of the spike in counter-attack (both sets won and sets lost) are not normally distributed so the nonparametric analysis of difference must be performed.

Discussion

The main aim of this research was to analyze the differences between winning and losing sets in the spike's efficiency in the attack and the counter-attack separately. The analysis of differences determined differences in spike efficiency between winning and losing sets only in counter-attack phase. These findings are not in accordance with the results of the majority of previous research in which the spike in the attack was the skill most linked to success in the competition (Marelić et al., 2004; Hayrinen et al., 2004). However, Eom and Schutz (1992) determined that higher ranked teams were more efficient than the lower ranked ones only in the skills performed in the counter-attack phase. Also, winning teams differentiate from the losing ones in the performance quality of the block, the attack phase spike and the counter-attack phase spike, which partially confirms the results obtained.

In this research, the sets that teams won even have slightly greater efficiency in the counter-attack phase spike compared to the attack phase spike. This is not expected as the conditions of the play in the attack phase (after the opponent's serve) are far more predictive and easier compared to the counter-attack phase that occurs after the opponent's spike. Previous research indicates that time is one of the major constraints in elite level team sports (Williams et al., 2002; Savelsbergh et al., 2005), including volleyball (Mesquita & Cesar, 2007; Afonso et al., 2008). Players have considerably more time to prepare for the attack after receiving the serve compared to preparing for the counterattack after strong opponents' spikes. For this reason, emphasis in the attack phase is on the setting of quicker balls (Afonso et al., 2005), while in the counter-attack phase the game is mostly slower, which reduces the probability of winning the points by allowing the opponent's team enough time to organize their defensive system correctly (Afonso et al., 2006; Cesar & Mesquita, 2006; Mesquita et al., 2007).

Therefore, it is not easy to explain the higher spike's efficiency of sets that teams won in counter-attack phase compared to spikes in the attack phase. Possible causes should be searched for in the performance quality of other skills in the counter-attack which also condition the quality of the opponent's play in the attack phase. For example, a constantly efficient serve that complicates the opponent's play in the attack phase can result in a large percentage of counter-attacks played in easier conditions (free ball situations) when the opponent did not have the ability to execute a strong spike but only easily play the ball over the net (Costa, et al., 2010). In men's volleyball, jump serve has the importance to reduce the quality and efficiency of reception performance, thus determining the conditions for the following actions (Katsikadelli, 1998; Stromsik et al., 2002). Moras et al. (2008) determined that, in elite volleyball after the jump serve the ball achieves speeds similar to the spiked balls which makes it difficult to receive such serves. It is well known that the high quality of reception creates favorable conditions for the attack and increases the probability for winning points (Papadimitriou, et al., 2004; Rocha & Barbanti, 2004; Mesquita et al., 2007).

Well performed passive block that eases the opponent's spikes also greatly facilitates the performance of the counter-attack and can thus increase the team's efficiency in that phase. The finding that the relationship between the spike and the block can predict the winning or losing the set is confirmed with the results of the previous research (Rocha & Barbanti, 2006; Marcelino et al., 2011). In addition to the afore-mentioned, it is also possible that the attackers of the winning teams are more efficient in spiking in difficult conditions (counter-attack) against a compact double or tripple block compared to the attackers of the defeated teams. This indicates the importance of the outside hitters (opposite players and serve receivers) who spike almost all balls in such situations. It is clear, therefore, that the points won in the counter-attack, even though they are fewer than points won in attack, are very important for victory in a volleyball set.

Conclusion

This research is based on the descriptive and the regressive studies in which spike has been identified as a game phase that significantly impacts the competitive efficiency. Given the lack of research that compare winning and losing teams in the attack's and counter-attack's efficiency, this research has a great practical significance for further elaboration of this problem.

Although the most of the previous research in volleyball has focused on the analysis of the attack phase skills, based on the results of this research, it may be recommended to coaches to pay particular attention to the improvement of the counter-attack phase skills. In order to obtain more detailed information on the counter-attack phase efficiency, the authors suggest that the following counter attacks should be analyzed separately: counter-attacks after the opponent's free ball (situation without block execution and setter runs into the setting zone instantly), counter-attacks after opponent's spike in difficult conditions (also without block, but setter participates in court defense) and counter-attacks after opponent's spikes in favorable conditions (requiring the block performance).

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Results difference in elite short track speed skating on European and World championships in women's and men's 500m

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ABSTRACT
European and World championships, like in any other sport, are right behind Olympic games by competitiveness in short track speed skating. Considering that different athletes compete on these two Championships, mental requirement and motivation is different, one could assume that there must be a statisticaly significant difference between results. We made a hypothesis that there are statisticaly significant differences between results in 500m on European and World championship, for women and men separately. Statistical analysis was done on gathered data (Kolmogorov-Smirnovljev, Shapiro-Wilkov and T-test), which showed that there are no statisicaly significant difference between European and World championship results in men's and women's 500m. There are number of reasons for that phenomenon, which are described in the paper.

Introduction
Short track speed skating is an olympic competitive sport, which has been in olympic program for more than 20 years. It belongs to a group of speed skating sports, the other one being long track speed skating. Distances in mentioned sport are: 500m, 1000m, 1500m, 3000m women's relay and 5000m men's relay. Each of these distances lasts between 40s and 6-7 minutes. According to time needed to skate these distances, we can conclude that energy is mostly coming from anaerobic processes; the only distances that differ are relays and because of their duration, aerobic-anaerobic processes are also used.
Besides olympic games, World and European championships are the highest level of competition in this particular sport. They are held every year across the world. First European championship took place in 1997. with only 50 skaters attending, while today, there are more than 120 skaters. First World championship was held back in 1995 with less than 60 skaters; that number grew up to 140 skaters in past 20 years. Taking that information in account, we can surley say that competition has well improved, and so did results. From 46.1s to 42.8s in women's 500m and 43.3s to 40.4s in men's 500m. So far, the highest ranked countries are: Korea, China, Hungary, Canada, Netherlands, Russia, France, Italy and Japan. One could induce, like in every other sport, World championships are more competitive than European championships which leads to better results. That statement should obviously be true because there are more countries involved (and more developed ones). But is it so? So far there are no researches done on this objective, and

that's why, the goal of this paper is to analyze the differences between results on World and European championship and to seek and propose possible reasons od differences, if there are some. We made a hypothesis that there are statisticaly significant differences between results in 500m on European and World championship, for women and men separately.

Methods

1. Data acquisition

We gathered the results from 22 European championships and 24 World championships from 1995 till 2018. Data was taken from official ISU website.

2. Variables

We used 500m as our only variable because it's a sprint race and results dissimilarity should be the highest among other disciplines.

3. Statistical analysis

Kolmogorov-Smirnovljev and Shapiro-Wilkov tests were used for determining the type of distribution (normal) and difference T-test between two independent samples was used for testing the differences between arithemtic means. Aslo, basic descriptive statistic was done on the same data. It included: arithmetic mean, standard deviation, lowest and highest result.

Results

Table 1. Descriptive statistics of women's 500m results on European and World championships.

	European championships results				World championships results			
Disciplines	Arithmetic mean	Standard deviation	Lowest result	Highest result	Arithmetic mean	Standard deviation	Lowest result	Highest result
500 m	44,61	0,96	43,81	46,26	44,15	0,90	42,68	45,69

Table 2. Differences in arithmetic mean between women's results on European and World championships (s).

Disciplines	T-test	Significance of T test Sig.(T)
500 m	1,626	0,111

In women's 500m there aren't statisticaly significant differences between arithemtic means, because the difference between arthmetic means, based on T test, is 1,626 and T-test is significant (11,1% which is more than allowed 5%). We can conclude that there is no statisticaly significant difference in women's 500m results between European and World champioships.

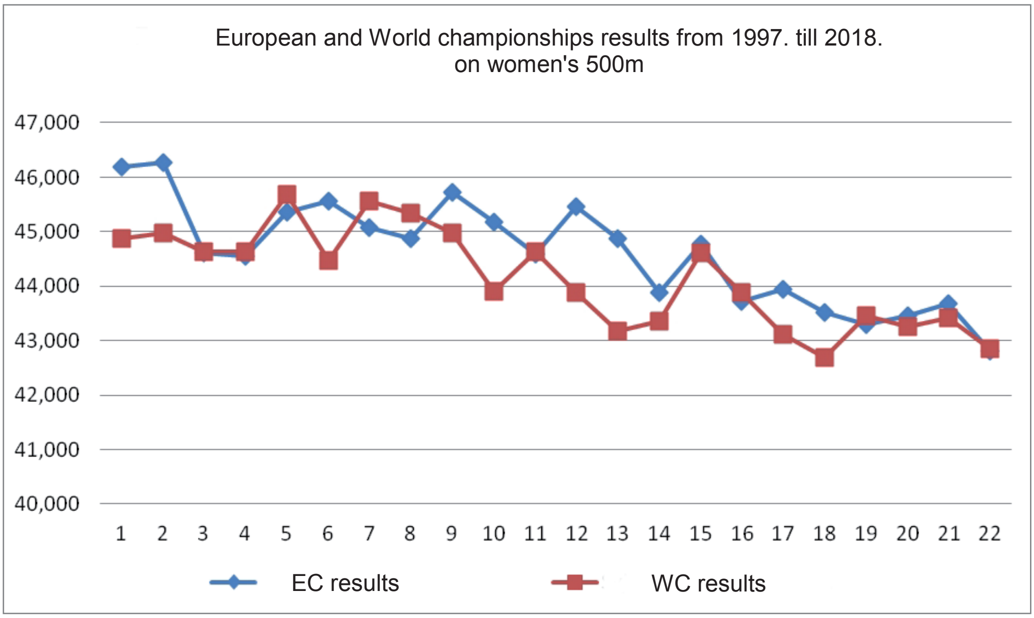

Chart 1. European and World championships results from 1997. till 2018. on women's 500m.

From chart 1 it is visible that women achieved better results on European championships only: 2001.(5), 2003.(7) and 2004.(8). In all other years women achieved better or same results on World championships than European championships. However, those differences aren't statisticaly significant.

Table 3. Descriptive statistics of men's 500m results on European and World championships.

	European championships results				World championships results			
Disciplines	Arithmetic mean	Standard deviation	Lowest result	Highest result	Arithmetic mean	Standard deviation	Lowest result	Highest result
500 m	42,08	0,82	40,60	43,30	41,68	0,80	40,16	42,98

Table 4. Differences in arithmetic mean between women's results on European and World championships (s).

Disciplines	T-test	Significance of T test Sig.(T)
500m	1,640	0,109

In men's 500m there aren't statisticaly significant differences between arithemtic means, because the difference between arthmetic means, based on T test, is 1,640 and T-test is significant (10,9% which is more than allowed 5%). We can conclude that there is no statisticaly significant difference in men's 500m results between European and World champioships.

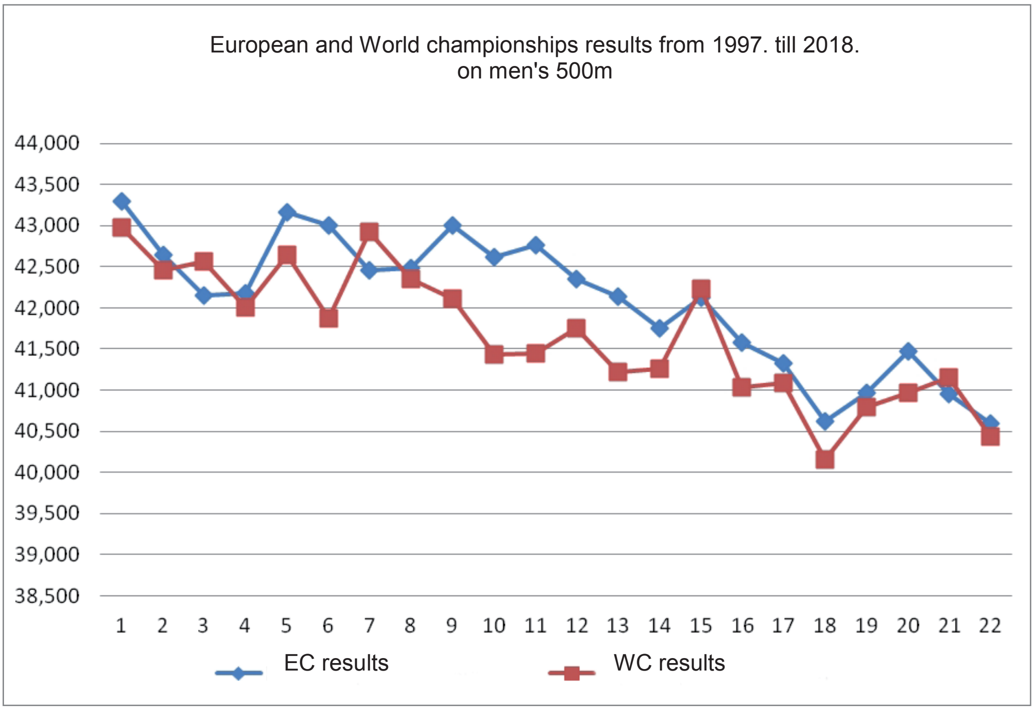

Chart 2. European and World championships results from 1997. till 2018. on men's 500m.

From chart 2 it is visible that men achieved better results on European championships only: 1999.(3), 2003.(7) and 2017.(21). In all other years men achieved better or same results on World championships than European championships. However, those differences aren't statisticaly significant.

Discussion

As we determined that there are no statisticaly significant defferences between results on World and European championship, we should present some of the acceptable possibilities for such phenomenon. First, and the most probable one, is that, athletes that are competing on European championships could also compete on World championship, but not the other way around. So, basically, the same athletes are competing on European and World championships and are achieving same results. The second one is sport development in the world. There are currently 24 european nation and 16 non-european nation that are competing, which tells us that it's mostly european sport and tells us about development quantity, not quality. Ten years ago, non-european countries dominated the world of short track, but in the last 7 years, europeans are beginning to take the throne. The main reason is the spreading of coaches from outside of Europe, into Europe. Also, many athletes followed their coaches, so non-european athletes became european athletes. So, there lies the third reason, which is the quality of training conditions. For quality training in short track, there has to be a specialized ice rink with no fence, but specific padding system, which soothes the impact of skaters into the pads when they lose their balance. Also, quality of equipment is another factor. In the past, only non-european countries made boots and blades for short track speed skating, but as the time goes, more and more european countries also started that kind of buisness. So as the time has passed, european countries equalized with non-european countries, which almost assimilated European and World championships. Furthermore, the quality of ice on which competition is held is of great importance. It depends on what water they

use, temperature of surface, temperature of ice rink and many other factors. Taking into account that competitions, European and World championships, are held on best ices, it’s no surprise that results are almost the same.
On the other hand, it came as some surprise that there are no statisticaly significant differences. European and World championships are two different levels of competition, World championship being the higher one and right behind Olympic games. As the level of competition rises, so does the level of competitiveness, which draws out more mental energy ,requires higher mental preperation and builds up motivation. Led on by that thought, skaters should have more adrenaline in their bodies on the account of higher motivation, which should lead to better performance and better results. But sometimes, motivation can exceed normal (optimal) levels that downgrades performance. This explains why there are differences, but are not statisticaly significant.

Conclusion
In last 4 years 3 skaters moved from non-european countries to Europe because they found better training quality in Europe. If that trend countinues, we could have much more competitive European championships, and even more competitive than World championships.
The reasons of no statisticaly significant differences are mentioned above, but time is just a collateral factor in short track. Let us not forget that time in short track speed skating is not of great importance, nay it does not even determine the winner. It is true that the winner is going to have the fastest time in that race (relative time), but that does not mean that he has the fastest time in the world (absoulte time). In short track speed skating, the winner is not the fastest, but the smartest and the one who stays on his skates till the end.

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An example of the physical development program from an first division Croatian soccer league team with emphasis on sport science and load management

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ABSTRACT
The main purpouse of this paper is to show an example of the physical development program from a First Division Croatian soccer league team with emphasis on sport science and load management with current limitations and potentional solutions. Throughout history there have been a lot of training systems and athlete development systems stated by the national sport organizations, but over the last 30 years, sport clubs have become a leaders in the development of system design to attain high performance in sport (Jukic et al., 2018). This paper shows an example of professional soccer team management in performance meaning, giving the readers insight what to focus on with emphasised approach to load management and sport science department. One of the motives of this paper was to draw attention to the responsible people that there is a way to adress the chanel of communication with other soccer clubs and with Croatian Football Federation. Using sRPE method and A:C ratios we can provide a deep insight at what state the player is before and after camp, tournament, championship. We can see that this is for now the best method for finding a solution for injury prevention and performance state of the players. There is a way.

Key words: load management, soccer, sRPE, GPS, fitness, fatigue

Introduction
Sport represents social phenomena of the modern age. Achieving international and especially Olympic success has become increasingly important to a growing number of countries (Veerle De Bosscher et al., 2009). Elite sporting success represents highly valuable tool for his ability to help achieve a wide range of non-sporting objectives. A systematic approach to design of sport preparation reflects the interests of many stakeholders in sport (Digel, 2005). There is no difference in soccer. The evolving nature of professional soccer has led to the requirement for a scientific background to training, planning and structure (Malone et al., 2014). Throughout history there have been a lot of athlete development systems stated by the national sport organizations, but over the last 30 years sport clubs have become a leader in the development of system design to attain high performance in sport (Jukic et al., 2018). This way of thinking started to be very popular in Croatian soccer clubs and their staff trying to implement all scientific evidence and practical experience to achieve the best sport result for their conditions. One of the ways will be explained here. When we talk about this segments we need to have in mind that they represent synergy and communication of the whole personal that

make this system to achieve not only factors of speed, strength, endurance but also wellbeing of the athlete, social, cultural factors in pursuit of sporting results. Gabbet (2017) in his work represents 7 tips for developing and maintaining a high performance team, in this case sport medicine:

1. Do the basics well. Focus on doing them at 99%
2. Innovate with best up to date practice
3. Communication with all system segments
4. „Put the right people in the bus“ – find a common goal
5. Operate in unison – work together, working hard is not enough
6. Leverage the wisdom of crowds – diversity should be considered as a strength
7. Maintain proper perspective - be on disposal to your team

Perceiving the first tip and knowing the obligations in system we divided the roles on 3 part:

1. Team management
2. Sport Science
3. Rehabilitation

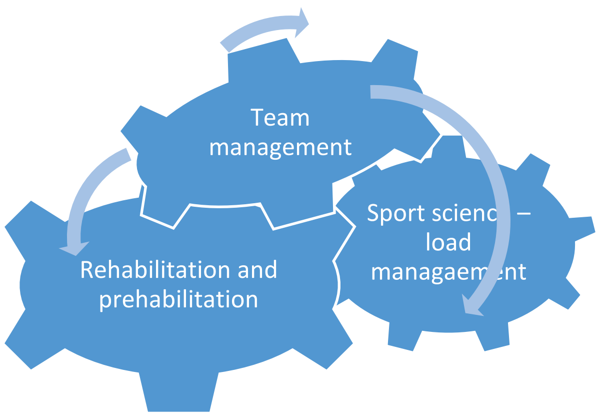

Figure 1. Strength and conditioning performance structure

Methods

Team management section

1. Schedule preparation and sending all the informations to the rest of the staff and players, so as personal of the club (website developers, sport directors, PR ecc.).. Starting at this point, we are making recognizable patterns of behavior.
2. Warm up strategies on the training sessions, on the friendly and official matches
3. Nutrition control and suplementation advices
4. Conducting individual sessions (strength session, endurance session, power and plyometric sessions)

Sport science section

Sport science department helps the team with up to date data in making timely and usefull decisions in terms of indecision and everyday life, to influence the improvement of collective work to achieve the desired results of sports preparation that includes satisfactory performance, reduced number of injuries as well as severity of injuries what will lead to sport succes. Together with this definition, the roles are:

1. Determining, execution and processing the diagnostics data
2. Load management (track and manipulating)
3. Determinating performanse state of the team and the players
4. Determinating weaknesses and strengths of the team so as individual needs
5. Giving up to date data to members of the staff

Rehabilitation section
All sections have the same responsibility of communication but the biggest importance is here. Rehabilitator needs to know at what state the player is at the time of injury so as in what state he will be in the middle or at the end of proces. At the end of rehabilitation, player will start to simulate the weekly training load of the team to be ready and not to be subjected to big spikes in load after returning to sport. The next step is converstation with head coach about the day he is returning to sport, at which level and when we can expect first minutes in matches. The responsibilities are: rehabilitation, prehabilitation, creating individual preventive programs, creating preventive programs for the team warm ups, injury evidention.

Results

Sport science – load management: Diagnostics
When we talk about diagnostics, depending on the schedule of competition, we can divide this part at yearly, monthly and weekly control. Yearly control of the team represents testing their abilities at the beginning of the preseason, end of the preseason, one or two times during the season and end of the season. At first point we start to test them during first week of the preseason. After advising with players and the reason that we do not want to gained rejection to diagnostics and logical thinking that most of the players comes in not so good shape, with little or none training history during off-season period, we started to conduct testing later in the preseason, giving them time to adapt to new stressors. Some of this test can lead to an increased stimuli of high intensity running or intensities that athlete havent been prepared yet. So we wanted gradualy make them feel safe and ready for that kind of work. This is not a problem if we know that every training is testing and we set it up like that.

Intemittent fitness test
Martin Buccheit (2010) constructed 30 – 15 intermittent fitness test in purpouse of creating a training protocol based on the test. It is importat to know how quickly performance on this test will improve if it is to be used for the prescription of training as an improvement of one level is considered a substantial change (Kelly, 2015). After diagnostics procedure, at early research (Matušinskij and Novačić, 2017) we showed that after 4 weeks of high intensity interval training in youth soccer players (n = 18, 17,4±0,50 year 179,83±6,93 cm , 70,16±6,08 kg) increased maximum oxygen uptake for 1,77 ml/kg/min (graph) , which is 3,4 % higher than in initial testing seassion. The increase of result is 4,35 % in second testing session, which represents 0,97±1,26, hence , one level of test. P-value is set on 0,05. From that, the conclusion is that with 95% certainty, there are significant differences between first and second testing session. In preparatory period, beside the training protocol for this ability, other forms and technologies of training were used (strenght trainig, prevention, saq, small sided games,technical and tactical training). Because of that, we can’t conclude that this improvement is only result of protocol for maximal oxygen uptake. We can only conclude that there are differences between initial and final testing session. We continue to use this test to follow our players adaptations to training so as creating high intenisty drills.

Countemovement jump, squat jump, stiffness jump

Countermovement jump represents valid and reliable instrument for meassuring vertical jump power (Malone et al., 2015). Cormac et al., (2008), Anderson et al., (2008) reported lower CMJ values after australian football and soccer mathes. Implementation of CMJ jumps have a big role in our system. We use it to create group and individual strength, power and plyometric programs, to track improvements in performance but also to track fatigue. We have noticed that after a week with increased total distance running the CMJ values were decreased. Every decreasement in % of the last time we meassured jumps in combination with other variables (TQR, A:C ration) giving us a signal to react. Following in season results in CMJ authors (Milanović, Matušinskij and Likić, 2018) noticed statisticaly significant increasement (p = 0,10) in two transitional meassurement from week 5 to week 7 (8,5%). The trend is also seen in week 9 of in-season on 10 soccer players of Croatian first division. Been conscious limitation of the research (small sample size, no control group) we can state that during in season period we can improve power abilities of our players. This research change the way we look at in season period. We have also seen improved values of the results after short activation (power, strength and plyometric drills with short volume during warm ups) comparing to the results before (3-4%). We havent publish this data yet.

Table 1. T-test for dependet variables (Milanović, Matušinskij and Novačić, 2018)

Paired Samples Test									
Mean		Paired Differences					T	Df	Sig. (2-tailed)
		Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference					
				Lower	Upper				
Pair 3	T_T3 - T_T4	-2,95000	2,89108	,91424	-5,01815	-,88185	-3,227	9	,010

Stiffness test

One of the reasons we implement this test was his relationship, more precise ground contact time with starting speed, accelereration and maximal sprinting speed. Most studies have shown that shorter ground contact times are seen in faster subjects compared to slower subjects (Mann, 1986; Weyand et al. 2000; Morin et al. 2012; Lockie et al. 2013) but this is not always the case (Brughelli et al. 2011). Mero et al., (1981) demonstrated functional links between jumping and sprint performance. The mean power developed during hopping in place can be estimated from the time the foot is in contact with the ground and from the flight time. The stiffness of the legs can be evaluated throughout the spring-mass model (Chelly et al., 2001). Hopping in place has basic mechanical features similar to the spring-mass model used during forward hopping or run (Chelly et al., 2001). At research conducted on 39 youth soccer players (n=39) of different ages (U13=15, 57,09±8,03kg, 169,04±8,34, cm U15=8, U17=16, 66,91±8,47kg, 176,6±4,37 cm, 69,85±5,42 kg, 177,61±7,46cm) middle league authors found that there is no significant correlation between these two variables (r = -0,128, *P* = NS) (Matušinskij and Dadić, 2018.). For this reason we interpret results now with caution and differently. We start to implement drop jumps with different heights.

Screening system (FMS)

In a meta-analysis Dorrel et al., (2015) indicated that FMS was more specific (85.7%) than sensitive (24.7%), with a positive predictive value of 42.8% and a negative predictive value of 72.5%. The area under the curve was 0.587 (LR+, 1.7; LR-, 0.87; 95% CI, 0.6-6.1) and the effect size was 0.68. Based on analysis of the current literature, findings do not support the predictive validity of the FMS. We still use this kind of diagnostics aware of the results of this research. It is important to be concious. This type of screening we use the first week of the in-season period. We want to check with what kind of limitation our players are coming to our facilites how could we create individual programs and on what should we focus more in prehabilitation programs before sessions. Superior movement proficiency is essential for safe and effective long term physical development and performance in athletes (Ryan et al.,2018). In this procedure we use deep squat test, split squat test, lunge test, active leg raise test, dorsiflexion, internal and external rotation, landing technics bilateral and unilateral and hop test.

Diagnostics in rehabilitation (steps)
After establishing sound load on player, before we let him to include with the team he needs to pass diagnostics procedure that incorporates IFT, CMJ, single leg CMJ, hop test, deep squat test on the first day. On second day we wanted to put player in more specific situation bringing him into a state of fatigue. After proper warm up, he is doing 2x5 minutes of high intensity interval training on 95% of Vift. We finish procedure with 2 sets of Lounborghow soccer passing test (LSPT). After subjective criteria (no pain on the scale from 0-10) and objective values (10% rule) he can join the team. We also use one guidline, we want that injured player undertake at least 5-7 days of training with the team before playing a match, and progressively increasing the minutes of play (this will depend of the severity of injury, location, missed days, and main coach decision).

Discussion

Load management: what do we know and in which direction do we go
Load is a combination of sport and non-sport stressors. Load is more than workload or training load alone and also includes competition, work, recreational activities, familiy, homework ecc. We need to ask ourself, what do we want to track, what are the reasons (injury prevention, managing fatigue, tracking performance,managing training load), how much time do we want to spend on it, what kind of materials do we have on disposal. We wanted valid and reliable data, sensitive to change, time efficient, easy to administrate, non expensive with immediate feedback. In sport science world, sport scientist usually obtain measurements of a prescribed external training load (physical work), accompained by an internal training load (physiological or perceptual response) (Gabbet, 2016). Simple, valid and effective method of measuring internal load is to use the session-rating of perceived exertion (RPE) scale developet by Dr. Carl Foster. This technique requires the athlete to rate each sessions overall difficulty (sRPE) on a 10-point scale. The multiplication of the session difficulty by the session durations (in minutes) provides the „Load“ for that session in arbitrary units (Load=RPE x duration in minutes). We started to use this method to track under what kind of load our players are, where we need to direct our training and are we at some risk. The variables are:

1. Chronic load (average weekly load, in our case 3 weeks)
2. Acute load (current week)
3. Freshness index - similar to training stress balance proposed by Andrew Coogan, represents the difference between chronic and acute (CL-AL) or between fitness and fatigue state
4. Monotony – measures the fluctuation of daily loads within the week. Intensive training combined with high monotony indeks (>2) is important risk factor for illness and overtraining
5. Strain – 89% of illnesses and injuries could be explaned by spikes in invididual strain in the 10 days perceding the incident

6. Acute:chronis workload ratio (ACWR) – measure the relationship between acute load and chronic load.
7. Week to week changes

In the paper of Gabbet (2016) if A:C ratio is more than 1.5, the risk of injury increases comparing with values bellow 1.5 (40% , 4%). Using results form Austalian football, rugby and soccer we can see the same trend using total distance as a variable. To minimize the injury risk we are trying to keep our players in „safe“ zone between 0,8 and 1,3. Paolo Menaspa (2016) sends correspondence to Drew and Purdam; are rolling averages the best way to asses training load for injury prevention? Tim Gabbet and his team (2016) answers that rolling averages are for now the best way for injury prevention. Sean Williams and group of authors (2017) determinate the better way to manipulate acute to chronic ratios. They proposed exponentional weighted moving averages (EMWA) that gives more weighting to the high loads undertaken towards the end of the 28 (in our case 21) days period and so produces a higher acute:chronic workload ratio on 28 day (or 21). After short time, Murray et al., (2016) wrote a paper that states that exponential weighted moving averages provides a more sensitive indicator of injury likelihood than rolling averages. The next step in manipulating acute:chronic ratios is creating optimisation strategies what we can see in study of Carey et al., (2017). Detailed study of the literature was the first step.

Table 2. Average team GPS values on weekly basis

DAY	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sun
TACTICAL GOAL	INTRO +TE-TA	INTRO + VELOCITY+TE-TA	PREP+TE-TA	GAME	REC+COMP +TE-TA	TE-TA	OFF
LOAD	MEDIUM	MEDIUM	LOAD	GAME	EASY	EASY	OFF
Day type	MD-3	MD-2	MD-1	MD	MD+1	MD+2	OFF
Distance (90')	6559	6559	5115	10350			
Zone 6 (>21 km/h)	57	57	70	292			
Hard Running	295	295	314	1119			
Work Rate	67	67	68	99			
Duration	98	98	75	95			
Sprint effort	21	21	20	61			
RPE	4,5	5	3,6	8,8	3/8	4	

Legend: INTRO: introduction day (each name represents type of a day during the week); VELOCITY: velocity day (elements of high speed running, additional work, PREP: preparatory day before a game; COMP: compensation day; TE-TA: technical-tactical session; MD-4, MD-3, MD-3, MD-1, MD: 4 , 3, 2, 1 day before a match, match day

At the end of every week sport performance team are preparing and sending infromations to all members of the staff. On the table 3. there are variables like total duration, high intensity running, sprint effort, sRPE that we follow. On a MD-3 what represents 3 days before a match players are asked for their wellbeing throughout total quality recovery questionare (TQR). We ask them before session on the first day in the week and day before a game. We do it like this to check their state after a game, how much time certain athlete need to recover and what kind of strategies do we need to take. Frst day in the week we measure body weight (control, rehydration) and CMJ. Every day after session we take sRPE also as GPS data. Using the data from sRPE and A:C ratio we can see that on the MD-2 and MD-1 (two and one day before a game) training loads are the lowest and we want to achieve highest TQR values on this days.

GPS

When we are looking at GPS variables (SPT system), we focus more on work rate as a measure of metabolic power, zone 6 (>21km/h), sprint effort (number of sprints) and hard running (running more than 17,5km/h). One of the ways we manipulate the data is to create the same paterns on MD-4, MD-3,MD-2,MD-1. On this way we know what kind of load we can put on our players and what reaction we can expect. In one example, higher values of total distance on MD-2 and MD-1 have been correlated with lower values on a game variables (hard running, sprint effort, total distance, not published data) showing that we need to direct our training proces in different way. This is the way how we can create a buckets of technical and tactical drills to see what kind of drill will give what kind of response from player (internal and external).With this infromation we recommend to head coach what drill we can put, for example, pass and move drills on the first day of the week to start the „engines" of the players, medium do big dimensions with small number of accelereations, not to overload small sided games on MD-2 or MD-1 ecc.

Acute to chronic workload ratio

The next important information that goes to head coach is about fitness and fatigue state of the players. The first report consist of data about the previous week that we were (7 days period). With this data we know at what A:C workload ratio (ACWR) of the player is, what is happening with his freshness index (WEEK 3 – WEEK 4) and also to check week to week changes in load (Table 3.)

Table 3. Acute to chronic workload ratio report

WEEK_1	WEEK_2	WEEK_3	AVG_(W1-W3)	WEEK_4	A:C	F_INDEX
1815	3375	3652	2947.333333	3910	1.32662294	-258
1580	4195	3524	3099.666667	4185	1.35014518	-661
2425	3600	4082	3369	3475	1.03146334	607

Legend: INTRO: introduction day (each name represents type of a day during the week); VELOCITY: velocity day (elements of high speed running, additional work, PREP: preparatory day before a game; COMP: compensation day; TE-TA: technical-tactical session; MD-4, MD-3, MD-3, MD-1, MD: 4 , 3, 2, 1 day before a match, match day

After analysing the data from table 3 we can see some trends. If the player is overloaded comparing with the previous week and weeks, is he in increased risk of injury and do we need to put him on recovery work or vice versa. Lets say that after week 3 the player is under 1,1 zone value comparing with the previous week, what means that he is in state of maintenance the performance. With this number we are more precise in planning the next week what will be explaned in table 4. For strength and conditioning coaches and sport scientist it is important to know that there are different types of players. Some of them will react very well on high jumps in loads (what also depends on training, history, injury history, fitness status). There are also some threshold that some players simply can not tolerate (big week to week jumps, 450-550 AU per week increase from one example, not published data). After we know the current state of the player showned in table 3, we are using the table 4 to plan next weeks load (example: player 1 = 3910 x 0,8/ 1,1 / 1,3). Using this value we decide do we want to keep him in deload, load zone or maintenance zone, taking into account previous week, opponent, TQR values, ACWR values, week to week changes, freshness index, CMJ values.

Table 4. Example of planification upcoming week

ACUTE	0.8	1.1	1.3
3910	3128	4301	5083
4185	3348	4603.5	5440.5
3475	2780	3822.5	4517.5

ACUTE: current week load; 0,8: deload; 1,1: maintenance; 1,3: load

Conclusion

The main purpouse of this paper is to show an example of the physical development program from an First Division Croatian soccer league team with emphasis on sport science and load management with current limitations and potentional solutions. When we are categorising the groups of players that we have in the team (first squad, bench players, reserves, non travel, national team players, injured players) here is also a categorisation that we can call „new players“, the players that are arriving to preseason (lets say one of the intense parts of the year) after they skip 3 or 4 weeks of it. That means that this player missed minimaly 4 short inteval training session, 4-6 strength training sessions, techincal and tactical sessions. We need to approach them differently like other groups we have in the team. We can see that this is big problem in team sports. One of the solutions can be short converstions before first session with the athlete about his training and injury history. Next step will be to check his motoric abilities at what level they are. If we notice some deficites we start to attacking them during period we decide. We use begining of the week as a starting point. One more way and solution for this problem can be implementing sRPE. Implementing this strategy in league clubs and use Croatian Soccer Federation to teach coaches and athletes about his method. What is also important is that this method is not time consuming, it is non invasive and giving us very fast feedback. We only need to learn. In every moment the national teams and clubs will have the informations at which state the player is if he is going on a camp and at which state he will come back. This way communication with the clubs will be even better so as with Croatian Soccer Federation as a head institute in Croatia. The number of injuries, severity of injuries, perfromance of the players so as talent development programs can be more efficient in achieving their goals whats need to be the first thought in developing young and resilient wellbeing persons/athletes. There is a way.

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Psychological coping skills in female senior volleyball players

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ABSTRACT
To determine the differences related to age and player position in psychological coping skills, 70 female senior players, whose mean age was 20.60±2.90 years, filled out the Athletic Coping Skills Inventory (ACSI-28; Smith et al., 1995). Female senior volleyball players are characterized by low level of Freedom from worry (2.82), moderate level of Peaking under pressure (3.21), Concentration (3.22) and Coping with adversity (3.42), and somewhat higher level of Coachability (3.89) and Confidence & Motivation (3.82). Among the 7 measures of the questionnaire, significant difference related to age was determined only in the Freedom from worry variable (F=3.09; p=.047), as the eldest players had significantly higher values in this variable in relation to the other two age groups. The experience of playing at senior level contributes to better control of state anxiety of players. There were no statistically significant positional differences determined in psychological coping skills. The obtained results suggest that psychological coping skills do not cause positional differences between female senior volleyball players as some other dimensions of anthropological status do (e.g., anthropometric characteristics, motor skills, technical and tactical skills, etc).
By dividing players into three groups (types) according to their level of psychological coping skills, significant differences are determined between groups of senior players in all the measured variables. It would be justified to assume that psychological skills of players of one group (*type 3*) may have a great negative effect on their individual sports achievement in a volleyball match.

Key words: ACSI-28, metric characteristics, ANOVA, player position, age

Introduction
Volleyball is characterized by dynamic and quick alteration of active and passive phases (Janković & Marelić, 2003; Ayal et al., 2012; Gaurav et al., 2014). Considering the high demand for quality performance, apart from good conditional abilities and good technique and tactics, players are required to have high level of psychological skills (Milavić et al., 2013). Coping with adversity is the ability to remain emotionally stable and positive during sport performance or competition no matter the situation (Weinberg & Gould, 2011), and to utilize other psychological skills and coping strategies. *Athletic Coping Skills Inventory-28* (*ACSI-28* hereinafter) (Smith et al., 1995) is one of the most widely used questionnaires for assessing coping skills in sport. This version of the questionnaire measures 7 out of the 8 dimensions which made up the *Survey of Athletic Experience* (Smith et al., 1990) questionnaire from which the ACSI-28 is derived. Metric characteristics of the questionnaire have been tested in volleyball, and age and positional differences have been analyzed on a sample of youth female volleyball players (Milavić et al., 2013). Therefore, the main goal of this study is to analyze differences in coping skills related to age and player position, on a sample of female senior volleyball players.

Methods

The subject sample of this study included 70 female senior volleyball players aged 16 to 30 years. The players were members of the 6 clubs which competed in the *Croatian A1 Women's league* in the 2016/2017 competitive season, categorized according to player position: 11 setters, 10 opposite players, 22 passer-hitters, 16 middle blockers – 1st tempo attackers, and 11 libero players.

The measurement of the subjects' psychological coping skills was performed by applying the ACSI-28, Smith et al. (1995). The inventory measures 7 psychological coping skills and it consists of 28 five-point Likert-type items: *Coping with Adversity* (abbreviation COPE); *Peaking under Pressure* (abbreviation PEAK); *Goal-Setting & Mental Preparation* (abbreviation GOAL); *Concentration* (abbreviation CONC); *Freedom from Worry* (abbreviation FREE), *Confidence & Motivation* (abbreviation CONF); and *Coachability* (abbreviation COACH). A more detailed description of each scale and basic metric characteristics of the questionnaire validated on a sample of female volleyball players can be found in a paper written by Milavić et al. (2013).

In agreement with the coaches of the senior volleyball teams, the questionnaires were distributed among the players and group testing was conducted during the volleyball season. Underage players filled out the questionnaire after the parents/guardians gave their written consent. At the beginning of the testing, the researcher explained to the players the importance of answering the questions sincerely. In case a participant needed help filling out the questionnaire, or asked for some additional information, the researcher was available during the entire testing.

After calculating the basic descriptive indicators, age and positional differences were determined by analysis of variance, whereas the differences between separate age groups and positions were analyzed by *Fisher's LSD test*.

All variables were positively oriented, i.e., a higher result also represented a more desirable result.

At the end, by using taxonomic analysis (K-means clustering), all volleyball players were categorized into 3 groups, according to the level of measured psychological characteristics, so that the differences between mean results of one group differed as much as possible from the mean results of other groups.

The tests and data gathered were entered and analyzed by the *Statistica Ver. 13.00* software.

Results

Results of basic metric characteristics of the ACSI scale – 28 questionnaires for the sample of female senior volleyball players (N=70) are presented in Table 1.

Table 1. Basic descriptive characteristics of ACSI scales – 28 questionnaires (N=70)

VARIABLE	AM	SD	D(KS)	MIN	MAX	SKEW	KURT
COPING WITH ADVERSITY	3.42	0.59	0.12	1.75	5.00	0.09	0.44
COACHABILITY	3.89	0.69	0.15	2.50	5.00	-0.10	-1.11
CONCENTRATION	3.60	0.57	0.12	1.75	4.75	-0.44	0.41
CONFIDENCE & MOTIVATION	3.82	0.55	0.11	2.50	5.00	-0.03	-0.34
GOAL-SETTING & MENTAL PREP.	3.22	0.70	0.10	2.00	5.00	0.44	0.31
PEAKING UNDER PRESSURE	3.21	0.82	0.12	1.25	5.00	0.09	-0.24
FREEDOM FROM WORRY	2.82	0.75	0.12	1.00	4.50	-0.48	-0.02

LEGEND: AM – arithmetic mean; SD – standard deviation; D (KS) – coefficient of K-S test; SKEW – measure of distribution asymmetry; KURT – measure of distribution peakedness.

The cutoff value for determining significant deviation from normal distribution for all results in the applied variables was determined by K-S test, and in this case for N=70 its value was 0.16. By analyzing Table 1, it can be seen that there was no significant deviation from normal distribution in any of the results of the measured variables, the measures had good sensitivity and further use of parametric statistical procedures in this study was justified. All the results and all the variables had mild positive and negative peakedness, except for the variable *Coachability*. Arithmetic means in certain scales of the questionnaires varied between 2.82 (*Freedom from worry*) to the highest 3.89 (*Coachability*). Female senior volleyball players were characterized by low level of *Freedom from worry* (2.82), moderate level of *Peaking under pressure* (3.21), *Concentration* (3.22), and *Coping with adversity* (3.42), and somewhat higher levels of *Coachability* (3.89) and *Confidence & Motivation* (3.82).
Analysis of variance of female senior volleyball players across different age groups according to the level of psychological coping skills is presented in Table 2.

Table 2. Age differences among female senior volleyball players according to the level of psychological coping skills

	PLAYER'S AGE							
	16-18 years N=20		19-21 years N=26		22 years and older N=24			
VARIABLE	**AM**	**SD**	**AM**	**SD**	**AM**	**SD**	**F**	**p=**
COPING WITH ADVERSITY	3.30	0.66	3.39	0.57	3.55	0.54	1.05	0.36
COACHABILITY	3.90	0.70	3.83	0.70	3.94	0.68	0.16	0.85
CONCENTRATION	3.41	0.76	3.64	0.51	3.70	0.43	1.53	0.22
CONFIDENCE & MOTIVATION	3.76	0.62	3.84	0.59	3.85	0.45	0.16	0.85
GOAL-SETTING & MENTAL PREP.	3.19	0.81	3.37	0.65	3.08	0.64	1.13	0.33
PEAKING UNDER PRESSURE	3.14	0.89	3.22	0.78	3.27	0.84	0.14	0.87
FREEDOM FROM WORRY	2.61#	0.84	2.71¥	0.75	3.11#¥	0.59	3.09	0.05*

LEGEND: AM – arithmetic mean; SD – standard deviation; F – coefficient of analysis of variance; p= – level of statistical significance; * – statistically significant difference; # – statistically significant difference by post-hoc Fisher's LSD test between the youngest (16-18 years) and the oldest group (22 years and older) of female senior volleyball players with the level of significance of p=0.03; ¥ – statistically significant difference by post-hoc Fisher's LSD test between the second oldest (19-21 years) and the oldest group (22 years and older) of female senior volleyball players with the significance level of p=0.05.

By analysis of variance of coping skills in senior volleyball players of different age, statistically significant difference was determined for the variable *Freedom from worry*. The eldest group of volleyball players (22 years and older) has significantly higher results in this variable in relation to the other two age groups. In other variables of the ACSI questionnaire, no significant age differences were determined.
Positional differences between female senior volleyball players regarding their level of psychological coping skills are presented in Table 3.

Table 3 Positional differences between female senior volleyball players regarding their level of psychological coping skills

	PLAYER POSITION											
	SETTER N=11		OPPOSITE PLAYER N=10		PASSER-HITTER N=22		MIDDLE BLOCKER N=16		LIBERO N=11			
VARIABLE	AM	SD	AM	SD	AM	SD	AM	SD	AM	SD	F	p=
COPING WITH ADVERSITY	3.34	0.38	3.13	0.67	3.48	0.63	3.56	0.54	3.45	0.66	0.98	0.43
COACHABILITY	3.93	0.75	3.90	0.60	3.97	0.61	3.67	0.76	3.98	0.78	0.51	0.73
CONCENTRATION	3.52	0.56	3.58	0.87	3.56	0.56	3.69	0.40	3.64	0.57	0.18	0.95
CONFIDENCE & MOTIVATION	3.89	0.67	3.70	0.57	3.68	0.52	3.91	0.48	4.02	0.54	0.98	0.42
GOAL-SETTING & MENTAL PREP.	3.09	0.87	3.38	0.73	3.28	0.70	3.22	0.64	3.09	0.63	0.35	0.85
PEAKING UNDER PRESSURE	3.09	0.84	2.98	0.96	3.15	0.84	3.28	0.60	3.59	0.92	0.91	0.47
FREEDOM FROM WORRY	2.91	0.67	2.53	1.03	2.83	0.70	2.83	0.55	2.98	0.90	0.54	0.71

LEGEND: AM – arithmetic mean; SD – standard deviation; F – coefficient of analysis of variance; p= – level of statistical significance; * – statistically significant difference.

The obtained results varied from moderate 2.53 (*Freedom from worry* in *opposite players*) to moderately high 4.02 (*Confidence & Motivation* in *libero players*). Analysis of variance of groups of female senior volleyball players playing different player positions regarding the level of psychological coping skills showed no statistically significant difference.

Characteristics of differences between three types of female senior volleyball players with different psychological coping skills are analyzed in Table 4.

Table 4 Descriptive values of psychological characteristics of types of female senior volleyball players

VARIABLE	GROUP						F	p=
	Type 1 N=26		Type 2 N=33		Type 3 N=11			
	AM	SD	AM	SD	AM	SD		
COPE	3.38	0.43	3.70	0.53	2.70	0.43	17.64	0.000***
COACH	3.33	0.47	4.35	0.48	3.82	0.65	29.42	0.000***
CONC	3.53	0.43	3.89	0.46	2.86	0.47	22.05	0.000***
CONF	3.67	0.46	4.06	0.48	3.45	0.66	7.85	0.001***
GOAL	3.03	0.62	3.46	0.71	2.95	0.62	4.12	0.021*
PEAK	2.79	0.55	3.67	0.73	2.86	0.96	12.64	0.000***
FREE	2.90	0.56	3.10	0.62	1.80	0.62	19.76	0.000***

LEGEND: AM – arithmetic mean; SD – standard deviation; F – coefficient of analysis of variance; p= – level of statistical significance; * – statistically significant difference at the level of p<.05; ** – statistically significant difference at the level of p<.01; *** – statistically significant difference at the level of p<.001.

Due to the small size of the total sample, the subjects were divided into three groups (types according to psychological characteristics), and the results of analysis of variance between the groups confirmed that the groups differed significantly in all the measured variables.

Type 1 players were characterized by moderate mean values of 4 variables (COPE, COACH, CONC, CONF) and low levels in 3 variables (GOAL, PEAK, and FREE), and they made up approximately 37% of the subject sample.

Type 2 players were characterized by the highest mean results in all the variables, as compared to the other two groups, and they made up approximately 47% of the subject sample. Very good results in variables COACH and CONF were most pronounced, whereas the results in the remaining 5 variables were moderate. Variable FREE was least expressed in this group of players as well.

Type 3 players were characterized by moderate values in only 2 variables (*Coachability and Confidence & Motivation*), and low or very low values in all five remaining measures, and they made up approximately 16% of the subjects. Low mean value of 1.80 in the variable FREE was particularly noticeable.

Discussion

The results of psychological characteristics indicate that senior players are characterized by the highest values of *Coachability* and *Confidence & Motivation*, and the lowest values of *Freedom from worry*. Players are burdened with worry of performing poorly or making a mistake, so they put more pressure on themselves during a match. Furthermore, senior players mostly do not handle pressure during a match well. Players are quite open to coach's critics and instructions. Compared to the findings regarding psychological characteristics of youth volleyball players (Milavić et al., 2013), senior volleyball players display much more pronounced *Peaking under pressure* and *Goal-setting & Mental preparation*, but also lower *Freedom from worry*. These two first noticeable "differences" are understandable and expected. However, noticeably lower value of the measure *Freedom from worry* indicates that the higher level and quality of play in senior volleyball produce situations in players which they find more stressful. Moreover, youth volleyball players have higher level of *Freedom from worry* (3.23), junior players somewhat lower level (2.98), and senior players the lowest level measured (2.82). It is possible that "stressfulness" of situations is for senior volleyball players related to the environment they are playing in (playing in front of a greater audience; presence of press and electronic media; higher pressure of individual and collective achievement; high personal and club expectations). The other 4 measures of psychological characteristics have very similar levels in both senior and younger players (youth and junior). In any case, it is justified to recommend implementation of different programs of intervention with the aim of lowering the level of state anxiety in senior female volleyball teams (Gould et al., 2001; Jurko, 2013; Milavić, 2013).

Generally, the results of psychological coping skills of senior players in all age categories show that average results of metric characteristics (except for the *Freedom from worry* scale) have very little correlation to players' chronological age. Out of the 7 measures of psychological characteristics between groups of players of different age groups (younger aged 16-18 years; middle aged 19-21 years; older aged 22 years and older), significant difference is found only in one variable – *Freedom from worry*. The lowest mean value of *Freedom from worry* (2.61) is determined in the youngest group of senior players (16-18 years). This indicates that players ages 16-18 years are most worried about their performance so as not to make a mistake during performance. Older and more experienced senior players (22 years and older) have the highest level of *Freedom from worry* (3.11) and differ significantly from the middle age group (2.71). This result seems opposite to that in the previous paragraph in which it has been determined, by comparing players of different age category that state anxiety increases with chronological age. However, the authors believe these findings can be reasonably explained.

First, only 20 players aged 18 years or younger, who have sufficient individual player quality for their clubs to put them on their senior team roster, are included in this study. By measuring players of younger age group who play for their junior and/or youth teams, many players of „poorer" player quality were measured as well, which might have resulted in their lower anxiety. Secondly, young players who play for senior teams at high competition level, play in substantially different conditions (high expectations and high team achievement orientation) than those playing within their age group. Thirdly, these young players might be included too early or be poorly prepared for what is expected of them in senior volleyball. Lastly, being among the youngest in their teams, they might not have developed good cohesion with other, older players, which might be causing higher state anxiety (worry) because of possible mistakes during play. Namely, it has been determined that in sports teams with lower cohesion, team members exhibit higher level of individual state anxiety (Cox, 2005). Nonetheless, it is recommended for special attention to be paid to working with the youngest players in senior teams, so that they are well prepared and gradually included in the senior team, to lower expectations and obligations during the first year, to pay enough attention and time to developing cohesion between older and the youngest players (possibly even by introducing a system of mentorship).

Generally, differences in psychological skills between groups of senior players playing at different positions are not determined. Similar results are determined by comparing youth volleyball players (Milavić et al., 2013; Milavić et al., 2013). Other studies have confirmed that positional differences are much more determined by other anthropological characteristics (e.g., Sporiš, 2011), and certain motor abilities (e.g., Duncan et al., 2006 Woodfield, & Al-Nakeeb, 2006)), rather than psychological characteristics.

Even if most frequent positional differences between players have already been determined in literature in anthropometric characteristics (Gualdi-Russo & Zaccagni, 2001; Sporiš, 2011), and in some motor abilities (Duncan, Woodfield, & Al-Nakeeb, 2006; Marques, van den Tillaar, Gabbett, Reis, & González-Badillo, 2011).

By dividing players into three groups according to their level of psychological coping skills, significant differences are determined between groups of senior players. By such typing of senior players it has been determined that: the first group of players (*type 1*), which makes up about one third of the total sample (~37%) is characterized by low values of variables *Goal-setting & Mental preparation, Peaking under pressure* and *Freedom from worry*, and moderate values of the other variables; the second group of players (*type 2*), which makes up about half of the total sample (~47%), are characterized by higher *Confidence & Motivation* and *Coachability*, and moderately high results in other variables, while all the results of psychological characteristics of this group are the highest in relation to the other two groups; the third group of players (type 3), which makes up about one seventh of the total sample (~16%), are characterized by moderate values in only two measures (*Coachability* and *Confidence & Motivation*), and low or very low values in all five remaining measures, with particularly low value of the variable *Freedom from worry*. It would be justified to assume that psychological skills of groups 3 and 1 may have a negative effect on their individual sports achievement in a volleyball match. This is particularly true for players in group 3. The profile of psychological coping skills for *Type 3* players indicates the possibility of negative determination of individual sports achievement over a longer period of time due to lack of sufficiently expressed coping skills. Such profile of skills portrays players who will often appraise distinct and specific situations in a match as a threat due to their lack of sufficiently expressed psychological coping skills. Psychological skills are acquired or improved by practice, and it is recommended to implement collective or individual programs in which they would be practiced and perfected. There is a need for this in the other two groups of players as well, but it is somewhat less pronounced. Limitations of this study include: a small subject sample and subjects from only one country; measurement of players' chronological age, but not of other possibly significant individual or team characteristics of players (such as duration of playing experience at senior level competition).

Conclusion

Generally, low level of certain skill in players points to the necessity of their systematic improvement, especially of skills *Freedom from Worry. Peaking under Pressure*; *Goal-Setting & Mental Preparation*, and to a somewhat lesser extent *Coping with adversity*. On a sample of senior volleyball players, there were no significant differences determined in psychological coping skills according to player position. The eldest group of players with most experience differed significantly from the other two groups in the measured variable *Freedom from worry*, while having significantly lower and more desirable level of state anxiety in relation to the other two groups of players. Thus, only by long-term experience of playing volleyball at the highest level, the players acquire adequate level of skill freedom from worry which allows them to better realize their player potential in a match. Within the subject sample, one group of players (type) stood out with their psychological coping skills profile, which has a much more expressed need for practicing skills to be more successful in performing volleyball skills in matches.

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A pagerank approach to the NFL ranking problem

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ABSTRACT
The NFL faces the challenge of ranking teams that do not play against each other. The team ranking is mainly based on total of wins and losses during the season, even with each team playing against only a small fraction of opponents. So, it is an interesting challenge to create a ranking system that is mathematically well grounded for such problem. The objective of this article is to propose a ranking based on the Google's PageRank algorithm, which weighs not only the number of wins and losses, but also the quality of each opponent faced. The results indicate that the proposed approach does, in fact, create more efficient rankings when compared to the official one used by the NFL.

Key words: sports ranking systems; Google' algorithm; graphs

Introduction
The NFL (National Football League) features 32 teams, divided equally into two conferences (the NFC – National Football Conference; and the AFC – American Football Conference) and each conference has four divisions (North, South, East e West).
On a regular NFL season, each team plays sixteen matches: (i) six matches against teams at the same division; (ii) four matches against teams at another division at the same conference, where such division is selected on a three year rotating cycle; (iii) four matches against teams at another division at the other conference, where such division is selected on a four year rotating cycle; and (iv) two matches against teams at the same conference according to the previous year ranking (the team that finished the last regular season in first on its division, will face the other two teams from the other two divisions that were not picked on previous criteria; the same applies to the teams that finished the last regular season on second, third and fourth).
So, on a regular season, each team plays sixteen matches, against thirteen different opponents. At the end of the regular season, the eight teams with the highest number of wins at each division (win-tie-loss records) are classified to play the post-season matches (playoffs). Other than that, the two teams with the most wins, at each conference, besides the eight teams leading each division also qualify, creating the group with twelve teams that will play the playoffs and the NFL final match.
Another point worth noting is the order for picking the players during the draft for next season. The NFL draft is an annual event where the 32 teams are able to choose new players from college teams. The choosing order is also based on the win-tie-loss records on the regular season, with the exception of the two teams that played the NFL final (Super Bowl), those are the last ones to choose.
But since each team does not play against every other team on the league, how is possible to create a unique ranking comparing teams that do not face each other? In other words, if a supposed team A does not play against a supposed team B, how may both be included at a single ranking?

The actual ranking system used by the NFL, where only the number of victories is mainly taken account, ends up blurring the difficult that each opponent represents (Vaziri *et al*.; 2018). In addition, the fact that each of the 32 teams dispute their matches against another 13 teams only also brings an unbalance component to the league fixtures, except when considering teams on the same division (Winchester & Stefani; 2013) and makes the ranking system underdetermined or contradictory or both (Park & Newman; 2005).
An efficient ranking system should consider not only the number of victories of each team, but also how strong the opponents that were defeated. Since, a victory against a stronger opponent is more significant than against a weaker one (Lazova & Basnarkov; 2015).
Based on this scenario, the objective of this article is to propose a ranking of the professional football teams during a regular season (different from the league's official ranking), where not only the number of victories is taken account, but also the overall quality of each opponent faced and the difficult level of the matches.
There are several studies that address the application of alternative rankings for sports results. In most of them, rankings are based on comparisons of the statistics of each team during a season or based on performance over the years of competition, and are analyzed with the application of linear programming algorithms or multicriteria analysis.
A tool that addresses such objective is the PageRank method. This method was originally conceived by (Page & Brin; 1998) and (Page *et al*.; 1999) to evaluate the websites importance through their respective link structures. However, in spite of its specific proposal, the mathematical algorithm behind the method proves to be generative and applicable to any network of graphs (Gleich; 2015).

Method
Although it is the simplest measure for ranking, the number of wins and losses (win-tie-loss records) is almost the only one measure that everyone seems to agree with (Park & Newman; 2005). However, in competitions where each team does not play their matches against all the others, this measure lacks efficiency in demonstrating the best ranking, since the difficult level of the opponents ends up being disregarded.
In order to correct such issue, the method proposed in this article will consider not only the direct victories and defeats of each team, but also indirect victories and defeats.
An indirect victory or defeat of a given team represents the result of a match between direct opponents with an indirect opponent. That is, considering that although a given team *A* does not play matches with a given team *C*, may team *A* have won its match against a given team *B* and team *B* has won its match against team *C* (Figure 1). So, in that case, team *A* has an indirect victory over team *C*.

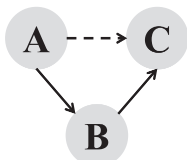

Figure 1. If team wins over team and that same team wins over team , the team has an indirect victory over team (represented by the dotted arrow). Adapted from (Park & Newman; 2005).

Capable of capturing not only the edges between adjacent nodes, but also the edges that the adjacent nodes receive, PageRank is an efficient algorithm that allows to rank the importance of each node of the network. In the academic literature, PageRank has been applied successfully in the most diverse areas of knowledge, including in the sports

field. For ranking of alternatives, both to determine the ranking of sports teams, (Lazova & Basnarkov; 2015), (Kim; 2018) and (Park & Newman; 2005), to rank player performance, (Brown; 2017) and (Mukherjee; 2012), or to predict sports results, (Swanson *et al.*; 2017) and (Balreira *et al.*; 2014).
Thus, for this article, each NFL team is considered as a single node and two nodes are connected if, in that regular season, the two teams have faced each other at least once, for the direction of the arrows it starts from the winning team and ends on the defeated team.
The weight of each edge is determined by a function involving the number of wins of a team time over a team , as well as the number of draws between teams and , as shown in Equation 1.

$$w_{i,j} = v_{i,j} + {}^{e_{i,j}}/_{2} \qquad \text{(Equation 1)}$$

Therefore, an adjacency matrix is formed with elements formed by (Equation 2).

$$A_{i,j} = \begin{cases} w_{i,j}, if\ there\ are\ more\ victories\ than\ losses\ of\ team\ i\ over\ j \\ 0, else \end{cases} \qquad \text{(Equation 2)}$$

The PageRank is then used to calculate the relevance of each node of the directed graph created (Gleich; 2015). This measure of centrality will then determine how important and influential the node within the network is (Martin *et al.*; 2014).
It is worth noting that the PageRank result is affected by the so-called damping factor. The damping factor is the probability of a supposed random walker jumps straight from a node to another random node within a graph (Page & Brin; 1998). The damping factor is required in order to ensure a convergence to zero in case of occurrence of such random path through the graph. The standard used in the academic literature to analyze the ranking of alternatives is 0.85.
Although the graph generated by matches played in a given NFL regular season is dense and complex, teams do not play matches against all other teams. Therefore, the damping factor will mean adding the team's winning score to everyone else, including those who did not have disputed matches.
The PageRank is then calculated through the interactive algorithm (Equation 3), which identifies the dominant eigenvalue of the matrix that corresponds to the non-variation of the distribution of times a random flux spends in a certain node (Langville & Meyer; 2004).

$$\pi^T = \pi^T Q \qquad \text{(Equation 3)}$$

By normalizing the adjacency matrix , we obtain the transient probability matrix with its elements, as shown in Equation 4.

$$Q_{i,j} = (1-\alpha).\frac{A_{i,j}}{\sum_{k=1}^{N} A_{i,k}} + \frac{\alpha}{N} \qquad \text{(Equation 4)}$$

Having found the PageRank indexes for each element, a ranking is then constructed where the element with the highest index is the one with the highest representativeness (importance) in the set. Therefore, this decreasing ranking may then be compared to the official ranking used by the NFL. For the proposed PageRank method, the *IGRAPH*

(Csardi & Nepusz; 2006) library was used combined with the software *R* and *Rstudio* v. 0.99.903.

The data used for the application of the PageRank algorithm were obtained from *sports-reference.com* (Sports-reference; 2018), it provides statistics about American sports and has all data relating to the results of each match played in the regular 2008 to 2017 seasons.

For every NFL franchise there is information about the faced opponents and the number of matches won, tied and lost. The database includes the information of the 32 football teams as well as statistics on 2,560 matches in the regular seasons from 2008 to 2017. On the last 10 seasons (2008 to 2017), the NFL had 32 teams. Throughout this article, the franchises are referred according to the abbreviations given in Table 1.

Table 1. NFL Franchises. The “Franchise” and “Abbrev” columns of the table refer to the name and initials of each of the 32 NFL teams, respectively. The “Division” column refers to the Conference and Division to which the team belongs. * The *San Diego Chargers* team in 2017 was renamed to *Los Angeles Charges* (LAC). ** The St. Louis Rams team in 2016 was renamed to *Los Angeles Rams* (LAR).

Team	Abbrev	Division	Team	Abbrev	Division
Arizona Cardinals	ARI	NFC West	Miami Dolphins	MIA	AFC East
Atlanta Falcons	ATL	NFC South	Minnesota Vikings	MIN	NFC North
Baltimore Ravens	BAL	AFC North	New England Patriots	NWE	AFC East
Buffalo Bills	BUF	AFC East	New Orleans Saints	NOR	NFC South
Carolina Panthers	CAR	NFC South	New York Giants	NYG	NFC East
Chicago Bears	CHI	NFC North	New York Jets	NYJ	AFC East
Cincinnati Bengals	CIN	AFC North	Oakland Raiders	OAK	AFC West
Cleveland Browns	CLE	AFC North	Philadelphia Eagles	PHI	NFC East
Dallas Cowboys	DAL	NFC East	Pittsburgh Steelers	PIT	AFC North
Denver Broncos	DEN	AFC West	San Diego Chargers *	SDG	AFC West
Detroit Lions	DET	NFC North	San Francisco 49ers	SFO	NFC West
Green Bay Packers	GNB	NFC North	Seattle Seahawks	SEA	NFC West
Houston Texans	HOU	AFC South	St. Louis Rams **	STL	NFC West
Indianapolis Colts	IND	AFC South	Tampa Bay Buccaneers	TAM	NFC South
Jacksonville Jaguars	JAX	AFC South	Tennessee Titans	TEN	AFC South
Kansas City Chiefs	KAN	AFC West	Washington Redskins	WAS	NFC East

In addition, through the official website of the American Football League (NFL; 2018) the official NFL rankings of the regular seasons under analysis were obtained, from which were picked the teams that played the playoffs of the respective seasons, as presented in Table 2, as well as the orders of choice of the drafts of the subsequent seasons were selected.

It is worth noting that for the past ten seasons the *Cleveland Browns* and the *Tampa Bay Buccaneers* did not play postseason matches, while the *Green Bay Packers* and the *New England Patriots* teams were the ones that most of the times advanced to the playoff phase, eight and nine times, respectively.

Table 2. Official NFL rankings for seasons 2008 to 2017. (*) teams qualified for the post-season as the best ranked in each division; (**) teams qualified for the post-season as the best campaign teams by conference, except the ranked teams as the champions of each division.

Team	Position in the ranking of the regular season									
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
ARI	12*	8*	27*	13**	26	10	6**	2*	20	18
ATL	6**	11	2	7	1*	26	23	14	5*	8**
BAL	7**	12**	3**	5*	9*	14	11**	26	17	11
BUF	22	24	29	23	23	24	13	15	21	12**
CAR	2*	16	32	24	18	3*	19*	1*	25	5**
CHI	13	21	5*	14	10	15	26	22	29	25
CIN	27	9*	30	10**	11	6*	10**	3*	24	19
CLE	28	25	28	28	27	27	20	31	32	32
DAL	14	5*	20	15	15	16	1*	29	2*	13
DEN	17	17	31	16*	2*	1*	2*	4*	11	26
DET	32	31	21	8**	28	20	7**	17	12**	14
GNB	24	6**	8**	1*	6*	13*	3*	8**	9*	20
HOU	18	13	22	9*	3*	32	14	12*	13*	29
IND	3**	1*	9*	31	7**	7*	8*	16	18	30
JAX	25	22	15	26	31	28	29	27	30	9*
KAN	30	28	10*	21	32	8**	15	6**	3*	10*
MIA	8*	23	17	25	19	17	17	23	10**	22
MIN	10*	4*	23	30	12**	25	21	7*	19	1*
NOR	19	2*	6**	3*	20	9**	22	18	22	7*
NWE	9	10*	1*	2*	4*	4*	4*	5*	1*	2*
NYG	4*	18	11	11*	14	21	24	24	6**	31
NYJ	15	14**	7**	17	24	18	27	9	26	27
OAK	26	26	16	18	29	29	30	19	4**	23
PHI	11**	7**	12*	19	30	11*	12	20	23	3*
PIT	5*	15	4*	6**	16	19	9*	10**	7*	4*
SDG/LAC	20	3*	14	20	21	12**	16	30	27	15
SEA	29	27	18*	22	8**	2*	5*	11**	8*	16
SFO	23	19	24	4*	5*	5**	18	28	31	24
STL/LAR	31	32	19	32	17	22	25	21	28	6*
TAM	16	30	13	29	22	30	31	25	14	28
TEN	1*	20	25	12	25	23	32	32	15	17**
WAS	21	29	26	27	13*	31	28	13*	16	21

Results

For the construction of the new ranking based on the indexes obtained with the PageRank algorithm, each regular season was analyzed independently. In each season, 256 matches were evaluated and, in each of them, three possible results were found: victory, defeat or tie.

It should be noted that in the 2,560 games analyzed, during the last ten seasons, only five of them resulted in a draw, while in the other 2,555 games, a winning team was observed. Based on the results of these games, the NFL team adjacency matrix was built. From the matrices of adjacencies, the graphs of the matches were created, and, therefore, ten directed and independent graphs, one for each regular season, were developed.

Then, in order to reflect the difficult of the matches of each team, the PageRank algorithm was then applied and obtained a new ranking, for each regular season from 2008 to 2017. Table 3 refers to the result of PageRank when applied to each regular season.

Table 3. Results of PageRank to the seasons from 2008 to 2017.

Team	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
ARI	0.0338	0.0533	0.0090	0.0257	0.0307	0.0507	0.0435	0.0534	0.0181	0.0293
ATL	0.0388	0.0563	0.0541	0.0356	0.0406	0.0327	0.0212	0.0207	0.0301	0.0427
BAL	0.0543	0.0479	0.0456	0.0371	0.0340	0.0262	0.0506	0.0147	0.0376	0.0325
BUF	0.0274	0.0200	0.0378	0.0252	0.0291	0.0260	0.0257	0.0266	0.0254	0.0349
CAR	0.0523	0.0240	0.0252	0.0246	0.0123	0.0448	0.0274	0.0589	0.0282	0.0441
CHI	0.0388	0.0330	0.0447	0.0434	0.0519	0.0204	0.0270	0.0343	0.0127	0.0286
CIN	0.0229	0.0211	0.0316	0.0451	0.0333	0.0301	0.0398	0.0574	0.0407	0.0173
CLE	0.0213	0.0157	0.0305	0.0131	0.0224	0.0125	0.0183	0.0228	0.0212	0.0142
DAL	0.0199	0.0498	0.0137	0.0363	0.0360	0.0325	0.0324	0.0136	0.0828	0.0356
DEN	0.0125	0.0186	0.0097	0.0355	0.0638	0.0470	0.0701	0.0472	0.0302	0.0163
DET	0.0141	0.0119	0.0281	0.0496	0.0296	0.0271	0.0560	0.0374	0.0246	0.0373
GNB	0.0284	0.0209	0.0426	0.0666	0.0512	0.0319	0.0678	0.0468	0.0418	0.0360
HOU	0.0327	0.0341	0.0126	0.0131	0.0536	0.0088	0.0344	0.0323	0.0293	0.0160
IND	0.0420	0.0800	0.0342	0.0081	0.0247	0.0422	0.0579	0.0304	0.0245	0.0195
JAX	0.0225	0.0204	0.0271	0.0177	0.0146	0.0198	0.0138	0.0111	0.0157	0.0275
KAN	0.0160	0.0170	0.0265	0.0309	0.0080	0.0424	0.0143	0.0512	0.0460	0.0221
MIA	0.0485	0.0214	0.0384	0.0246	0.0266	0.0274	0.0317	0.0121	0.0425	0.0215
MIN	0.0424	0.0654	0.0414	0.0238	0.0424	0.0150	0.0318	0.0450	0.0235	0.0432
NOR	0.0329	0.0257	0.0416	0.0269	0.0110	0.0443	0.0255	0.0159	0.0311	0.0454
NWE	0.0521	0.0444	0.0474	0.0459	0.0486	0.0433	0.0411	0.0414	0.0603	0.0464
NYG	0.0366	0.0348	0.0375	0.0281	0.0291	0.0375	0.0186	0.0195	0.0428	0.0190
NYJ	0.0221	0.0221	0.0456	0.0368	0.0248	0.0283	0.0223	0.0369	0.0161	0.0206
OAK	0.0142	0.0163	0.0203	0.0353	0.0154	0.0132	0.0166	0.0441	0.0608	0.0262
PHI	0.0329	0.0440	0.0293	0.0328	0.0147	0.0420	0.0305	0.0153	0.0347	0.0712
PIT	0.0535	0.0193	0.0609	0.0481	0.0246	0.0232	0.0165	0.0367	0.0479	0.0486
SDG/LAC	0.0329	0.0623	0.0280	0.0434	0.0246	0.0079	0.0335	0.0322	0.0112	0.0316
SEA	0.0199	0.0201	0.0227	0.0255	0.0405	0.0624	0.0407	0.0447	0.0212	0.0330
SFO	0.0249	0.0242	0.0126	0.0518	0.0486	0.0537	0.0239	0.0252	0.0114	0.0227
STL/LAR	0.0118	0.0165	0.0209	0.0210	0.0313	0.0422	0.0241	0.0267	0.0100	0.0396
TAM	0.0282	0.0190	0.0451	0.0220	0.0238	0.0378	0.0161	0.0126	0.0214	0.0331
TEN	0.0522	0.0256	0.0106	0.0127	0.0183	0.0135	0.0131	0.0091	0.0204	0.0169
WAS	0.0171	0.0151	0.0246	0.0136	0.0396	0.0133	0.0140	0.0238	0.0358	0.0270

Discussion

Through the analysis of the PageRank indexes found, it is possible to observe that the *Kansas City Chiefs* franchise, in the 2012 season, was the team with lower PageRank, 0.0079, considering the ten seasons under analysis. That represents the results of that season when it was considered the difficult of *Kansas* matches and its defeated opponents.

It should be noted that the *Kansas City Chiefs* in the 2012 regular season achieved few direct victories against teams with little significance. The franchise obtained a negative result, that is, won less games than lost (two and twelve, respectively). The direct victories were against teams with equally negative campaigns: *New Orleans Saints* (seven wins and nine losses) and *Carolina Panthers* (seven wins and nine losses). In addition, regarding the victories of the latter two, only two *Carolina* victories were against teams with positive campaigns: *Washington Redskins* (ten wins and six losses) and *Atlanta Falcons* (thirteen wins and three losses). The figure 2 depicts the *Kansas City Chiefs'* winning graph on two levels (the first level is the KAN direct wins and the second level shows the victories of the teams that were defeated by the KAN).

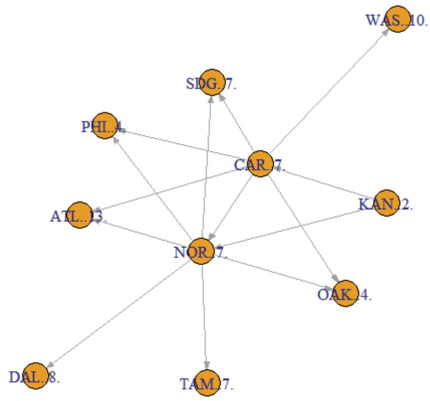

Figure 2. *Kansas City Chiefs'* winning graph for the 2012 season. The nodes are represented by the acronym of each team and their respective number of victories.

On the other hand, the *Dallas Cowboys* franchise in the 2016 season was the team with the highest PageRank, 0.0828, considering all ten seasons under review. That represents the results of that season when it was considered the difficult of the *Dallas* matches and its defeated opponents.

The *Dallas Cowboys*, in the regular season of 2016, got thirteen direct wins and only three losses. Of these thirteen victories, seven of them were against strong teams, that is, franchises with positive campaigns: *Washington Redskins*, twice (eight wins and eight losses); *Green Bay Packers* (ten wins and six losses); *Pittsburgh Steelers* (eleven wins and five losses); *Baltimore Ravens* (eight wins and eight losses); *Minnesota Vikings* (eight wins and eight losses), and; *Tampa Bay Buccaneers* (nine wins and seven losses). The figure 2 depicts the *Dallas Cowboys'* winning graph on two levels (the first level is the DAL direct wins and the second level shows the victories of the teams that were defeated by the DAL).

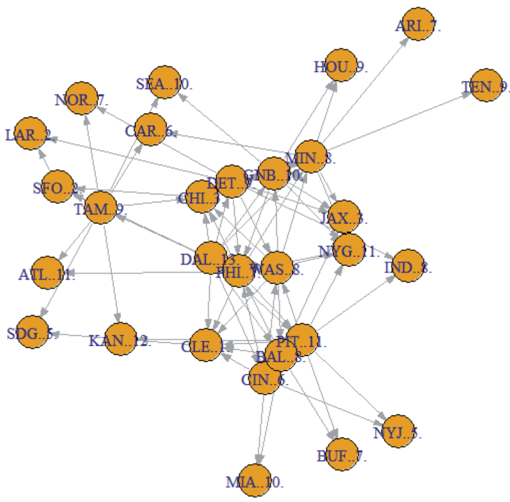

Figure 3. Dallas Cowboys' winning chart for the 2016 season. Nodes are represented by the acronym of each team and their respective number of victories.

Based on this scenario, the rankings obtained through the application of the PageRank algorithm were then compared to the official NFL rankings. In a regular season, the 32 NFL franchises are ranked according to their number of victories. In case of a tie in the number of wins, other criteria are considered, such as: the number of wins within the division; the performance within the division, and; results of direct matches. At the end of a regular season, teams are then ranked in descending order, which forms the official NFL ranking.

It is worth mentioning that, in order for the method that considers the PageRank algorithm to be better in than the official NFL method, in some aspect, both rankings would necessarily have to differ, at least in some results. Table 4 presents the ranking obtained through the application of *PageRank* [2] and the official NFL ranking [1] for the seasons 2008 to 2017.

Table 4. Comparison between the official NFL ranking, column [1], and the ranking obtained with the application of PageRank, column [2].

Team	2008 Season		2009 Season		2010 Season		2011 Season		2012 Season		2013 Season		2014 Season		2015 Season		2016 Season		2017 Season	
	[1]	[2]	[1]	[2]	[1]	[2]	[1]	[2]	[1]	[2]	[1]	[2]	[1]	[2]	[1]	[2]	[1]	[2]	[1]	[2]
ARI	12	12	8	5	27	32	13	19	26	15	10	3	6	6	2	3	20	26	18	17
ATL	6	9	11	4	2	2	7	12	1	8	26	14	23	23	14	23	5	15	8	7
BAL	7	1	12	7	3	4	5	9	9	12	14	21	11	5	26	27	17	10	11	15
BUF	22	19	24	23	29	12	23	21	23	18	24	22	13	18	15	19	21	18	12	12
CAR	2	3	16	16	32	22	24	22	18	30	3	5	19	16	1	1	25	17	5	5
CHI	13	10	21	12	5	7	14	8	10	3	15	24	26	17	22	14	29	29	25	18
CIN	27	21	9	19	30	15	10	6	11	13	6	17	10	9	3	2	24	9	19	28
CLE	28	24	25	30	28	16	28	29	27	25	27	30	20	25	31	22	32	24	32	32
DAL	14	26	5	6	20	27	15	11	15	11	16	15	1	12	29	28	2	1	13	11
DEN	17	31	17	26	31	31	16	13	2	1	1	4	2	1	4	5	11	14	26	30
DET	32	30	31	32	21	18	8	3	28	16	20	20	7	4	17	11	12	19	14	9

GNB	24	17	6	20	8	8	1	1	6	4	13	16	3	2	8	6	9	8	20	10
HOU	18	16	13	11	22	29	9	30	3	2	32	31	14	10	12	15	13	16	29	31
IND	3	8	1	1	9	14	31	32	7	21	7	9	8	3	16	17	18	20	30	26
JAX	25	22	22	21	15	20	26	27	31	29	28	25	29	31	27	31	30	28	9	19
KAN	30	28	28	27	10	21	21	16	32	32	8	8	15	29	6	4	3	5	10	23
MIA	8	6	23	18	17	11	25	23	19	19	17	19	17	14	23	30	10	7	22	24
MIN	10	7	4	2	23	10	30	24	12	7	25	26	21	13	7	7	19	21	1	6
NOR	19	14	2	13	6	9	3	18	20	31	9	6	22	19	18	25	22	13	7	4
NWE	9	5	10	8	1	3	2	5	4	5	4	7	4	7	5	10	1	3	2	3
NYG	4	11	18	10	11	13	11	17	14	17	21	13	24	24	24	24	6	6	31	27
NYJ	15	23	14	17	7	5	17	10	24	20	18	18	27	22	9	12	26	27	27	25
OAK	26	29	26	29	16	26	18	14	29	27	29	29	30	26	19	9	4	2	23	21
PHI	11	15	7	9	12	17	19	15	30	28	11	11	12	15	20	26	23	12	3	1
PIT	5	2	15	24	4	1	6	4	16	23	19	23	9	27	10	13	7	4	4	2
SDG/LAC	20	13	3	3	14	19	20	7	21	22	12	32	16	11	30	16	27	31	15	16
SEA	29	25	27	22	18	24	22	20	8	9	2	1	5	8	11	8	8	23	16	14
SFO	23	20	19	15	24	28	4	2	5	6	5	2	18	21	28	20	31	30	24	22
STL/LAR	31	32	32	28	19	25	32	26	17	14	22	10	25	20	21	18	28	32	6	8
TAM	16	18	30	25	13	6	29	25	22	24	30	12	31	28	25	29	14	22	28	13
TEN	1	4	20	14	25	30	12	31	25	26	23	27	32	32	32	32	15	25	17	29
WAS	21	27	29	31	26	23	27	28	13	10	31	28	28	30	13	21	16	11	21	20

Through Table 4, it is possible to observe that of the 320 rankings analyzed (each team is ranked in one of 32 positions in each of the ten seasons), the NFL ranking results were similar to those of PageRank in only 27 situations. Therefore, PageRank ranked teams differently from the NFL in 91.5% of cases. This fact confirms the assertion that the classification system currently employed may not be the most efficient in comparing the performance of the teams.
In line with the above, for all other seasons, differences of ranking between the two were also identified, as presented in Table 5.

Table 5. Standard deviation per regular season. The second row of the table represents the standard deviation relative to the difference between the ranking formulated through the PageRank algorithm and the official NFL ranking.

Regular season	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Standard Deviation	2.96266	3.55976	4.28250	4.93987	3.87903	5.04821	3.95630	3.49497	4.06154	3.98385

It should be noted that the regular season of 2013 was the one with the highest divergence between the NFL ranking and the ranking obtained with PageRank, σ = 5.04821. This is due to the wide range between the two rankings (the NFL ranking and the *PageRank* ranking), especially for the SDG teams (NFL ranking = 12th position, PageRank ranking = 32nd position) and TAM (NFL ranking = 30th position, PageRank ranking = 12th position).
This confirms the assumption that PageRank is capable of taking account not only the number of wins, losses and draws of each team, but also the difficult level of each opponent faced. Noting the fact that the *San Diego* team had, in the regular season

of 2013, nine victories while the *Tampa Bay* team had four victories. However, teams defeated by TAM (MIA, ATL, DET and BUF) had a better rating than teams defeated by SDG (PHI, DAL, IND, JAX, KAN twice, NYG, DEN and OAK).
These divergences, therefore, end up affecting the list of teams that advanced to post-season phase. For example, the 2017 season, where the teams PHI, NOR, MIN, LAR, CAR and ATL (classified by the NFC) were classified for the playoffs; PIT, NWE, JAX, KAN, BUF and TEN (classified by the AFC). While the National Football Conference qualifiers are consistent with the results obtained with PageRank, those that were classified by the American Football Conference differ. When considering the indirect wins, as well as the difficult level of each team matches, BAL and LAC would be those classified by the AFC as opposed to KAN and TEN.
From the above, it is possible to emphasize that PageRank, when used as a ranking method, assigns higher scores to the nodes that have neighbors with high ranks. This high ranking can be attributed, mainly, to two factors: for having received significant amounts of votes (few neighbors, but each with many victories); or because many neighbors have low ratings (many neighbors, but with few victories). Therefore, a team has a high ranking in case it has defeated many low ranking teams or has defeated, even in a smaller number, highly ranked opponents.

Conclusion

The objective of this article was to propose a ranking system for a sports tournament, capable of efficiently compare teams that do not necessarily play matches against all the other teams in the competition.
Using the PageRank algorithm to the results (victory, draw or defeat) of the 2,560 matches played during the regular seasons from 2008 to 2017, shows a great difference between the proposed method and the official rankings.
With the results, it was possible to understand the inefficiency of the current NFL ranking in comparing the result of teams that do not dispute matches between themselves. However, the combination of solid and believable results with a strong common sense base makes the algorithm results a compelling ranking system for the American football league, capable of combining the victories of each team with their indirect victories and the difficulty level of each opponent.
It is worth noting that the proposed method can also be applied to other ranking problems besides American football, including games, sports or other problems. In the same way, the application of the algorithm per round could be an interesting future research, being able to provide a more efficient ranking for each set of games played.

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Normative values of specific motor tests for handball goalkeepers

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ABSTRACT
Specific motor abilities have been analyzed by batteries of tests on a sample of 181 male handball goalkeepers (from 15 to 25 years old), participants at the International Handball Goalkeeper's camp. There were 13 newly designed measuring instruments in different conditions of competition, mostly for assessment of frontal-plane movement, lateral agility and explosive power in a lateral jump. In accordance with the results of the study, marginal values have been analyzed for five qualitative classes of different age categories, which were based on statistical parameters. Quantitative assessment of specific motor abilities on a Likert scale was achieved by comparing the results of each goalkeeper with the corresponding normative value of the test and the age. To make the evaluation more precise, we have presented the mathematical procedure for its validation. The results of the study have an applicative value in the processes of selecting and training handball goalkeepers.

Key words: assessment, goalies, norms, team handball

Introduction

According to the rules of the handball game, the goalkeeper plays an important role and has specific technical and tactical actions that are significantly different from the actions of field players. Unlike other players, the goalkeeper operates independently within a limited area (goalkeeper's area), being in a position to most directly influence the outcome of every opponent's attempt to finalize the attack. Due to his particular responsibility, a goalkeeper contributes more significantly than the rest of the players to the positive or negative emotional state of the whole team (Rogulj and Srhoj, 2000). Handball goalkeepers have completely different physical requirements from field players and therefore should be trained and selected using different approaches (Hansen et al., 2017).

In modern handball, there are attackers with strong and precise shots (Van den Tillaar and Ettema, 2003), so the goalkeeper must focus on conditional, tactical and technical preparation (Arslanagić, 2013). The goalkeeper must have specific morphological characteristics (Šibila and Pori, 2009; Vila et al., 2011). Conditional skills of goalkeepers are determined by physical parameters and by the rules of the game (Rogulj, 2000). Because of the field size on which they are playing, the other players are more oriented toward spatial mobility and speed endurance. The goalkeeper is more focused on maximum speed and the explosive implementation of simple movements in restricted space and in restricted time conditions that are not particularly energy-demanding because of the limited dimensions of the area in which he can move (Rogulj and Srhoj, 2003). Due to periodic changes in the time of attack and defense, the goalkeeper more than the other players has the ability to regenerate energy resources for the upcoming reaction for a save (Šibila and Pori, 2009; Urban, et al., 2010). The goalkeeper needs aerobic endurance in order to concentrate throughout game conditions. With regard to conditional preparation, motor abilities play an essential role. The following are the most important for the goalkeeper's success: speed, agility, explosive power, coordination and flexibility (Justin, et al., 2011, Pori, et al., 2011). In sports games, it is important to set priorities. The most important priorities of success are the highly developed motor potential and conditional preparation of players (Castagna et al., 2008; Wisbey et al., 2010; Federolf and Nigg, 2012). Conditional abilities are assessed by batteries of motor-function tests (Drinkwater et al., 2008; Holm et al., 2004). However, the same tests should not be used for different sports games, and the same test should also not be used for different positions within the same game (Wagner et al., 2014). In a certain sport game, it would be useful to create specific tests separately for each playing position. In accordance with the abovementioned facts and based on the specific role of the goalkeeper, the scope of this study is to present normative values of specific and situational tests for the evaluation of the dominant motor skills of a goalkeeper in men's handball.

The purpose of this paper is to define normative results in field situation-related tests for assessing specific motor abilities in handball goalkeepers, which can be used as referential orientation values by which any goalkeeper can compare the level of his abilities measured by the same tests. Thus, we can detect in which specific motor abilities a certain goalkeeper falls behind and in which ones he is average or dominant, and this is important in programming the training process for development of these abilities. As the level of specific motor abilities greatly determines the resulting efficiency of players in handball (Wagner et al., 2017), the results of this research may be used in the process of selecting handball goalkeepers.

Material and Methods

Participants

Sample-based tests were carried out for 181 male handball goalkeepers 15 to 25 years old. In accordance with their age, the goalkeepers were divided into three main groups: cadets (15-16 years, n=69), juniors (17-18 years, n=63), and seniors (19-25 years, n=49). The examinees were the participants of the International Handball Goalkeeper's camp that has been taking place in Makarska (Croatia) since 2011. This camp is a unique sports project given that it is the only one in the world specialized in training handball goalkeepers, involving a great number of participants from around the world. The sample mainly consisted of goalkeepers who were the members of national teams or the teams from the first competition level. The sample was representative according to the number of participants since it presents the largest sample of handball goalkeepers in history.

The sample of variables consisted of 13 newly designed measuring instruments in different conditions of competition for the evaluation of dominant motor abilities. The tests were created at the Faculty of Kinesiology in Split as field versions of similar tests with verified metrical characteristics (Rogulj et al., 2017).

Measures

Performance tests

1. *Situation movement touching the goal frame (SMTGF)* for the assessment of specific lateral agility and the speed of defensive movements. The aim of the examinee is to perform 5 cyclic taps as fast as possible, touching the goalposts from the basic goalkeeper position. During one movement, the examinee successively touches the upper part of one goalpost and then another (maximum of 20 cm of beam) with his hands as if he is blocking a high shot. Then, he successively touches the lower part

of the first and second goalpost (maximum of 20 cm from the ground) as if he blocks the low shot. The realization of the task is measured in seconds. Time is measured from the acoustic signal to the last touch of a goalpost.

2. *Specific lateral moving (SLM)* for the assessment of lateral agility. The aim is to perform six lateral movements interchangeably between two parallel lines at a distance of 3 m. While starting and changing direction, a performer's foot must touch or cross the line. The result is measured in seconds.
3. *Single leg lateral hop (SLLH)* for the assessment of specific explosive strength. Stand on the dominant leg. Place the foot on the outside of the parallel line without touching the ground with the other leg. Jump to the side in the direction of the other leg, landing on the same leg. The result is the length measured in centimeters between the line of the jump and the point of landing.
4. *Single lateral squat hop (SLSH)* for the assessment of specific explosive strength. Place the jumping leg behind the parallel line and do the jump squat in the direction of the other leg landing on it. Try to reach the longest distance possible. The result is the length measured between the line of the jump and the point of landing.
5. *Lateral Leg Tapping on the Five Squares (LLTFS)* for the assessment of the specific coordination and leg frequency speed of a goalkeeper. Stand in the middle of a goal line. When signaled, approach a goalpost with a side movement. Tap with the tips of your toes the first five squares of the goalpost successively from the lowest to the highest and vice versa. After each tap, touch the ground with the leg. Make 9 taps on one goalpost (1-2-3-4-5-4-3-2-1). After the last tap, move laterally towards the opposite goalpost and do the same action. The test ends after the leg is landed on the ground following the last goalpost tap. The time is measured in seconds, and the person measuring the time is positioned 3 meters in front of the performer, so every tap is easily observed.
6. / 7. *Lateral (sideway) single leg triple jump with dominant and non-dominant leg (3XSLTJD / 3XSLTJNDL)* for the assessment of explosive strength in the lateral jump. Put the foot of the jumping leg behind the parallel line without touching the ground with the other leg. Perform a lateral triple jump, trying to reach the longest distance in the three successive lateral jumps. The distance is measured in centimeters from the takeoff mark to the outer point of the foot of the other leg after the third jump.
8. *Specific agility / simulation of blocking the lob (SASBL)* of 4 cyclic movements for the assessment of the specific combined agility. At the beginning of the test, a performer holds the goalpost and waits for the time sign. When signaled, a performer moves as fast as possible using free movement technique to the pin in the four-meter line. Then, he touches the pin with the hand and moves to the opposite goalpost. He performs 4 movement activities; one movement activity includes two movements to the pin and a return to the starting goalpost. The measurement is finished after the examinee performs 4 movement activities and touches the starting goalpost. The result is measured in seconds.
9. *Lateral movement 2X20 m (LM2X20)* for the assessment of lateral agility. The aim is to perform six lateral movements interchangeably between two parallel lines at a distance of 20 m. While starting and changing direction, a performer's foot must touch or cross the line. The result is measured in seconds.
10. *Lateral jumps or lateral movements 20 m (LJLM20)* for the assessment of specific speed and explosive strength of lateral takeoff. An examinee is in the one leg parallel position, in which the takeoff leg is placed parallel behind the line and the other leg cannot touch the ground. He performs lateral jumps in the frontal plane, keeping the parallel position in 20 m length. The test is finished when the examinee touches the goal line with his takeoff leg. The result is measured in seconds.

11. *Positioning around the goal* (PAG) for the assessment of specific combined agility. At the beginning of the test, the examinee holds the goalpost with one hand and waits for the time sign. When signaled, the performer moves as fast as possible to the opposite goalpost and touches it, then touches a pin in the four-meter line and then the starting goalpost again. The measurement is finished after the examinee performs 3 movements and touches the starting goalpost. The result is measured in seconds.
12. *Throwing the ball to the opposite goal (TBBG)* for the assessment of the situational agility and precision. A goalkeeper takes the starting position in the middle of the goal line. When signaled, a goalkeeper in a free movement technique takes the first ball lying on the intersection of the goalkeeper's space and the horizontal line, throwing it to the opposite goal 20 meters away. In the same way, a goalkeeper throws another ball lying on the other side and two more interchangeably, which makes four. Measuring is stopped after the last ball passes directly between the goal. The result is measured in seconds. If a goalkeeper misses the goal or the ball hits the ground before passing through the goal, the test is invalid.
13. *Diagonal goalpost tapping (DGT)* for the assessment of specific lateral agility and the situational speed of the defensive movements. A goalkeeper, standing in the middle of the goal line, has to perform 5 cycles, tapping the outermost part of the goalpost from the basic posture as fast as possible. One cycle implies tapping of the upper outermost square with both hands (max. 20 centimeters above the goal post) in the same way as it is performed when defending high shots and then tapping a lower outermost square of the opposite goalpost in the same way as it is performed when defending low shots. The time is measured from the acoustic sign marking the beginning to the last post tap in seconds.

Statistical Analysis

Methods of data analysis comprised the basic descriptive parameters: the arithmetic mean, minimal value, and maximal value for each age category. Standard deviation, skewness coefficient and kurtosis were calculated for the analysis of distribution features. Normality of distribution was tested by the *Kolmogorov–Smirnov test of distribution.* The distributions of the measurement results were classified into five categories based on standard deviation (SD).

Results

Basic descriptive and distribution parameters of variable analysis for each age category are shown in Table 1.

Table 1. Basic descriptive parameters and parameters of distribution

Test	SENIORS 19 –						
	Mean	Minimum	Maximum	Std.Dev.	Skewness	Kurtosis	Max D
SLLH	204.13	179.00	226.00	15.19	-0.23	-0.91	0.13**
SMTGF	15.45	14.02	17.04	0.92	-0.26	-0.99	0.18**
SLSH	255.40	231.00	274.00	13.78	-0.27	-1.15	0.17**
SLM	5.89	5.32	6.97	0.45	1.38	1.57	0.23*
LLTFS	6.67	5.70	8.19	0.65	0.43	0.55	0.11**
3XSLTJD	548.20	456.00	645.33	57.11	-0.31	-0.13	0.31
3XSLTJNDL	532.67	458.33	659.00	59.43	0.93	1.14	0.15**
SASBL	7.12	6.69	7.54	0.28	0.16	-0.53	0.14**
LM2X20	9.77	8.97	10.90	0.49	0.41	0.21	0.10**

LJLM20	5.92	5.04	7.22	0.59	0.62	0.00	0.13**
PAG	9.32	8.71	9.80	0.30	-0.47	-0.42	0.16**
TBBG	15.76	14.45	17.35	0.77	-0.19	-0.22	0.16**
DGT	8.46	7.25	9.41	0.61	-0.34	-0.14	0.15**
				JUNIORS 17-18			
SLLH	192.30	144.00	228.00	23.12	-0.32	-0.61	0.15**
SMTGF	15.97	14.10	18.78	1.16	0.43	0.40	0.12**
SLSH	243.60	182.00	280.00	25.90	-0.63	0.14	0.13**
SLM	6.06	5.41	7.24	0.49	0.66	0.04	0.11**
LLTFS	6.69	5.84	7.86	0.66	0.27	-0.59	0.11**
3XSLTJD	543.92	358.33	677.33	85.81	-0.78	0.44	0.20*
3XSLTJNDL	506.94	452.67	646.67	56.06	1.52	2.59	0.19*
SASBL	7.37	6.85	7.78	0.31	-0.29	-1.36	0.18*
LM2X20	9.88	9.13	10.80	0.56	0.23	-1.20	0.17**
LJLM20	6.02	5.28	6.92	0.54	0.37	-1.14	0.18*
PAG	9.37	8.71	10.00	0.44	-0.05	-1.24	0.12**
TBBG	16.00	14.20	17.64	1.10	-0.46	-0.96	0.23
DGT	8.65	7.97	10.59	0.72	2.01	4.51	0.21*
				CADETS 15-16			
SLLH	181.50	142.00	213.00	20.78	-0.80	-0.11	0.21*
SMTGF	16.78	14.20	21.15	1.68	0.93	0.95	0.16**
SLSH	237.65	178.00	269.00	20.09	-1.08	3.15	0.15**
SLM	6.46	5.58	8.86	0.76	1.63	3.96	0.14**
LLTFS	7.14	5.87	8.14	0.86	-0.42	-1.62	0.20*
3XSLTJD	524.75	460.67	621.00	55.07	0.60	-1.18	0.27
3XSLTJNDL	490.96	371.33	567.00	58.42	-0.50	-0.65	0.15**
SASBL	7.42	7.05	8.14	0.33	0.94	-0.19	0.21*
LM2X20	10.18	9.40	12.31	0.78	1.98	4.98	0.23
LJLM20	6.14	5.25	8.59	0.93	1.79	3.99	0.20*
PAG	9.53	8.83	10.78	0.53	1.27	1.90	0.19*
TBBG	16.43	14.20	17.57	0.92	-1.36	2.33	0.19*
DGT	8.89	7.80	10.79	0.75	0.63	0.20	0.09**

** = normally distributed variable on level p>0.01
* = normally distributed variable on level p>0.05

The table shows that all the variables of different age categories have normal distributions, except variable 3XLATON, especially on the subsample of senior goalkeepers and, minimally, BACLOP on the subsample of junior and BOC2X20 on the subsample of cadets. There are insignificantly positive or negative asymmetries of distributions with the positive asymmetry and convexity of distribution in variables SPEKUS, BOC2X20 and LATSK20 on the subsample of cadets.
It is evident that the results of examinees in these tests for the evaluation of specific lateral agility and speed of movement of continuous lateral jumps have higher values. This means that the abovementioned tests are slightly insensitive. Based on the descriptive and statistical parameters of distribution, that is, on the table of frequencies under the normal curve, marginal distribution values have been defined for five qualitative classes corresponding to grades from 1-5 on the Likert scale in Table 2.

Table 2. Marginal values of qualitative classes

TEST	Grades				
	1	2	3	4	5
			SENIORS		
SLLH	173.12<x<=184.87	184.88<x<=196.62	196.63<x<=208.37	208.38<x<=220.12	220.13<x<=231.87
SMTGF	16.66<x<=17.41	15.90<x<=16.66	15.15<x<=15.90	14.39<x<=15.15	13.64<x<=14.39
SLSH	225.62<x<=236.37	236.38<x<=247.12	247.13<x<=257.87	257.88<x<=268.62	268.63<x<=279.37
SLM	6.76<x<=7.17	6.35<x<=6.76	5.93<x<=6.35	5.52<x<=5.93	5.11<x<=5.52
LLTFS	7.87<x<=8.49	7.25<x<=7.87	6.63<x<=7.25	6.01<x<=6.63	5.38<x<=6.01
3XSLTJD	432.33<x<=479.66	479.67<x<=527.00	527.01<x<=574.33	574.34<x<=621.66	621.67<x<=669.00
3XSLTJNDL	433.25<x<=483.41	483.42<x<=533.58	533.59<x<=583.75	583.76<x<=633.91	633.92<x<=684.08
SASBL	7.43<x<=7.64	7.22<x<=7.43	7.00<x<=7.22	6.79<x<=7.00	6.58<x<=6.79
LM2X20	10.65<x<=11.13	10.17<x<=10.65	9.68<x<=10.17	9.20<x<=9.68	8.72<x<=9.20
LJLM20	6.94<x<=7.49	6.40<x<=6.94	5.85<x<=6.40	5.30<x<=5.85	4.76<x<=5.30
PAG	9.66<x<=9.93	9.38<x<=9.66	9.11<x<=9.38	8.84<x<=9.11	8.56<x<=8.84
TBBG	16.98<x<=17.70	16.25<x<=16.98	15.53<x<=16.25	14.81<x<=15.53	14.08<x<=14.81
DGT	9.14<x<=9.68	8.60<x<=9.14	8.06<x<=8.60	7.52<x<=8.06	6.98<x<=7.52
			JUNIORS		
SLLH	133.50<x<=154.50	154.51<x<=175.50	175.51<x<=196.50	196.51<x<=217.50	217.51<x<=238.50
SMTGF	18.19<x<=19.36	17.02<x<=18.19	15.85<x<=17.02	14.68<x<=15.85	13.51<x<=14.68
SLSH	169.75<x<=194.25	194.26<x<=218.75	218.76<x<=243.25	243.26<x<=267.75	267.76<x<=292.25
SLM	7.01<x<=7.46	6.55<x<=7.01	6.09<x<=6.55	5.63<x<=6.09	5.18<x<=5.63
LLTFS	7.61<x<=8.11	7.10<x<=7.61	6.59<x<=7.10	6.09<x<=6.59	5.58<x<=6.09
3XSLTJD	318.45<x<=398.20	398.21<x<=477.95	477.96<x<=557.70	557.71<x<=637.45	637.46<x<=717.20
3XSLTJNDL	428.41<x<=476.91	476.92<x<=525.41	525.42<x<=573.91	573.92<x<=622.41	622.42<x<=670.91
SASBL	7.66<x<=7.89	7.43<x<=7.66	7.20<x<=7.43	6.96<x<=7.20	6.73<x<=6.96
LM2X20	10.58<x<=11.00	10.16<x<=10.58	9.75<x<=10.16	9.33<x<=9.75	8.91<x<=9.33
LJLM20	6.71<x<=7.12	6.30<x<=6.71	5.89<x<=6.30	5.48<x<=5.89	5.07<x<=5.48
PAG	9.83<x<=10.16	9.51<x<=9.83	9.19<x<=9.51	8.86<x<=9.19	8.54<x<=8.86
TBBG	17.21<x<=18.07	16.35<x<=17.21	15.49<x<=16.35	14.63<x<=15.49	13.77<x<=14.63
DGT	10.26<x<=10.91	9.60<x<=10.26	8.95<x<=9.60	8.29<x<=8.95	7.64<x<=8.29
			CADETS		
SLLH	133.12<x<=150.87	150.88<x<=168.62	168.63<x<=186.37	186.38<x<=204.12	204.13<x<=221.87
SMTGF	20.28<x<=22.01	18.54<x<=20.28	16.80<x<=18.54	15.06<x<=16.80	13.33<x<=15.06
SLSH	166.62<x<=189.37	189.38<x<=212.12	212.13<x<=234.87	234.88<x<=257.62	257.63<x<=280.37
SLM	8.45<x<=9.27	7.63<x<=8.45	6.81<x<=7.63	5.99<x<=6.81	5.17<x<=5.99
LLTFS	7.85<x<=8.42	7.29<x<=7.85	6.72<x<=7.29	6.15<x<=6.72	5.58<x<=6.15
3XSLTJD	440.62<x<=480.70	480.71<x<=520.79	520.80<x<=560.87	560.88<x<=600.95	600.96<x<=641.04
3XSLTJNDL	346.87<x<=395.79	395.80<x<=444.70	444.71<x<=493.62	493.63<x<=542.54	542.55<x<=591.45
SASBL	8.00<x<=8.27	7.73<x<=8.00	7.45<x<=7.73	7.18<x<=7.45	6.91<x<=7.18
LM2X20	11.94<x<=12.67	11.21<x<=11.94	10.48<x<=11.21	9.759<x<=10.48	9.03<x<=9.75
LJLM20	8.17<x<=9.00	7.33<x<=8.17	6.50<x<=7.33	5.66<x<=6.50	4.83<x<=5.66
PAG	9.66<x<=9.93	9.38<x<=9.66	9.11<x<=9.38	8.84<x<=9.11	8.56<x<=8.84
TBBG	16.98<x<=17.70	16.25<x<=16.98	15.53<x<=16.25	14.81<x<=15.53	14.08<x<=14.81
DGT	10.41<x<=11.16	9.66<x<=10.41	8.92<x<=9.66	8.17<x<=8.92	7.42<x<=8.17

Discussion

Arithmetic means reveal that senior players have the best numerical test results, followed by juniors, while the cadets had the lowest results. The size and the significance of these differences should be analyzed in future studies. This does not come as a surprise, since older goalkeepers are fully developed, and they have the greatest anthropological potential and motor abilities. The long duration of training processes for older goalkeepers contributed to the development of their specific motor abilities. Training process and long-term competition activities contributed to the development of specific motor skills and movement structures, which are very similar to the kinesiological structures of applied measurement instruments. These tests are newly designed and applied for the first time, so comparison with the previous measurements on some other samples cannot be made. It may be assumed that metrical characteristics of these tests are satisfactory, since the tests are created in a simple way with unambiguous measurement objects, expertly modeled and based on basic kinesiological structures of the goalkeepers' defensive techniques. Comparing the results of individual goalkeepers with the corresponding normative value of the test and the age, the evaluation of specific motor abilities shown on a Likert scale is calculated. For example, if a 16-year-old goalkeeper underwent a *single leg lateral hop* test to evaluate his specific explosive power in a lateral jump and achieved a result of 189.5 m, the comparison with the table of normative values will calculate a grade of 4.

Normalization of the grade from an ordinary to an interval scale by relation was implemented in order to enhance the sensitivity of the evaluation:

NO = OO + (R-DGR) / (GGR-DGR)

where:

NO *= normalized grade on interval scale*

OO *= grade on ordinary scale*

R *= result of goalkeeper in a test*

DGR *= bottom limit of qualitative class for the achieved result*

GGR *= upper limit of qualitative class for the achieved result*

For the abovementioned example, the final normalized grade is:

NO = 4 + (189.5-186.4) / (204.1-186.4) = 4.18

The described tests are designed for the evaluation of the motor abilities that play an important role in reaching situation-related efficiency. According to the rules of the handball game and physical conditions, a goalkeeper is characterized by specific motor abilities such as different aspects of speed, especially speed during frontal-plane movement, different aspects of agility, especially lateral agility, explosive power, and lateral jump and flexibility.

Conclusion

The goalkeeper is a very important player with specific tasks. The goalkeeper's actions are specific, so special attention should be paid to individualization and differentiation of his training process. Optimal modeling and programming of training processes cannot be done without precise and concise analysis of anthropological and motor characteristics. The results of this study provide orientation norms for the valorization of specific and dominant motor abilities of goalkeepers of different age categories. Norms may be quite helpful in the process of goalkeeper selection and in evaluating training effects.

Normative orientation values can be used in training and selection processes in handball. Since these tests are designed for the assessment of motor abilities that are genetically determined, they can be used for the primary and secondary selection of goalkeepers. The results can be applied for the valorization of motor efficiency during the implementation of training transformation processes, as well as for the evaluation of training processes in initial, transitional and final tests. The tests can be applied in programming and creating individual training processes for each and every goalkeeper.

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Body composition profile of elite football referees in Bosnia and Herzegovina

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ABSTRACT
Studies in the field of analysis of performances and body composition of football referees have developed great interest of researchers recently. The aim of this research was to examine and analyze body composition of elite football referees in Bosnia and Herzegovina. Sample subjects of this research were 60 referees divided in 2 groups: 30 referees of Premier League B&H (Age=34.87±3.19; %BF=10.87±2.20) and 30 referees of First league of Federation (Age=32.20±4.0; %BF=9.74±3.01).
Results show that groups are statistically differentiate only in age, where referees of higher rank of competition in B&H are older than their colleagues. If we look at the other variables it is noted that referees of First league of B&H have bigger weight, bigger BMI and lower percentage of body fat. However, there is no statistically significant difference between referees of First league and referees of the Premier league of B&H. These results indicate that referees, regardless of the level of competition, need to work on their physical preparation which directly affects level of body composition.

Key words: soocer, BMI, anthropometry, fitness, body fat

Introduction
Body composition, especially body fat, are shown as important element which affects health (Casajús & Gonzalez-Aguero, 2015), but also body composition has important role in sport and sport performances (Čaušević, 2016; Carling & Orhant, 2010; Sutton et al., 2009). Analysis of body composition became one of basic parameters for testing performances in professional sport, all over the world, because it helps easier understanding relation of changes in body composition especially body fat, through time, as a response to certain training stimuli. Of course, not every change in body composition characteristic plays important role in achieving optimal performances of athletes, but authors Rienzi et al. (2000), and Gil et al. (2005) pointed to the fact that lower means of body fat are desirable for achieving optimal performances in soccer because body mass needs to oppose to gravity.
In last few years, there is an interest for studies which refer to football referees. Official study of FIFA showed that there are 840,000 registered football referees all over the world (Inácio, 2011). Study of Casajus and Castagna, (2007) point to the fact that football referees have 12% of body fat, in average, where there is no difference between younger and older referees. However, a few years later, Casajus et al. (2014) through analysis of studies in Spanish league, conclude that referees younger than 33 have lower percentages of body fat than referees older than 38. This knowledge is very significant because optimal age of referees is around 40 (Casajús & Gonzalez-Aguero, 2015), taking into consideration element of experience which is crucial for top-level football referees (Casajus et al. 2014). Modern soccer is more demanding and faster than it was before

(Stølen et al. 2005) and it demands bigger and higher fitness level in order for referee to fulfill demands of football match. Football referees are in average older than players (10 to 15 years) (Weston et al. 2010), and they run 11.7 km, in average (Weston et al. 2011). Therefore, it is very important that referees are on high level of physical fitness, in order to endure the loading of and demands that are presented to them.
These demands are not simple because body composition changes, as the body gets older (Jackson et al. 2002). Therefore, the aim of this research is to examine and analyze body composition of elite football referees in Bosnia and Herzegovina.

Methods

Participants

Sample subjects in this research included 60 healthy football referees, divided in 2 groups based on level of competition. Group 1 included referees who perform in higher level of competition in B&H, Premier league of B&H n=30 (Mean±SD: age 34.87±3.19), and group 2 included referees of first league of B&H (Mean±SD: age 32.20±4.0). Football referees were educated on importance of determination of body composition, and the process of testing is explained to them properly. Referees subjected themselves to testing voluntarily.

Variables sample

Body height of subjects is measured with precision of 0.5 cm, using portable anthropometry (Holtain 610, Crymych, United Kingdom). All subjects were barefoot with joined feet, and position of the head in so called Frankfurt horizontal (Lohman & Going, 2006). Body weight, body mass index (BMI), percentage of body fat (%BF) is measured with error of 0.1 kg on digital scale TANITA BC- 420MA (TANITA Europe GmbH, Sindelfingen, Germany) (Čović et al., 2017). All subjects were barefoot and dressed only in underwear and testing was conducted in the morning (8:30) right after the first urination.

Statistical Analysis

Results were obtained by statistical program SPSS 23. (IBM Corp. Chicago). All variables are calculated in arithmetic means and standard deviation, after which T-test is done for independent samples.

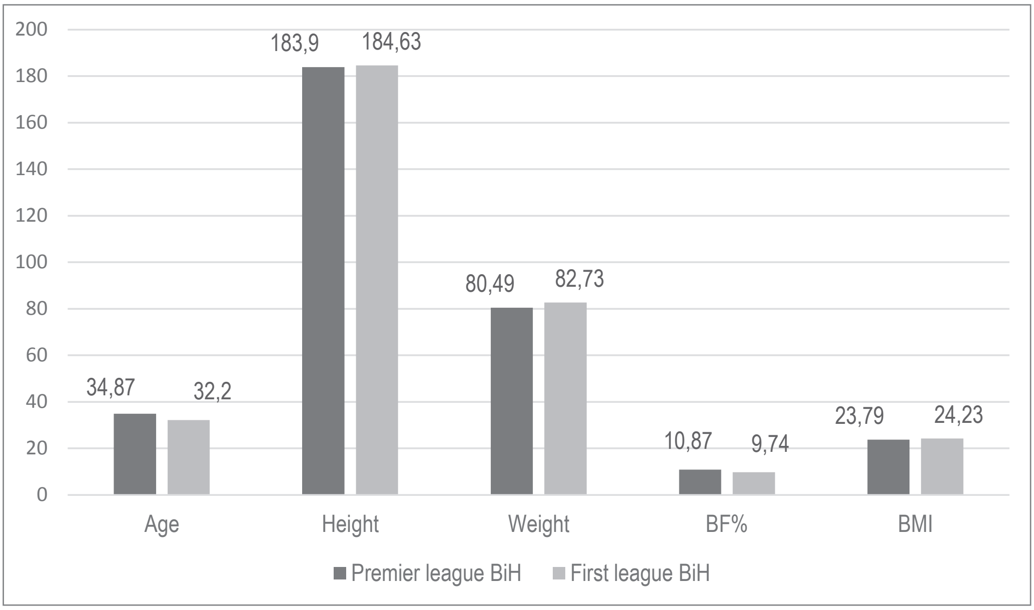
Results

Results of descriptive parameters of variables: age, height, weight, BMI and percentage of body fat for both groups of subjects are displayed in table 1. Analyzing both groups, it can be noted that groups of subjects statistically differentiate only in average age, where referees of higher rank are older than their colleagues. However, when we look at the other variables it is noted that referees of first league of B&H are heavier with higher BMI and lower percentage body fat, but they are not statistically different than their colleagues of premier league of B&H.

Table 1. Descriptive parameters and T - test

	Premier league (N=30)	First league (N=30)	
	Mean±SD	Mean±SD	P
Age (years)	34.87±3.19	32.20±4.0	.006
Height (cm)	183.90±4.82	184.63±8.09	.671
Weight (kg)	80.49±6.87	82.73±9.90	.314
Body fat percentage (%)	10.87±2.20	9.74±3.01	.101
Body Mass Index (kg/m^2)	23.79±1.61	24.23±2.20	.372

p ≤.001



Graph 1. Descriptive parameters of B&H referees

Discussion

The aim of this research was to examine and analyze body composition of elite football referees in Bosnia and Herzegovina. The main finding of this study is that referrers of the top level of competition in B&H, are older but their body composition and percentage of body fat and BMI, respectively, do not differentiate significantly than their colleagues in lower level of competition. Referees of lower level of competition have lower percentage of body fat (9.74±3.01) in relation to their colleagues of premier league (10.87±2.20). Both groups of subjects have very good and acceptable level of %BF in relation to means of Pichard et al. (2000) research, conducted on 3393 healthy subjects. Results obtained in this research are similar to previous studies conducted on European football referees, in terms of age and body composition (Castagna et al. 2004; Krustrup & Bangsbo 2001; Krustrup et al. 2002).

Casajus and Castagna, (2007) in their research did not find statistically significant differences of body composition and %BF in relation to different age groups, which is the case with this research. Many studies confirmed that process of ageing affects body composition, negatively and it increases %BF (Zamboni et al. 2005; Forbes, 1999; Hughes et al. 2002). Regardless of changes of body weight, %BF is increased with age (Prentice & Jebb, 2001), which is visible in this study. In fact, the amount of body adiposity is considered a limiting factor for the performance, so most of elite level athletes present low values of body fat (Inácio, 2011). These results are very significant because experience of young football referees is one of the most important features, and referees reach their peak at the age of 40 (Helsen & Bultynck, 2004). It is noticeable that in the last few years football referees work on improvement of their body composition (Casajús & Gonzalez-Aguero, 2015), which is noticeable in this research too. Of course, apart from improvement of body composition, it is important to work on physical condition preparation of football referees, and in that way to find quality balance and optimal preparation.

Conclusion

Considering obtained results of this research we can conclude that referees in B&H, which were subjects of this research have similar results as referees of European and world leagues in the top level of competition. It is noticeable that younger referees have lower %BF. However, experience is crucial for success of football referees. Older referees with higher %BF (which does not affect their performance) officiate on the highest level of competition in B&H, Premier league. Results of research show that regardless of the level of competition they officiate or their age, referees need to continuously work on improvement and maintenance of body performances and level of body composition, respectively.

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Key intelligence needs identified by high-level cricket coaches

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ABSTRACT
Very little is known about key intelligence needs (KINs) of high-level cricket coaches that direct data collection and analysis for the development of a competitive strategy. It is against this background that the aim of this study was to identify the KINs of cricket coaches, using the 4Cs competitive intelligence (CI) process model of Weiss (2002) as a framework. Semi-structured interviews were conducted with high-level cricket coaches of South Africa. Content analysis was performed whereby a codebook was developed as theory and data driven codes were created with ATLAS.TI™ computer assisted qualitative data analysis software. The codes were derived through the identification and classification of key informational needs (KINs), which were categorized according to the business CI functional key intelligence topics (KITs) categories. Results indicated that cricket coaches' informational needs could be translated into all three of the business type KITs, namely strategic, early warning, and key player KITs. However, coaches identified inadequate exclusive strategic decision and early warning type KITs, and over-emphasized key player KITs. In conclusion, the application of the business CI process model of Weiss (2002) highlighted shortcomings in coaches' KINs identification for the competitive intelligence process.

Key words: key intelligence topics, cricket coaches, competitive intelligence

Introduction
Businesses world-wide challenge one another for dominion by gaining knowledge of their own operations and especially that of their adversaries (Weiss, 2002). Businesses employ competitive intelligence (CI) processes to collect and analyse data to ultimately enhance decision-making, competitiveness and the formulation of suitable counter-strategies (Bose, 2008; Wright *et al.*, 2012b). Data collection is the primary stage incorporated into CI process (Franco *et al.*, 2011; Gatsoris, 2012). Business managers as intelligence users, direct the data collection and analysis process by identifying and communicating their key informational needs (KINs) to CI specialists. On the other hand, CI specialists conduct the data search and analysis based on key intelligence topics (KITs) derived from the KINs (Herring, 1999; Nasri, 2011b). Therefore, the identification of KINs and subsequent KITs is the initial activity of the CI process model data collection stage (Weiss, 2002). The main objective of KITs is to provide direction to conduct effective intelligence operations which are generally assigned to one of three functional categories: 1) strategic decisions and actions; 2) early-warning topics; and 3) descriptions of key players (Herring, 1999). Strategic type KITs refer to the complete range or scope of information aimed at the formulation of strategic plans and new competitor strategies, while early warning KITs typically focus on aspects and activities that prevent management from being caught unaware (Herring, 1999). Among the three KIT categories, key players KITs are the least actionable since it reflects a manager's need to better understand the opposition. In this regard, key player KIT activities allow managers to obtain a competitor profile and a

common understanding of the competitor so that individual managers can develop their own ideas on how to react to competitors (Herring, 1999). However, KITs are not mutually exclusive and a strategic type KIT may also require a competitor profile and some form of early warning intelligence to alert the user to changes in competitor activities or environmental aspects (Herring, 1999). The combination of all three KIT categories is the key to producing intelligence for decision making during the last stage of the CI process (countering) (Weiss, 2002).

This study used the business 4Cs CI model by Weiss (2002) and KITs theoretical underpinning to investigate this CI phenomenon within the sport coaching and performance analysis (PA) domain. In the sport domain, data collection and analysis processes form part of PA, which is mainly directed by the coach (Bampouras *et al.*, 2012). In this regard sport coaches, just as business managers are involved in data collection activities in order to analyse the opposition as well as their own team (Cooper *et al.*, 2007). Very little is known about the needs, functional categories or topics of information that coaches identify to direct data search, collection and analysis, which is used to develop a strategy to gain a competitive advantage (Wright *et al.*, 2012a).

In the sport PA context, collected performance specific data is governed by key performance indicators (KPI), which is utilized in the coaching context to identify critical elements of sport performance (Cooper *et al.*, 2007; Petersen *et al.*, 2008b). KPIs are valid measures of an athlete's or a team's performance level and usually have metric properties and a modus of interpretation (O'Donoghue, 2007). Therefore, in some instances KPIs are seen as data, and in other instances as information, since the data are processed as percentages or ratios (Ackoff, 1989; O'Donoghue, 2007). Coaches use this information to enhance their own team's or players' strengths, to exploit their opponents' weaknesses and to counter situations where opponents' strengths can overpower their own team's abilities (O'Donoghue, 2009). Coaches also consider information on the venue, conditions and the influence of decision-making on winning the toss before competition participation (Petersen *et al.*, 2008b). In this regard, cricket coaches very often refer to and use KPIs as an information source, which increase their knowledge regarding their own team, competitors and the environment to ultimately influence their strategy design and the match outcome (Petersen *et al.*, 2008b). However, this study will not focus on the identification of cricket specific KPIs by coaches, but rather on key intelligence needs as thematic information indicators. Therefore the aim of this study was to identify the KINs and subsequent KITs of cricket coaches, using the 4Cs CI process model of Weiss (2002) as a framework.

Method and design

This exploratory study is qualitative in nature and used semi-structured interviews in order to enhance the understanding and explain KINs and KITs identified by high-level cricket coaches (Henning *et al.*, 2004). Semi-structured interviews were used since this method allows for a wide scope of inquiry, depth of data collection, flexibility of methodology, and allows researchers to organise information according to specific areas of interest and to the particular theme of KINs in this study (De Vos *et al.*, 2005).

Participants

Purposeful, convenience sampling was utilised as it was considered appropriate since the researcher intended to discover, understand and gain insight into the specific phenomenon of KINs as identified by cricket coaches (Merriam, 1998). Expert and assistant cricket coaches were targeted since they are responsible for team strategy and individual player development, and usually use a variety of information for this purpose (Cooper *et al.*, 2007).

A total of fourteen cricket coaches who matched the inclusion criteria, participated in semi-structured interviews. Twelve coaches were head coaches of their respective teams and two were assistant coaches. Three coaches had between six and nine years coaching experience; nine coaches between ten to nineteen years; and two coaches more than twenty years of experience. Five coaches obtained the Cricket South Africa (CSA) level 2 qualification, four the level 3, and five coaches the highest possible level, namely a level 4 qualification. A total of six out of the fourteen coaches coached at franchise/professional level, with one coaching at national level, four at provincial, two at premier league and one at university level. The majority of coaches coached male teams, with two coaches who coached both genders and one coach a female team.

Procedures

Ethical approval for the study was obtained from the Ethics Committee of the institution, where the research was conducted (NWU-00185-15-S1). Face-to-face, telephonic or Skype interviews were arranged and two group interviews were conducted with four participants and two participants respectively, while the rest of the interviews were performed one-on-one. The interview voice recordings were transcribed verbatim. The interview schedule contained six questions relating to the four stages of the CI process, namely data collection, conversion, communication and countering, as well as questions related to CI awareness, culture, planning, identification and focus (i.e. KITs) (Weiss, 2002). Typed transcriptions of interviews were emailed to participants for validation purposes (Creswell, 2003).

Data analysis

Researchers analysed the content of each interview according to the method of DeCuir-Gunby *et al.* (2011) to create a codebook as a critical first step and reference for analysing interviews. Theory driven codes related to the four stages of the CI process model, were generated and then entered into the ATLAS.TI™ system (DeCuir-Gunby *et al.*, 2011). Data driven codes were also developed by reducing the raw data into smaller units of meaning as a second manner to create codes (DeCuir-Gunby *et al.*, 2011). The second step of the codebook development process involved the collaborative revision of codes by a colleague researcher within the context of the data and led to the creation of additional data driven codes (DeCuir-Gunby *et al.*, 2011). Meticulous care was taken in creating specific codes, and researchers ensured that code definitions were precise, encompassing the constructs and that example quotes illustrated each code appropriately (DeCuir-Gunby *et al.*, 2011). The reliability of the coding procedures was determined by making use of Cohen's Kappa (DeCuir-Gunby *et al.*, 2011). The intra-rater reliability was calculated to be $\kappa = 0.78$ and inter-rater reliability to be $\kappa = 0.79$. Research suggests that reliability values between the 0.8 and 0.9 range are deemed to be rich in analytical value (Anderson *et al.*, 2001). The fair agreement indicates the consistency in the creation and application of codes during the analysis and therefore validates the qualitative method used (Campbell *et al.*, 2013; DeCuir-Gunby *et al.*, 2011). The qualitative analysis was performed through a constant comparative analysis whereby researchers simultaneously analysed the content in applying the code book and codes to the data, together with data collection through interviews (Boeije, 2002; Henning *et al.*, 2004). Data saturation was reached and researchers determined that no additional data were found (Guest *et al.*, 2006). For the purpose of this study, researchers only included and discussed those codes which were related to the KINs and KITs as part of the overall interview schedule and data analysis. The coach quotes and codes related to KINs were categorised according to the three functional KITs categories for further explanation.

Results

Coded data

The coded data on KINs of the coaches' and assistance coaches was categorized and presented in Table 1.

Table 1: KINs identified by cricket coaches and assistant coaches

Coach quotations	KIN categories
And then you will also try and gather information on, for example, the brand of cricket they (opposition team) play and then implement a game plan to that and try and execute it with your skills (P8a*) …when you talk about brand of cricket, it is either a team that is very attacking, or very conservative in the method of going to collect their runs (P5a)	Brand of cricket
We then also have to look at the experience of their team as well. Sometimes there are more experienced players, and there are certain players that you try and get out. You know which are the key players and obviously we have a certain game plan for that as well, so that goes into specifics…and then we will go and look at each player (P17a)	Countering experienced and key player
I think one is to have an idea what their team will look like, so you will have a strong idea of your game plan, you need to know who you are playing against…(P11a) Knowing, this is their line-up, this is how we are planning of getting those players out, this is where their strengths and problems are and these are our plans (P2a) You can anticipate from the last game, this is the possibility of their team (P16a)	Opposing team to influence own game plan, anticipate opposition player inclusion
You want to know - this player's release shot is this, so you want to build pressure and then you know he is going to release with that shot… (P13a)	Opposing players' pressure outlet
That is why I think it is vitally important to have a thorough knowledge of your own players before you go to the competitors because you then know, ok this is plan A and we go accordingly (P8b) You have to constantly be aware of the situation of what is happening within your team and know exactly where they are in terms of performance (P3a) As far as opposition is concerned I would go through each one of my particular weapons that I have at my disposal and we might even strategize to the extent that our team selection will depend on where we play and the wicket we play on and sometimes the opposition (P10a)	Own team information and competence, own team weapons
There are a couple of things; the first thing would be conditions…you will tell your players: these are the sort of conditions you are going to get; this is how we need to combat those conditions, in terms of batting and bowling. Then obviously in terms of our bowling, in those conditions down at the coast, you have to be a lot more patient, a lot more dot balls, where on the Highveld you can be more attacking, you can run in and bowl quick and bouncers (P17b) The key things for me are: the first one – let's say it is a home game or like we are playing away (P9a) There are also variables like the ground you are playing at and the pitch that you are playing on, which plays a big part (P3b)	Environmental influences, venue, pitch condition
What I want on opposition is about their character. Where can I find the soft areas, because I don't think high level sport is only about technique, it is more about the character and we talk about mental strength and all of those things. (P8c)	Character, mental aspects
I also check if the team that we are playing against has won games before, like are they under pressure, is the coach under pressure, is there drama, you know like in their side The biggest thing for me in T20 cricket is where players do get under pressure and what do they normally do when they get under pressure (P9b)	Overall functioning, handling pressure
You get to know their (opposition players) fears, theirs strengths and weaknesses, their opportunities and threats, so I think it is important that when they (own players) give that info on those players just to get the edge. They may know something I don't know, because the player can come to me and say coach, I was with this guy in Australia, he prepares like this, and he looks to do this and that, so I have more info on that certain player then I can share it with my team. You don't get this info anywhere, it is close and personal (P9c) I will look at their strengths and weaknesses (P14a)	Fears, SWOT analysis of individual players
You focus on how certain players bowl at the death (P14b)	Death bowling
So there will be various variables that you need to consider as a coach in terms of your planning, in terms of how you are going to execute your plan to win games. So you made an example about the competitors that you are playing against, so that information will be key. Most of the teams, if you have played against them, you would have seen them once or twice or a couple of times, so you do have some sort of information about them. And then you look at how they score their runs, for example if it is a batsmen, is he a guy that scores a lot of boundaries or is he a guy that scores a lot of ones and twos. That type of information will play a big part in your planning as a coach and for you to make sure that you are making the right decisions with your team. There are also variables like the ground you are playing at and the pitch that you are playing on, which plays a big part because you get things like averages so, in a season you look at what is the average score for a particular pitch. Then you will set your own target on the number of runs you want to score and for example you will use that data as a baseline to do your planning. So that is very important (P3c)	Competitors (runs scored, boundaries, score in one or two runs), competition venue specifics (average score for venue)
Because we thought that if we get the chance that we would bat first, looking at their blowing combinations (P1a)	Bowling combinations

* The number refers to the participant while the alphabet letter refers to the comment number by the participant.

Coaches indicated the need for information on the specific *brand* of cricket that the opposition team plays, i.e. are they *attacking or conservative in their method of obtaining runs* (P8a, P5a). Additionally, coaches indicated that they focus on information on *experienced and key players* (P17a). The *oppositions' team line-up* and *knowing the opposing players' strengths* were also highlighted as important information (P11a, P2a and P16a). The fact that the opposition team line-up is unknown to coaches until very close to the commencement of the match, forces coaches to make predictions of opposition team inclusion (P16a). However, coaches would normally change their own team strategy and game plan immediately after they received information on the opposing *teams' line-up* (P11a, P2a and P16a). Information on players' *reaction towards pressure* and the *release shot* are also typically used (P13a). *Knowledge and situation of own players* (P8b, P3a and P10a), especially focused on their *own weapons* or *strengths* (P10a), is also important to coaches. Information on certain environmental aspects such as *weather conditions*, *venue* and *pitch conditions* influences cricket matches and should also be considered (P17b, P9a and P3b). Opposition players' *character*, *soft areas and mental condition* (P8c), the *overall team functioning*, *pressure on the coach* and how individual *players handle pressure* (PP9b) are KIN categories that coaches identified. Likewise, coaches need information on opposition players' *fears, strengths, weaknesses, opportunities and threats* (P9c and P14a). Coaches also focus on how certain players *bowl at the death* of the match (P14b) and opposition *bowling combinations* (P1a). A single quote by P3c indicates that coaches' KINs can be categorised into *competitor information*, mentioning measurable aspects such as runs scored, as well as mentioning the *ground and pitch* the team would be playing at and referring to average scores for a pitch. This quote contained specific measurable variables such as the runs scored, which is classified in the sport domain as a KPI.

Discussion

The scope and nature of an organisations' KINs are portrayed by KITs (Herring, 1999). In this regard, this study identified and categorised the KINs of high level cricket coaches into the functional KIT categories of strategic, early warning and key player KITs (Table 2). With strategy formation in mind, coaches indicated a variety of KIN categories such as the *brand of cricket* that the opposition is playing, *experienced and key* opposition team *players, players' outlet shot to release pressure, included opposition players* as well as *environmental factors* such as the venue, location, pitch and weather. These KINs can be categorised as strategic type KITs since coaches indicated the need for this information in order to devise a strategy. In this regard, coaches pointed out that the inclusion of certain key players in the opposition team line-up, sometimes govern their decisions on their own team line-up. The brand of cricket opposition teams play as well as certain environmental aspects such as the type of pitch that was prepared and the way in which it may influence play on the match day, also compels coaches to rethink their own match strategy.

Table 2: Cricket coaches' KIN and KIT categories

Cricket coaches identified KIN categories	Business CI KITs type
• Brand of opposition cricket, attacking or conservative # • Countering opposition experienced and key players # • Opposition team member inclusion #@ • Opposing players' pressure outlet # • Environmental influences – weather, venue, pitch and conditions @ • Own team information on competence and strengths*	Strategic decision type (# Key player) (@ Early warning)
• Character and mental aspects of opposition players • Overall team functioning • Individuals and team handling pressure • Opposition players' fears, strengths, weaknesses, opportunities, threats. • Death bowling • Bowling combinations • Competitors' performance (batting and bowling KPIs)	Key player
• Opposition players included in team • Environmental influences (weather, pitch and conditions)	Early warning

* Not categorised as a strategic type KIT, however included since it is used to develop a strategy
# Additionally classified as a key player type KIT
@ Additionally classified as an early warning type KIT

Information of the *own team's competence and strengths** cannot exclusively be classified as a strategic type KIT, since the focus of information is inward towards own team and player. However, this information is still very relevant to the coaches' strategy design. No KIN was exclusively assigned to only a strategic type KIT. Similar to the business CI domain, where managers need some form of education in order to identify and verbalise their strategic type KITs (Herring, 1999), coaches need to be educated to define their informational needs.

The first activity of KITs identification within the CI data collection process stage is essential and consequently coaches should learn to discern and identify functional strategic topics that will drive the collection and analysis of relevant information for strategy design (Fleisher & Wright, 2010). Coaches only referred to a limited number of strategic decision type KITs, which accentuates the need to also include KITs identification theme as niche area in coaches' education programmes. However, since KITs are not mutually exclusive, the KINs within this category can also include competitor profiles or early warning signal KITs. In this regard the KINs indicated with "#" also belong to key player type and the KIN indicated with "@" to the early warning KITs.

The strategic type KITs, namely the *brand of cricket*, *experienced* and *key players*, *opposing players included in match team* and *players' pressure outlet shot* can also be categorised into the key player KITs functional category, since the focus is on attaining information on the opposition. Additional KINs categorised within the key player category, are *character* and *mental aspects*, *overall team functioning*, *pressure* on individuals and team, the opposition *strengths, weaknesses, opportunities, threats, fears,* and *handling pressure*. Likewise *death bowling*, *bowling combinations* and specific information on *competitors* such as runs scored and information on the environment (i.e. previous scores achieved at the venue), all contribute to the analysis and profile development of competitors.

The third functional category of early warning topics was not commonly found within cricket coaches' KINs. In the business CI process, the early warning KITs category centres around the elimination of surprises or threats by analysing changes in the environment (Weiss, 2002). However, coaches' needs and knowledge on cricket competition *environmental aspects* such as the *venue, pitch and weather conditions*, were assigned to the early warning KITs. Sudden changes in weather conditions as well as the way in which the pitch is prepared, need to be considered well in advance as well as close to the start of the match as these factors may influence the strategic decisions coaches make regarding for example own team line-up. Additionally, the lack of information concerning the *opposition team line-up*, is another informational need within the early warning KITs category. Coaches repeatedly indicated that their decision-making, game plan development and own team selection often depend on the availability of information regarding opposition team members. This information is usually not available to the coach until very close to the start of the match. The need to avoid unexpected and unanticipated opposition team player selections is very apparent. Even though all three KITs categories could be assigned to the coaches' KINs, it is evident, that coaches predominantly identified key player KITs and mainly focused on competitor information. However, since KPIs can be viewed as a key player KIT, it is also the least actionable KIT as it only allows coaches to gain a better understanding of the competitor (Herring, 1999). Even though coaches use KPIs in PA as information to enhance their own teams' or players' strengths, to exploit their opponents' weaknesses and to evade or counter situations where opponents' strengths can overpower their own teams' abilities by itself, it cannot be used to direct a data collection and analysis process with the aim to provide actionable intelligence. At best, KPIs can provide knowledge on competitors or own players or the environment, as is the current practice within PA. Conversely, it is up to the coach to react on this knowledge.

Effective decision-making through intelligence operations depends on how well the initial identified informational needs of an intelligence user can be met, and cricket coaches need guidance in identifying a variety of KITs. If coaches are educated to identify additional and more encompassing KITs, their data collection and analysis process will improve.

Conclusions

The study succeeded in identifying the KINs of high-level cricket coaches by making use of the theoretical underpinnings of the 4Cs CI process model of Weiss (2002) as a framework and translating them to the functional KITs categories. Consequently, the mentioned business CI process model may provide coaches and sport managers with a systematic procedure to identify KINs and use KITs in the coaching domain to drive a successful data collection and analysis process. Findings of this study suggest that research needs to explore the development of strategic decision and early warning type KITs on competitors and environment to gain a sport competitive advantage. In this regard, coaches need to be properly educated in the CI process, especially as it relates to articulate KINs and identifying KITs, as the first step of the data collection stage. An over- emphasis of key player KITs indicates the need for coaches to be taught how to explore knowledge creation through various KITs identification. This study paves the way for current and future coaches to construct and implement a systematic procedure based on KINs to create applicable knowledge for decision-making and to direct the CI process in sport.

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Analysis of the physical variables in the FIFA World Cup 2014 and 2018

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Purpose: To compare the physical variables, the total distance, distance to low, medium and high intensity, and the number of sprint among the competitors of the FIFA World Cup 2014 and 2018.

Methods: Data were obtained from the FIFA website and the live stats provided during each match of the World Cup. We compared the total distance, distance to low intensity (LIR; <11 km/h), distance to moderate intensity (MIR; 11 to 14 km/h), distance to high intensity (HIR; 14 to 25 km/h) and sprint (SPR; >25 km/h) among the finalists of the FIFA World Cup 2014 and 2018. The variables were collected in 24 matches from the group stage up to the semi-finals and were analyzed through the t-test for independent samples.

Results: There are no significant differences ($p>0.05$) in the total distance travelled, distance to low intensity, distance to moderate intensity, distance to high intensity and the number of sprints.

Conclusion: The finalists of the FIFA World Cup 2014 and 2018 do not show differences in physical aspects during the tournament.

Influence of climate conditions projected for World Cup 2022 in Qatar on soccer players' performance of repeated maximal exercises

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Purpose: Top-level soccer tournaments such as the World Cup are held in variable, often adverse, weather conditions. The ambient conditions are important modifiers of players' physiological responses to exercise (Nassis et al., 2015). The study aims to seek relationships between players' ability to perform repeated maximal exercise and climate conditions for the 2022 FIFA World Cup in Qatar simulated in an environmental test chamber.

Methods: The study group will consist of 24 male soccer players aged 17-18 years. The players will perform an exercise test comprising ten 6-second maximal exercises on a cycloergometer (MONARK LT2), with 90-second passive rest breaks between. The measured variables will include lactate, acid-base homeostasis, and arterial-blood gas levels and heart rate. The measurements will be taken twice in an environmental test chamber (Weiss Technik WK-26): 1) in thermo-neutral conditions (20.5°C, 58.7% RH); and 2) in conditions typical for 21st November in Doha, Qatar (day and place of the 2022 World Cup inauguration) (28.5 ± 1.92°C, 58.7 ± 8.64% RH). The study will be conducted in June 2018, funded from the National Science Center grant no. 379162.

Expected results: Significant differences in players' physiological and biochemical parameters in thermo-neutral and in climate conditions of Qatar are expected (Chmura et al., 2017). According to Grantham et al., (2010) playing soccer in an ambient temperature of 22°C does not incur a risk of body overheating. This risk is low in the temperature range of 22 - 28°C, and high at above 28°C. Players' incremental fatigue in high ambient temperatures reduces the distance covered by them with a high intensity in the last phase of the game. More over fatigue also decreases the number of performed explosive efforts, e.g. accelerations, sprints, and jumps (Mohr et al., 2010).

Conclusion: Data on players' responses to exercise in heat stress should be used by coaches in their player preparation programs for the 2022 FIFA World Cup in Qatar.

Analysis of performance differences between medalist and non-medallist players in elite women's badminton

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Purpose: The analysis of player's performance in elite badminton has been widely investigated differentiating by gender, group stages during championships, winners and losers, or best vs. worst players (Barreira et al., 2016; Chiminazzo et al., 2018). However, the analysis of key variables that may define the success to gain a medal or not during an International Championship is still inconclusive in elite women's badminton. Therefore, the aim of the present study was to identify the differences between medallists and non-medallists players' performance (temporal and notational variables) in elite women's badminton.

Methods: The sample was composed by 18 matches played by the medallists from the 2016 women's singles Olympic Games (Rio, Brazil). The final sample included the analysis of 1,340 rallies. The independent variable studied was medallist/ non-medallist; while the dependent variables were serve type, point outcome (winner, forced error or unforced error) according to the complex of game (C1: serving and C2: receiving) and temporal variables (rally time, rest time, density and frequency of strokes). The analyses were carried out using an observation tool on a video analysis program (Dartfish, Friburgo, Switzerland). The crosstabs commands were used to study the relationships (Pearson's Chi-square test) between medallist/ non-medallist condition and point outcome and type of serve. The student t-test was applied to differentiate medallist conditions of temporal variables.

Results: The temporal variables studied showed that only rest time was different for medallist players with more time spent after the rally (29.88s vs 26.77s). Rally time, density and frequency of strokes was non-significant differentiating both conditions ($p>0.05$). In addition, the medallists obtained more points when serving than non-medallist (greater winners and more unforced errors from the opponent). Conversely, the non-medallists performed better when received due to more forced and unforced errors from the opponent. Lastly, the type of service was different in both players (medallists and non-medallist) with medallists using more backhand short service and non-medallists using more forehand short service.

Conclusions: The performance of medallists and non-medallists women's badminton players is different from a temporal (rest time spent) and a notational analysis perspective (points obtained when serving the medallists and when receiving the non-medallists).

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Influence of contextual-related variables on rally time and rest time in elite men's and women's badminton

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Purpose: The temporal structure of badminton has been described in the available research as intermittent intensity sport with high variability of rally time and rest time during the match (Laffaye and Phomsoupha, 2015). However, the influence of some factors and specific events (i.e., point and match constraints such as match duration or situational variables) are unclear when performing the rallies in elite badminton. Therefore, the aim of the present study was to identify the effect of contextual-related variables on rally time and rest time in elite men's and women's badminton.

Methods: The data was composed by 54 men's (n=4475 rallies) and 60 women's (n=4989 rallies) matches randomly selected from international competitions (World Championship and BWF Super Series circuit) during the year 2015. The dependent variables gathered were rally time and rest time. The independent contextual-related variables were: match duration, set number, interval of each set (Points 0-11 and points 12-21), quality of opposition (ranking differences between opposing players: ranking player A – ranking player B), and the score-line (points differences in the score). The statistical analysis used was the multiple linear regression trying to identify the importance of each independent variable (contextual-related variable) on the dependent variable (rally time and rest time). Two independent models were done by sex (men and women) for rally time and rest time. The positive or negative coefficients obtained indicate higher or lower propensity to increase/decrease the time duration (s) of the rally or the rest time, respectively.

Results: The model for rally time showed the significant effect of match duration (0.07) for men's players and the effect of match duration (0.04), quality of opposition (-0.03), score-line (0.08) and interval of points (-0.46). On the other hand, the models for rest time showed the significant effect of match duration (0.17), score-line (0.12), interval of points (-2.50), and the set 1 (1.88) for men's players; and match duration (0.18), score-line (0.11), interval of points (-2.31), and the sets 2 (-1.47) and 3 (-2.44) for women's players.

Conclusions: The results of the analyses showed the different influence of some contextual-related variables on rally time and rest time in men's and women's elite badminton. Thus, the current findings allow the coaches to prepare specific training tasks based on the performance demands and situational variables effects in elite men's and women's badminton.

Acknowledgement: the present study was supported by the Ministry of Economy and competitiveness of Spain with the project "Estudio de los complejos de juego y los perfiles de rendimiento en bádminton de élite COMPLEXBAD" (DEP2015- 67231-R).

Analysis of the performance of the last stroke in elite tennis players

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Purpose: The competitive performance in sport is determined by the effectiveness of technical and tactical actions (Gómez-Ruano, 2017). In a sport such as tennis, analyses of competition statistics have been carried out (Reid et al., 2010); characteristics of winners and losers players (Martínez-Gallego et al., 2013; Torres-Luque et al., 2017); players' movement profiles (Pereira et al., 2017) or technical and tactical efficiency (Filipcic et al., 2015). In spite of this, there is no much information about the differences that may exist on the criteria which define the winner or loser with respect to the last stroke executed. Therefore, the main purpose of this study is to analyze the differences between the winner and loser of the game in terms of the last point executed in elite tennis players.

Methods: Fifteen individual men's tennis matches belonging to the ATP World Tour Finals were determined. A total of 1434 strokes were analyzed. Some variables of each stroke were analyzed: a) Type of stroke (nine strokes without service); b) Strike zone (twelve areas); c) Bounce zone (four areas); d) Type of continuity (winners or errors).

Results: The results show the importance of the backhand, left and passing shot strokes to win the match ($p<0.001$) and the importance of the closer ball bounce to the baseline ($p<0.05$). There are no statistically significant differences in the strike zone ($p> 0.05$).

Conclusions: The winner players in the ATP World Tour Finals use more backhand, left and passing shot strokes to win the match. At the same time, it does not matter a lot the strike zone where you hit as the ball always bounces close to the baseline.

Influence of climate conditions projected for World Cup 2022 in Qatar on soccer players' physiological, biochemical, and psychomotor responses to incremental exercise

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Purpose: Climate conditions are significant modifiers of soccer players' physiological and psychomotor responses to exercise (Nassis et al., 2015). The study aimed at finding relationships between players' physiological, biochemical and psychomotor parameters during incremental exercise, and climate conditions for the 2022 FIFA World Cup in Qatar simulated in an environmental test chamber.

Methods: The study sample will comprise 24 male soccer players aged 17-18 years. The players will carry out an incremental exercise test on a Cybex 790T treadmill. The measured variables will include lactate, acid-base homeostasis, serotonin, arterial-blood gas levels and heart rate. The players will also take a psychomotor test before and after exercise. The measurements will be taken twice in an environmental test chamber (NITROXYcell, Wichary Technologies): 1) in thermo-neutral conditions (20.5°C, 58.7% RH); and 2) in conditions typical for 21st November in Doha, Qatar (day and place of the 2022 World Cup inauguration) (28.5 ± 1.92°C, 58.7 ± 8.64% RH). The study will be conducted in June 2018 and funded from the National Science Center grant no. 379162

Expected results: Significant differences in players' physiological and biochemical parameters and psychomotor skills in thermo-neutral conditions and in Qatar climate conditions are expected (Chmura et al., 2017). During a soccer match the ambient temperature does affect players' body internal temperature, and overheating may reduce the level of players' psychomotor skills, movement speed and precision, and concentration (Mohr et al., 2012). According to Grantham et al., (2010) playing soccer in the ambient temperature of 22°C does not incur a risk of body overheating. This risk is low in the temperature range of 22 - 28°C, and high at above 28°C.

Conclusion: Data on players' responses to exercise in climatic conditions of the planned 2022 FIFA World Cup in Qatar should be used by coaches in their player preparation programs.

Passing networks in football: Selected Manchester United matches during the 2015-2016 season

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Purpose: The interactions between players during a football match can be recorded as a matrix of passes and visualised as a network diagram. The diagram provides semi-quantitative insight into the operation of the team as a whole, the functioning of units of the team (defence, midfield, attack) and the importance of individual players to team effort. In addition, in-depth quantitative analysis of patterns of team passing using network mathematics techniques has given insight into team dynamics (Clemente, Martins and Mendes, 2016) and some network parameters have been shown to be correlated with team performance in football (Clemente, Martins, Kalamaras, Wong and Mendes, 2015; Grund, 2012; Peña & Touchette, 2012). In the present study, passing networks were analysed using both informal and formal mathematical methods in an attempt to relate network parameters to the performance of an elite level team.

Methods: Six national and international matches of Manchester United Football Club during the 2015-2016 season were annotated using Dartfish 10 software. The matches covered a range of team success in terms of match outcome. Account was taken of completed passes by players of the focus team, the pitch location of those passes, the context of passing in relation to opposition play and an enhanced set of match statistics.

Results: Data to be presented will relate informal and standard network measures (degree, centrality and modularity included) to match outcomes, unit performances and the influence of individual players, as supported in part by non-parametric statistics. The sensitivity of network parameters to errors in the recording of passes will be reported.

Conclusion: This study highlights the potential and potential constraints of using network parameters in the analysis of performance of a football team.

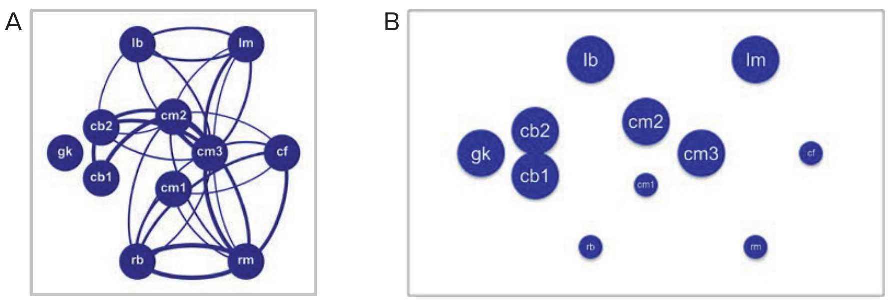

Figure 1. A) Partial, whole-match passing network for Manchester United. Manchester United 2 – 0 Crystal Palace, Premier League, 20.04.2016. United operated a modified 4-3-3 team formation; B) Modularity map for Manchester United for the same match.

Does backward passing influence end season ranking in English Premier League?

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Purpose: In professional soccer, most evident increase in skill level throughout the whole range of techniques is in passing (Frank and Hughes, 2016). This research will provide and analyze data, through notational analysis (Carling, Williams & Reilly, 2005; Hughes, 2003; Hughes & Bartlett, 2002; James, 2006), regarding different variables such as passes overall, goals conceded, backward passes and ranking at the end of each season, but will mostly investigate if there is a relevant correlation between backwards passing and season ranking. Therefore, the importance of this research is to clarify if backward passing is relevant to ranking, especially if comparing top and bottom teams in English Premier League.

Methods: This research examined data from 3648 English Premier League games played from the 2010-11 to 2017-18 season. Match performance was observed in top six teams and bottom six teams. The aim was to investigate performance trends of the top and bottom teams and to investigate the correlation between ranking and different variables such as passes overall, backward passes and goals conceded.

Results: Overall passes number during this period has increased both in the top and bottom teams in a linear trend. When comparing backwards passes, a greater increase has been noticed in top teams rather then bottom teams on season-by-season base (2804 ± 256 vs. 2188 ± 52). Furthermore, this could potentially be linked to possession as a success tool. In average 15% of passes overall are backward passes both in the top and bottom teams. Moreover, when comparing only the winners and last teams positioned during this eight-season period, there is a 25% difference between numbers of backward passes, which is shown to increase regularly from season to season. During this eight-year timespan, goals conceded decreased steadily in top teams but stayed mostly unchanged in bottom six teams (39.5 ± 1.9 vs. 65 ± 3.4).

Conclusion: This data demonstrates changes and evolving tactics throughout eight seasons timespan in the English Premier League and could be used to assist in pre-game tactics preparation. Future research should focus on bringing different European elite leagues datasets in one study, but range their data span only through one season. Another area of study should focus on the patterns of passes, whereas should one look at the location on the pitch when a backward pass is executed and accordingly add tags on different backward passes and their relevance to the whole game and what outcome is produced with them.

Differences in decision-making behaviour between the world's top two squash players

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Purpose: Murray, James, Perš, Mandeljc, & Vučković (2018) described shot selection in squash from a situation awareness (SA) perspective (Endsley, 1995). Shot selections of two elite players, ranked as the top two players in the world at the time of data collection, were analysed to provide a more detailed analysis of the differences evident between players of very similar ability.

Methods: Matches at the 2011 (n = 9) Rowe British Grand Prix, held in Manchester, UK were recorded and processed using Tracker software (Vučković, et al., 2014). The shot type (n=25) and ball location for each shot (denoted player A), excluding serve, return of serve and rally ending shots (winners, errors, lets and strokes), were recorded along with the same information for both the preceeding shot (B-1) and following shot (B+1). Additional information regarding time, speed and distance were recorded both between shots and at the time player A hit the ball.

Results: Differences were evident both between matches and between players in terms of the proportion of shots categorised according to attacking or defensive pressure.

Conclusion: Previous studies that have grouped players according to ability level have limited the usefulness of their findings, identified as a 'theory-practice gap' (Mackenzie and Cushion, 2013), as the results in this paper present the differences evident between very similarly ranked players. Grouping players and presenting an average value therefore fails to account for individual differences, of great importance in the applied setting.

Differences in kinematic parameters between elite sprint swimmers

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Purpose: The purpose of this research was to determine the differences in kinematic parameters between elite swimmers compared to the achieved results in the 50 m freestyle (t50).

Methods: Forty elite male sprint swimmers (participants of the preliminaries, semi-finals and finals events at the open championship of Serbia 2017 in 50 m free) were recorded (GoPro Hero 4 black edition, 120 fps) and analyzed with specialized software (Kinovea 0.8.15). The sample variables consisted of seven kinematic parameters: start time up to 10 meters (**t10m** in s), stroke length in the first 25 m (**SL1_50** in m), stroke length in second 25 m (**SL2_50** in m), stroke index in the first 25 m (**SI1_50**), stroke index in second 25 m (**SI2_50**), stroke rate in the first 25 m (**SR1_50** in stroke/min) and stroke rate in the second 25 m (**SR2_50** in stroke/min). The camera was set at a sagittal level in relation to the length of the pool at 25 m, while the calibration and marking of the distance was carried out using the lane buoys. The swimmers were divided by cluster analysis (K-Means Cluster Analysis), in three groups compared to the results achieved at the mentioned events. The first group consisted of fastest swimmers, i.e. swimmers whose results of 50 m free are above the average in relation to the total sample of swimmers (G1_50; t50 = 23.53 ± 0.27 s, n = 6;). The second group consisted of swimmers with average results (G2_50; t50 = 24.54 ± 0.33 s, n = 18;) and the third group consisted of swimmers with achieved results below average (G3_50; t50 = 25.52 ± 0, 33 s, n = 16). In order to determine statistically significant differences between groups in kinematic parameters in relation to the achieved results, a univariate variance analysis (ANOVA, Tukey HSD) was applied.

Results: The results show that there is a statistically significant difference in the kinematic parameters between elite swimmers represented by: **t10_50** (F = 16.79, p = 0.000; G1_50-G2_50 = -0.19s, p = 0.016; G1_50-G3_50 = -0.37s, p = 0.000; G2_50-G3_50 = -0.18s, p = 0.002), **SL2_50** (F = 4.44, p = 0.019; G1_50-G2_50 = 0.008, p = 0.048; G1_50-G3_50 = 0.10, p = 0.015; G2_50-G3_50=0,02, p=0,747) and **SI2_50** (F = 13.49, p = 0.000; G1_50-G2_50 = 0.25, p = 0.001, G1_50-G3_50 = 0.34, p = 0.000; G2_50-G3-50=0,03, p=0,124).

Conclusion: It can be concluded that swimmers who have the ability to be fast at the start and to maintain the effectiveness of stroke length and stroke index in the second part of the race have predispositions to achieve better results in sprint disciplines, which suggests that kinematics parameters and starting abilities should be monitored and improved in the training process so that the results at the competitions will be better.

Key words: 50 m freestyle, stroke length, stroke index, stroke rate

Using principal component analysis to identify performance indicators and score team performances in professional rugby league

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Purpose: Previous research on performance indicators in rugby league (Parmar et al., 2017) has suggested that dimension reduction techniques could be more appropriate when analysing large datasets.

Methods: Forty-five rugby league team performance indicators, from all 27 rounds of the 2012, 2013 and 2014 European Super League seasons, collected by Opta, were reduced to 10 orthogonal principal components with standardised team scores produced for each component. This dimension reduction technique resolved the multicollinearity, typically found in sporting data, where performance variables were related to each other, optimising the use of regression analysis. Forced-entry logistic (match outcome) and linear (points difference) regression models were used alongside exhaustive Chi-Square Automatic Interaction Detection (CHAID) decision trees to determine how well each principle component predicted success.

Results: The ten principal components were entered into linear and logistic regression models without stepwise methods which explained 81.8% of the variance in point's difference and classified match outcome correctly ~90% of the time. Results suggested that if a team increased 'amount of possession' and 'making quick ground' component scores, they were more likely to win (β=15.6, OR=10.1) and (β=7.8, OR=13.3), respectively. Decision trees revealed that making quick ground was an important predictor of match outcome followed by quick play and amount of possession.

Discussion: The use of PCA provided a useful guide on how teams can increase their chances of success by improving performances on a collection of variables, instead of analysing variables in isolation. Future studies can create contextual performance profiles to explore variations within and between team performances.

Influence of 2013 rule modification on scores and penalties awarded on two world judo championships

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Purpose: From 2009 International Judo Federation made significant rule changes in order to promote "positive judo", more attractive to the audience and with more scores and less negativity (penalties) (Calmet, Pierantozzi, Sterkowicz, Challis, & Franchini, 2017). The most important change was forbidding the leg grabbing techniques, first partially (2009), then totally (2013). Another significant modification was to reduce the importance of penalties and to modify the rules of the kumikata fight (grip fight). The aim of the research was to establish whether these modifications fulfill the IJF-s intention by analyzing the share of decisive scores (ippon), scores and penalties on two World Championship held before and after most important rules modification.

Methods: By using free performance analysis software Lince 1.2.1 (Gabín, Camerino, Anguera y Castañer, 2012), a total of 240 male fights from World Championship 2011 and 2014 was analyzed in order to establish the share of scores and penalties. The statistical analysis Chi-square ($\chi 2$) test with the significance of $P < 0.05$ was conducted to test the differences between frequencies of the samples. Z test was used to determine the proportion of the parameters and their individual difference between two championships.

Results: In 2011 there were 81 decisive points (ippon), 43 positive scores (yuko, wazari 1) and 175 penalties, while in 2014 there were 96 ippons, 74 positive scores, and 337 penalties. On the first sight, there is a notable improvement in the number of positive scores, but also in the number of penalties. Results of the $\chi 2$ test showed significant differences between two samples (sig=0,023). After conducting the Z test, results have shown the opposite to the first impression, the share of ippons was higher in 2011 (27,09%) compared to 2014 (18,93%) sig <0.001. In addition, share of penalties was significantly (sig 0.005) higher in 2014 (66,47%) compared to 2011 (58,53%), while there were no significant differences (sig 0,827) in the positive scores obtained (14,83% compared to 14,60%). These data imply that giving the higher importance to positive scores and reducing the importance of penalties resulted with a higher number of both positive and negative actions, but unfortunately share of penalties was significantly higher. These results are in line with results obtained by Emerson et al. (2013) and Challis et al. (2018).

Conclusion: The aim of promoting the "positive judo" was partially accomplished by increasing the total number of positive scores, at the same time this result was contaminated by a huge increase in penalties awarded.

Analysis of penalty kicks in soccer in accordance with the prevailing rules in European leagues

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Introduction: The team that would like to win a soccer match needs score goal(s). However, not many goals are usually scored during soccer matches, on average only 2.5 to 3. Thus, goals can be treated as rare events and even a single goal can determine whether a team wins. In course of this, penalties play a prominent role. The fact that about 80% of the penalty kicks result in a goal underpins the penalty kick's importance. In this set play a player shoots at the goal from 11 yards without being interfered by an opponent outfield player. Only the opponent goalkeeper can prevent the ball crossing the goal line. Subjectively, referees however still accept several rule breakings during a penalty kick. This could be players running into the box or the goalkeeper not staying on the goal line. In order to get an objective measurement of this impression, the aim of this research is to investigate if and in which way penalties are conducted irregularly and how the umpire decided.

Methods: 618 penalty kicks from four European Leagues (Austrian Bundesliga, German Bundesliga, Serie A, Premier League) and one Cup Event (German Cup), excluding penalty shootouts, from two complete seasons (2015/16, 2016/17) and the beginning of the 2017/18 season were analyzed. The video footage of all matches was provided by Sportradar. Using a systematic observation system, several aspects for each penalty kick were collected by an operator including rule violations and the player(s)/team(s) responsible for them. An intra-rater test revealed that the data is reliable ($.94 \leq \kappa \leq 1$). Statistical differences were determined using chi-square tests and Fisher's Exact tests (where necessary using Monte Carlo simulation) based on the alpha level .05.

Results: No penalty was executed without any rule infringement. However, the referees correctly judged 2.8% (n=17) of the infringements. Most of these corrected penalties (82.4%; n=14) were right because the executing player scores while his teammates behave correctly. In only three cases (17.6%; n=3) the umpire made the players repeat the penalty kick. In most cases (96.3%; n=595) both attackers and defenders entered the box too early and the goalkeeper concurrently moved irregularly. This behavior was slightly different from league to league ($p<.001$; Cramer's $V=.13$). No statistical difference was found between the cup contest and the leagues ($p=.809$). Interestingly, the goalkeeper behaved against the rules in 98.7% of the cases. However, no statistical difference ($p=.149$) was found that this helps the goalkeeper to save the ball more often.

Conclusion: In general, the penalty rule seems to be badly implemented. However, as in other sports (i.e. the time a tennis player has to serve) it can be an unwritten rule how exact the penalty rule is applied by the umpires. They only insist on the rules if the behavior of one of the players is salient against the penalty rule. In particular, it seems that the executing player should be able to profit from the advantage of a penalty kick. The only mistake he can make is to stop during the run-up.

A conceptual competitive intelligence framework for cricket coaches

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Purpose: Competitive intelligence (CI) provides the framework to collect and analyse environmental and competitor information for competitive knowledge creation. Currently no CI framework exists according to which elite coaches can analyse competitors and design a strategy. Therefore, the aim of this study was to develop a conceptual CI framework for cricket coaches to gain a competitive advantage by using the business 4Cs CI process model of Weiss (2002) as theoretical framework.

Method: The exploratory study utilized a dominant qualitative research method, followed by a quantitative exploration. Semi-structured interviews were completed with high-level cricket coaches and performance analysts, after which a constant comparative qualitative method of data analysis was employed using ATLAS.TI™ software. The theory and data driven interview codes and categories were quantitized into numerical values and a quantitative cluster analysis produced five conceptually concatenated themes with sub-categories.

Results: The themes of strategy design, review, information transmission, CI process dynamics and information parameters, each with specific sub-categories were derived from the tree diagram. A conceptual CI framework for cricket coaches was compiled in the form of a schematic representation of the concatenated tree diagram.

Conclusion: A structured CI approach applicable to cricket is the first step to advance the CI domain in sport coaching and coaches' intelligence creation activities to enhance strategic decision making and competitiveness.

Key words: competitive intelligence, framework, cricket coaches

The match-play sprint analysis of elite hurlers during competitive games

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Purpose: Hurling is an Irish field-based stick and ball invasion-type team sport. No research to date has described the specific sprint demands of competitive senior hurling match-play, which makes the design and application of match-specific sprint training programs difficult. The current study aimed to describe the sprint analysis of senior hurlers during competitive match-play, between halves and between positions.

Methods: GPS (10-Hz) were used to collect data from 48 hurlers during 17 games. The total sprint (≥ 22 $km \cdot h^{-1}$) distance (TSD), the number of sprints (NOS) classified as length (≤ 10 m, 10.1-20 m, ≥ 20.1 m) and relative speed (< 80%, 80-90%, > 90%), the between-sprint duration and the number of repeated-sprint bouts (≥ 2 sprints in ≤ 60 s) were analysed.

Results: The total NOS was 22.2 ± 6.8 accumulating 415 ± 140 m TSD. The NOS ≤ 10 m, 10.1-20 m, ≥ 20.1 m, < 80%, 80-90% and > 90% was 4.9 ± 2.5, 9.0 ± 3.7, 8.1 ± 3.6, 10.6 ± 4.3, 8.2 ± 3.6, 3.4 ± 2.4 respectively. The between-sprint duration and the repeated-sprint bouts were 208 ± 86 s and 4.5 ± 2.6 respectively. TSD (ES = -0.20), NOS (ES = -0.34), NOS 10-20 m (ES = -0.26) ≥ 20.1 m (ES = -0.24), 80-90% (ES = -0.35) > 90% (ES = -0.13) and repeated-sprint bouts (ES = -0.28) decreased between-halves. Mean length of sprint (ES = 0.25) increased in the second half. Full-backs performed a lower NOS < 80% than half-backs (ES = -0.66) and a shorter mean duration of sprints than half-backs (ES = -0.75), midfielders (ES = -1.00) and full-forwards (ES = -0.59).

Conclusion: The current study showed that players are required to perform high-speeds for the full duration of match-play. The present detailed sprint description could help coaches to tailor the conditioning of high-intensity sprint training in senior hurlers.

Performance analysis in youth sport

Analysis of qualitative (structural) changes of morphological and motoric characteristics of students under the application of regular physical education teaching

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ABSTRACT
Qualitative (structural) change in such changes that describe the differences resulting from the effect of transformational processes (teaching or training) on the properties of the respondents (entities), for which the relationships between the variables are manifested in different ways in relation to the initial state.
The main aim of the research was to determine the qualitative (structural) changes in the morphological and motoric status of secondary school students during the one-year longitudinal study in the course of one school year under the influence of the program contents of regular physical education teaching.
The survey was conducted on a sample of 166 examinees - the " Secondary technical school" of the male sex from Travnik, who regularly attended elementary education during the 2016/2017 school year. In the study 5 variables were used to evaluate morphological status and 9 variables to assess the motor status of the respondents according to the Eurofit battery test. The qualitative (structural) change of morphological and motor status of the pupils and the analysis of differences between initial and final measurement were determined by analysis of changes under the difference model and LSDIF analysis (Bonacin, 2004), and in the further procedure, similarity variables were measured for the morphological characteristics and basic motor abilities under the Krzanowski model.
In the process of analyzing the qualitative (structural) changes of the investigated space, the results of the LSDIF analysis were analyzed especially for morphological, especially for the basic-motor space. The analysis of the results of the LSDIF analysis showed that there is a difference because the trace function (having a Hi quadratic distribution) is high both in morphological (95.6796) and in the motor space (105.2999), so the probability is uncertain ($p = 0.0000$) . It is evident that one-year education (educational content of physical education) has caused statistically significant qualitative changes in both morphological and motor space.
Analyzing the qualitative changes of selected variables for the evaluation of morphological and motor characteristics, it can be concluded that the programmed curriculum of physical and health education for one school year, influenced the changes of the applied morphological variables. The similarity measures in the Krzanowski model with morphological characteristics show that the similarities in the two states are rather small and that the qualitative changes of the weaker intensity. The biggest changes were caused by sub-subtractive fatigue variables, because any quality process (teaching or

training) directly reflects on the reduction of ballast masses. Similarity measurements by the Krzanowski model in basic-motor abilities show that the similarities in the two states are rather small, but that the qualitative changes that are observed throughout the system of motor variables are greater than those of morphological variables. It is obvious that qualitative (structural) changes in motor skills have been affected by the teaching content of physical and medical education. The biggest changes were made in the static force of hand estimator variables, the agility estimation variables, and the variables for assessing overall endurance.

Key words: educational process, transformation process, structural changes

Introduction

Physical and health culture in Bosnia and Herzegovina is a compulsory subject in elementary and secondary schools and represents a significant part of the educational system aimed at improving and strengthening the health, growth and development of students. The quality of body and health culture enables proper bodily growth, development of motor skills and skills, as well as the formation of knowledge, attitudes, values, social skills, self-confidence, necessary for adopting and maintaining a person's active lifestyles and dealing with leisure sports (Findak et al., 2000, 2011). The effects of physical and health education are primarily reflected in the positive influence on the growth and development of the young organism, on the one hand, and on the increase of the motor skills, on the other (Blažević and Bonacin, 2006; Milanović et al., 2009, Neljak, 2011). The education system in Bosnia and Herzegovina is in the process of transition, and schools pass through a process of redefining the role of teachers and the position of students in the teaching process. Within the reform of the educational system, new curricula of TZK (Physical and health education, PE) schools are being introduced. At the same time, with their application, systematic monitoring of the effects of the program is also being initiated, with the desire to realize, not only a constant insight into the course of their realization, but also their upgrading and improvement based on the experiences gained. In order to be able to plan and systematically act upon the students, ie on its anthropological features, it is necessary to determine the existing situation and to determine the direction of their transformation. In this sense, there is a need for permanent monitoring and checking of students. The Eurofit battery test is used to monitor and test the physical development and motor skills of students in elementary and secondary education systems in BiH, as proposed by the European Council in 1988. The use of this test battery has brought certain newspapers in relation to the previous way of monitoring the physical development and motor skills of students and contributed to the improvement of the overall teaching quality of the TZK in BiH. However, in the past few years, in the US and some European countries, there has been quite a new look at the purpose and purpose of monitoring the physical development and the motor skills of students in the TZK teaching, mainly based on a number of researches pointing to the link between physical development, motor skills and health children and young people (Ortega et al., 2008). It is justifiably posed as a question of responding to changed living and working conditions in the modern society through the regular teaching of the TZK (and other extracurricular and extracurricular activities), and to make use of the comparative advantages of physical exercise in civilized living conditions (Findak et al., 1999; Milanović et al., 2015). In this respect, systematic and uninterrupted work throughout the school year must be the basic requirement that is placed upon the students and professors (teachers) of TZK. However, considering the systematic changes that are taking place on the students under the influence of programmed teaching contents, they are usually thinking about changes in absolute shift terms that are visible and understandable on some parameters. However, these

are not the only changes that trigger the programmed teaching process. Particularly interesting are those changes that lead to a change in the relationship of parameters assessed by students in the teaching process. Such changes are called qualitative or structural changes, which imply such changes that describe the differences resulting from the effect of transformational processes (teaching or training) on the properties of the subjects (entities), for which the relationship between the variables is manifested in a different way from the initial (initial) state.
Therefore, the aim of this study was to determine the qualitative (structural) changes in the morphological and motor characteristics of secondary school students through the longitudinal study of one school year under the influence of current program contents of regular program of physical and health education.

Methods

Sample of respondents

The survey was conducted on a sample of about 166 respondents - pupils 1st and 2nd grade of the "Secondary technical school" of the male sex from Travnik who regularly attended the TZK education in the school year 2016/2017. The total sample of 166 students is not based on any criteria that may be correlated with manifest anthropological dimensions. The only criterion by which students have the right to be a part of the sample, is to be consistently in the teaching process and to be completely healthy (all students who were in the period of measurement and testing were ill and came to classes were omitted from the sample). The research was carried out during regular Physical and Health education.

Sample of variables

To evaluate the morphological and motor characteristics of students, variables were applied according to the Eurofit battery test. The following variables were used to evaluate the morphological characteristics of a student: body height (AVISTL), body weight (ATEZTJ), biceps skin wrinkle (ANABIC), triceps skin wrinkle (ANATRI), skin wrinkle on the back (ANALEĐ), abdominal skin wrinkle (ANATRB) lower leg skin wrinkle (ANAPOT). The following variables were used to evaluate the motor characteristics: long jump MFESDM, crunches (MRCDTL), flexibility of hips (MFLPRK), hand tapping (MBFTAP), run 10 × 5 m (ŠATL10 × 5), pull up durability (MSAVIS), flamingo balance (FLAMIN), hand dynamometry (MBFDIN), running at 20 m with progressive acceleration (ŠATL 20) (Hadžikadunić et al., 2000).

Statistical analysis

The qualitative (structural) change of morphological and motor status of the pupils and the analysis of differences between initial and final measurement were determined by analysis of changes under the difference model and LSDIF analysis (Bonacin, 2004).
By projecting measurement data, a hypothetical measurement matrix is defined, by explicating a set of linear displacements on the matrix of an association comes a structural vector describing qualitative (structural) changes, taking into account the relations of the initial variables. In the further procedure, the measures of similarity of the variables for the evaluation of morphological and motor characteristics defined by the Krzanowski model were calculated.

Tzk (physical and health education) curriculum

Physical and health education curriculum for 1st and 2nd grade "Secondary technical school" was conducted for 70 school hours (2x per week for 45 minutes), during the school year 2016/2017. Within the planning of regular TZK teaching, goals and tasks are defined, time cycles for achieving them, as well as the necessary technical and material conditions. Programming was focused on determining content, loads and methods of work for the development of anthropological features and motor skills of students. A selection of exercise exercises, a defined loading dosage, and a schedule of content that is consistent with the goals and tasks of the program content was performed. Realization of program tasks of regular physical and health education was appropriate to the abilities and characteristics of the students, and was carried out within the framework of homogenised groups. The structure and contents, in the main part of the class, contained the teaching materials of sports games, general physical preparation, sports gymnastics, athletics, dance and social games, as well as additional exercises at the time when the students were waiting to come to the game.

Results

Various mathematical-statistical procedures can be used to analyze qualitative (structural) changes, but it is the simplest LSDIF analysis that allows hypothesis testing that correlations are different at different time points. This is because qualitative (structural) changes imply such changes that describe the differences resulting from the effect of transformational processes (teaching or training) on the characteristics of the respondents (entities), for which the relationship between variables is manifested in a different way from the initial (initial) state. A simple check is possible by verifying the hypothesis of the zero difference of the two matrices correlations obtained in two such states. What we are interested in is the actual trace of the square matrix of the correlation between two time points (initial and final), because the trace function also has a HI squared distribution, with the number of degrees of freedom that is the function of the number of variables describing two treatment states.
In this research, the LSDIF analysis was used to test the hypothesis that the programmed curriculum of physical and health culture influenced the changes in relationships, in this case the correlation of variables, in two different time points (at the beginning and end of the school year).

Results of LSDIF analysis of changes in morphological characteristics of students

Table 1 shows the results of LSDIF analysis of variables for assessing the morphological characteristics of students. By analyzing the results presented in Table 1, it can be seen that on a sample of 166 male respondents programmed TZK curriculum during one school year influenced the changes in relations of the selected variables to evaluate the morphological characteristics of the students. It is clear that there is a difference because the trace function (having a Hi squared distribution) is quite large (95.6796), and the statistical significance is p = 0.0000. Thus, under the influence of the curriculum content of the KZK during a school year, statistically significant structural changes of the morphological characteristics of the students were caused.

Table 1. Results of LSDIF analysis of variables for assessment of morphological characteristics of students

The actual trace of the square matrix difference	=	1.1528
HI-square (trace function)	=	95.6796
DF	=	7.0000
P	=	**0.0000**

Legend: DF - degree of freedom, P - probability (significance)

Qualitative changes of variables for the evaluation of morphological characteristics under the Krzanowski model

Table 2 shows similarity measures defined under the Krzanowski model. The results in Table 2 show that the similarities of the measured variables for the evaluation of the morphological characteristics in the two states (initial and final) are rather small and that the qualitative (structural) changes though lower intensity can be observed across a whole set of variables. Thus, under the influence of the curriculum content of the TZK, some changes have taken place, but they are still the most important structural ones because they are responsible for the different configurable correlations or variables. It is noted that the greatest changes are caused by the variables for the assessment of subcutaneous fat tissue, and most at the skin folds of the triceps (ANATRI 0.0255) and the skin fold of the abdomen (ANATRB 0.0923). This information should not be surprising because any qualitative process (teaching or training) directly reflects on the reduction of ballast masses. A high degree of similarity is observed in body weight (ATEZTL 0.9749), indicating that there were no significant changes in body weight and did not contribute to the described structural changes.

Table 2 Results of TRG1 analysis of qualitative changes of morphological characteristics. Similarity measures defined under the model of Krzanovski

Varijables	S
AVISTL	-0.1208
ATEŽTJ	0.9749
ANABIC	0.1940
ANATRI	0.0255
ANALEĐ	0.1256
ANATRB	0.0923
ANAPOT	0.1108

Legend: AVISTL - body height, ATEZTJ - body weight, ANABIC - fold of biceps, ANATRI - fold of the triceps, ANALEĐ - back fold, ANATRB - abdominal fold, ANAPOT- fold of the lower leg, S - measures of similarity - diagonal elements

Results of the LSDIF analysis of changes in the students basic motor skills

Table 3 shows the results of LSDIF analysis of variables for assessing the basic motor skills of students. By analyzing the results shown in Table 3, it can be seen that in the sample of 166 subjects of male sex in the baseline - motoric area there were more and statistically significant changes than in the morphological space.

It is evident that the difference exists because the trace function (which has a Hi-squared distribution) is quite large (105.2999), so the probability is undoubted (p = 0. 0000). Thus, under the influence of the curriculum content of the TZK, significant structural changes in basic-motor abilities were induced.

Table 3. Results of LSDIF analysis of variables for assessment of motor skills of students

The actual trace of the square matrix difference	=	1.2687
HI-squares test of significance (trace function)	=	105.2999
DF	=	9.0000
P	=	**0.0000**

Legend: DF - degree of freedom, P - probability (significance)

Qualitative changes of variables for the evaluation of basic motor skills under the Krzanowski model

Table 4 shows the measures of similarity of variables for the estimation of basic motor spasticity defined under the Krzanowski model. The results in Table 4 show that the similarities of selected variables for the assessment of motor abilities in two states (initial and final) are rather small and that the qualitative (structural) changes seen throughout the system of motor variables are greater than those of the applied morphological variables. Thus, under the influence of the curriculum content of the TZK, some changes have taken place, but the most important are the structural ones, because they are responsible for the different configuration of the correlation, ie the relation of the variables. The biggest changes occurred in the following variables: static force estimator variables (MSAVIS 0.0286), agility estimation variables, 10x5 m running here (ŠATL10 × 5) and variables for overall endurance evaluation, running at 20 m there - Here with Progressive Acceleration (ŠATL20). A high measure of similarity is observed in the equilibrium variable (FLAMIN 0.9950), which indicates that no significant changes have been made in the equilibrium test and that it does not contribute to the described changes in motor abilities.

Table 4. Results of TRG1 analysis of qualitative changes in motor abilities. Similarity measures defined under the model of Krzanovski.

Varijables	S
MFESDM	0.3908
MRCDTL	0.5112
MFLPRK	0.3012
MBFTAP	0.1927
ŠATL10×5	0.1418
MSAVIS	0.0286
FLAMIN	0.9950
MBFDIN	0.2629
ŠATL 20	0.1382

Legend: long jump MFESDM, crunches (MRCDTL), flexibility of hips (MFLPRK), hand tapping (MBFTAP), run 10 × 5 m (ŠATL10 × 5), pull up durability (MSAVIS), flamingo balance (FLAMIN), hand dynamometry (MBFDIN), running at 20 m with progressive acceleration (ŠATL 20), S - measures of similarity - diagonal elements

Discussion

Based on the results of the LSDIF analysis it can be concluded that the teaching contents of the TZK during one school year produced statistically significant qualitative (structural) changes in the morphological and motor characteristics of the pupils, which confirms the high trace function (having the Hi squared distribution) as in the morphological (95.6796) and in the motor space (105.2999), so the probability is undoubted (p = 0.0000). The similarity measures of the Krzanovsky model show that the similarities of selected morphological and motor variables in two states (initial and final) are rather small and that qualitative changes, though weaker intensity, can be observed across a whole set of variables. However, the results of LSDIF analysis of structural changes indicate that major and statistically significant changes have occurred in the motor space, relative to the morphological characteristics. The obtained results indicate that the educational content of the TZK during one school year has resulted in qualitative (structural) changes in morphological and motor characteristics of students. However, it should be noted that mild (moderate) changes have occurred. To what extent teaching content affects structural changes, it should be seen through the application of other curriculum content of the TZK and the second sample of respondents. Many previous researches in the

TZK system (Rađo et al., 2003, Borčić et al 2005, Selmanović et al 2008, Hodžić, 2008, Džibrić et al. 2009, Ferhatbegović et al., 2010, Milenković et al. , Bajrić et al, 2012b, Badrić et al., 2016) have shown that the effects on changes in anthropological characteristics of students are greater and more significant when regular classes combine with additional organizational forms of work in elementary and secondary schools (extracurricular and extracurricular activities, elective activities, various forms of supplementary education, school sports, etc.).

Conclusion

The main aim of this longitudinal study was to strive to determine qualitative (structural) changes in morphological and motor characteristics of students under the influence of the current one-year TZK teaching program. The results of the SSDIF analysis indicate that the current one-year curriculum at high school students caused statistically significant changes ($p = 0.0000$) in both research areas, but mild changes occurred without dramatic changes. The described effects of current one-year TZK curriculum (70 lessons, 2 times per 45 minutes a week) show and point to the fact that systemic and organized-programmed work can achieve many beneficial effects that students remain as significant capital for further development phases because they are middle-aged, where biological manifestations are still being formed. Given that the high level of industrialization and automation and the modern way of life “cause” the level of physical activity in all stages of growth and development of children is decreasing, and the long sitting time in school benches and work desks, along with television screens, computer games grow, research of this character should become even more important. Current issues and reforms through which the education and training system pass, and the results of this research should also encourage other researchers to research similar issues, as results and partial studies could contribute to the higher quality of planning, programming and monitoring the effects of the TZK system in its entirety on changes Morphological-motor characteristics of students.

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Effects of 8-week High Intensity Maximal Aerobic Speed Training combined with Change of Direction (COD) improving VO2max of 16-year-old players

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ABSTRACT
The purpose of the present study show the effects of HIIT Maximal Aerobic Speed training at intensity of 120% of MAS but with Change of Direction (COD). Responses in Heart Rate (HR) and maximal oxygen uptake V̇O2max were examined. Eighteen soccer player Age 16 year old of Football School were divided in two groups, one Test Group and the other Control Group.
The Test group participated for 8 weeks in the running circuit 125m with direction change 90 grade (45m) -180 grade (25m) -360 grade (5m) -180 grade (25m) -45 grade (25m). Realization time is 30 sec. Time between breaks is 4.30 min. The Series is 1x. Number of Repeats is First Week 4 Times, Second Week 5 Times and Four Weeks Left 6 Times, Volume 4 Times – 500 meter, 5 Times- 625 meter, 6 Times – 750 meter. Frequency and Duration of Exercise is 3 times a week for 8 weeks. The speed of running 120% of MAS: 3.6m / s (100% SHMA) * 120% = 4.33 m / s. The control group assigned according the annual plan, aerobic resistance long slow distance training protocol. Result of Test Group show, HR lowering moderately by 3% and VO2 Max in Astrand Test 6' increased by 7% and Cooper Test 12' by 12.9 %. From 11 soccer player of Test Group, 50% of them increased in meters covered in the Second Copper Test by 240-280 meter, 20% 140-190 meter and 30% 50-90 meter. The Control Group show increase in VO2 Max in Astrand Test 6' by 8 % and Cooper Test 12' by 4.5 %. From 7 soccer player of Control Group, 20% of them increased in meters covered in the Second Copper Test by 250 meter, 40% 140-170 meter and 40% 50-90 meter. Conclusion: High Intensity Maximal Aerobic Speed Training combined with Change of Direction (COD) boost VO2max of soccer player improving soccer performance by increasing the distance covered in Cooper Test 12'.

Key words: HIIT, maximal aerobic speed, soccer player, change of direction (COD)

Introduction

Soccer game is characterized by typical acyclic, acceleration and deceleration, multiple directional changes. In the 90-minute game, elite youth (ages 15 - 16) often cover 7 to 10 kilometers distance (Mendez-Villanueva, A., Buchheit, M., Simpson, B., Bourdon, P. C. 2012). The younger population is known to have lower aerobic capacity, which is limited by body size (for example, smaller heart size), and therefore they have lower maximal cardiac output than adults (Buchheit, M., et al., 2010), (Metaxas, Th., Koutlianos, N., Kouidi, Deligiannis, E. and S.,2005). Recent evidence suggests that many adaption are stimulate faster than previously thought about the effect of small volumes of high intensity (Buchheit, M., Haydar, B., Hader, K., Ufland, P., Ahmaidi, S. 2011), (Helgerud, J., Engen,L.Ch., Wisløff, U., Hoff, J. 2001), (Helgerud, J., Hkydal, K., Wang, E., Karlsen, T. Berg, P., Bjerkaas, B.,Simonsen, Th., Helgesen, C., Hjorth, N., Bach, R., Hoff, J.2007). Studies show that the amount of time spent at or above the 100% aerobic maximum speed (MAS) seems to be the critical factor for improving aerobic power. It was determined that performing a number of short intervals at ≥100% MAS was a more effective method than building aerobic strength through long distance running and low intensity training. This approach was even more effective than trying to train just one interval at 100% MAS. Specifically, a 120% MAS intensity was determined to be the best motion velocity for short intervals followed by a passive plus active break, based on the fact that this intensity allowed on the maximum pulse of the training pulse (x volume intensity), compared to 90, 100, and 140% MAS, (Baker, D. Recent trends in high-intensity aerobic training for field sports.2011).

Material and Method

Participants
In this study were recruited 18 football player's age 16-year-old of the Football Master's High School "Loro Borici" in Tirana.The football team participated in the activity organized by AFF, for the Amateur category, age U-17 season 2017-2018.The study was carried out with the permission of the school director "Loro Borici" and the approval of the coach of the players.

Tests
- Anthropometric measurements (Height, Weight and BMI).
- Cooper's 12 min running on the field
- Astrand test 6 min in ergo metric bicycle and Heart rate, POLAR

Protocol and test administration
The Cooper Test Run was conducted in a football field with artificial grass measuring 105 m x 68 m, in the training facilities of the Albanian National Football Team. The perimeter of the football field was modified in the form of a runway 300m (Figure 1). Footballers who were previously identified by a number from 1 to 18 before ran for 12 minutes at the perimeter of the set. At the end of the test, the data was thrown into a table in Excel format where the VO2 max levels were identified for each player according to the rates set by the Cooper test.

Determining 100% of Maximum Aerobic Power Speed
The definition was made using the following formula:
100% MAS = Running Distance / Time of Completion

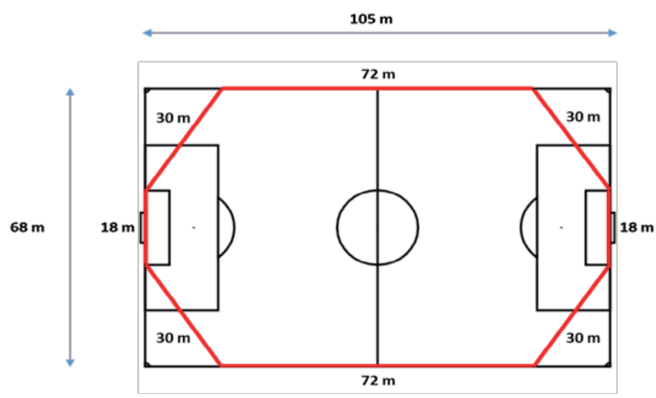


Figure 1. Runway perimeter

After defining the levels of Vo2 max of the players based on the Cooper test rates, we divided the subjects into two groups, the Control and the Test Group.

- The control group included seven players who had run in the Copper Test at a distance of 2770-2900 meters.
- The test group included 11 players who had run in the Copper Test 2400-2650 meters.

The control group's players, who had run in the Copper Test 2770-2900 meters, had the average of 100% of MAS the 3.8m / s. The players of the test group, who had run in the Copper Test 2400-2650 meters, had the average of 100% of MAS the 3.6m / s.

Astrand Test 6 minutes

At the start of the test, the footballer were informed that they will continue for six minutes, and that long this time he will have to keep the pace defined by the protocol. They can stop test at any time and for any reason, but especially if he experiences chest pain, shortness of breath, dizziness or blurred vision. Protocol and test administration:

- Before the test started, a 3 to 5 minute warm up was given to reach a heartbeat of just over 120 beat in a minute.
- The workload is determined as follows:
  - First minute with 300 (kgm / min) (50 watts)
  - second minute with 600 (kgm / min) (100 watts)
  - four minutes at 900 (kgm / min) (150 watts)

Protocol and Training Intervention

The training intervention in this study is comprised of a training circus as follows: Distance: 125m with direction change 90 grade (45m) -180 grade (25m) -360 grade (5m) -180 grade (25m) -45 grade (25m), (Figure 2). Realization time: 30 sec. Time between breaks: 4.30 min Series: 1x. Number of Repeats: First Week 4 Times, Second Week 5 Times and Four Weeks Left 6 Times. Volume: 4 Times – 500 meter, 5 Times- 625 meter, 6 Times – 750 meter Frequency and Duration of Exercise: 3 times a week for 8 weeks.120% of MAS: 3.6m / s (100% SHMA) * 120% = 4.33 m / s. With the pace of the player's move by 4.33 m / s in 30 seconds, he will can cover the distance of 130 meters. Due to the specificity of the running circuit which is with change of direction, the player could cover within 30 seconds only 125meters. The test was conducted every Monday, Wednesday and Friday at 10:00 am in an artificial grass field. The training intervention starts with a slight heat for 10 minutes. In each training session we monitored players with the POLAR monitoring system for measuring heartbeats during the test. Measurement of heart rate is performed at the beginning and end of each repeat. The footballers departed with a command of a distance of 5 seconds each other.

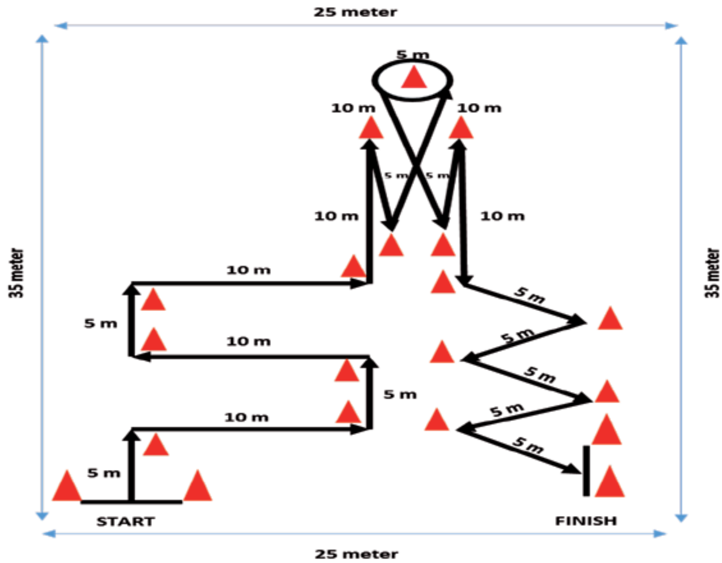


Figure 2. Running Circuit

Measures

All participants were subjected to anthropometric measurements (Table 1) and tests related to the VO2 max evaluation prior to the study protocols to be able to divide into two groups, a control group, and a testing group.

Table 1. Anthropometric measurements average data

Gender	Masculin
Number	18
Age (year)	16.4
Weight (Kg)	62.61
Height (cm)	172
BMI (Kg*m2)	21.22

Training Intervention

In a linear running, the speed of movement of 120% of MAS = 4:33 m / s, the subjects would have to travel the distance of 130 m. The study predicted that running in circuit should be pursued with the direction changes, within 30 seconds, which would correspond to movement speed to 120% of MAS = 4:33 m / s. In the control group, consisting of 11 players, three days before the start of training intervention was conducted several repetition of circuit, which will help us to determine the distance running. The evidence suggests that running distance with directional changes, which would have to be traversed within 30 seconds, was 125 meters.

- In the first and second week the group conducts training sessions Monday - Wednesday - Friday, where the circus was repeated 4 times.
- In the third and fourth week group perform training sessions Monday- Wednesday - Friday where the circuit was repeated five times.
- In the fifth week, the sixth, seventh and eighth groups perform training sessions Monday- Wednesday - Friday where circuit was repeated six times. At the end of each repetition, the subjects performed 1 minute of passive breaks, 3 minutes of

active breaks in the field with the ball and 30 seconds of passive breaks. The test duration depend on the number of repetitions and the number of present subjects lasted as follows: -4 times 24 min, 5 times 29 min and 6 times 35 min. In each training session the heart rate was monitored by POLAR system. The system records were checked immediately after the completion of each repetition and at the beginning of each repetition and recorded. The experiment period lasted for 8 weeks. The control group throughout the 8-week period was trained according to the planned annual program.

Results

Heart Rate

At the end of the intervention training one subject failed to complete the intervention training due to injury in the official match. During the training period another subject was absent for one week due to damage to the official match, but after the recovery resumed the intervention training. All other participants were present in 8 week of the intervention training. In the limits of this study, we may mention the inability to control the nutrition and daily regimen, and especially the time when subjects went to sleep at night. We emphasize the fact of the subject's sleeping time, because in all cases when we saw the time for the running circuit was over 30 seconds, most of the time resulted in the subject having slept too late and therefore showed signs of fatigue and show difficulties to recover within the defined time of 4.30 minute because their heart rate was 130-140 beats for minute. At the end of the 8-week period of intervention training, the average heart rate at the end of each repeat was reduced to 174 beats per minute, compared to the heart rate beating average in the first week of intervention initiation, which was 179 in minute (Table 2).

Table 2. Average of Heart Rate during Intervention Training

First Week	179
Eight Week	174
Difference in value	5
Difference in %	3

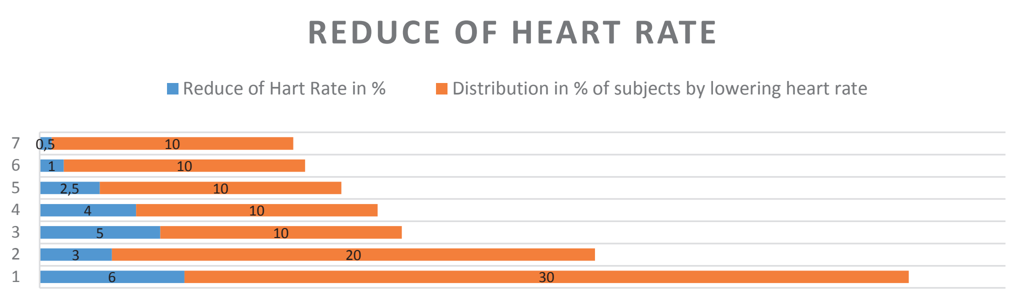
In the table below the results show the distribution of subjects (Table 3, 4 and Figure 3) by lowering heart rate in percentage.

Table 3. Reduce of Heart Rate in % rate

1	6
2	6
3	6
4	5
5	4
6	3
7	3
8	2.5
9	1
10	0.5

Table 4. Distribution in % of subjects by lowering heart

Reduce of Hart Rate in %	Distribution in % of subjects by lowering heart rate
6	30
3	20
5	10
4	10
2.5	10
1	10
0.5	10

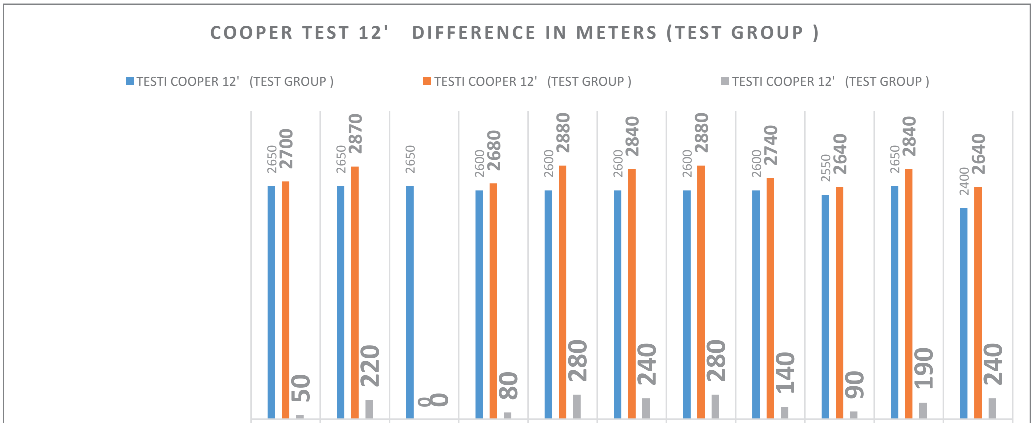


	1	2	3	4	5	6	7
Reduce of Hart Rate in %	6	3	5	4	2,5	1	0,5
Distribution in % of subjects by lowering heart rate	30	20	10	10	10	10	10

Figure 3. Distribution in % of subject by lowering heart rate after intervention

Cooper Test 12'

The distances data covered in the two Copper Tests conducted, one before the start of the interventional training and the second after the completion of the 8 weeks of training (Figure 4, 5) showed that the subjects had significant improvements compared to the control group.



	1	2	3	4	5	6	7	8	9	10	11
TESTI COOPER 12' (TEST GROUP)	2650	2650	2650	2600	2600	2600	2600	2600	2550	2650	2400
TESTI COOPER 12' (TEST GROUP)	2700	2870	0	2680	2880	2840	2880	2740	2640	2840	2640
TESTI COOPER 12' (TEST GROUP)	50	220	0	80	280	240	280	140	90	190	240

Figure 4. Difference in metersTest Group

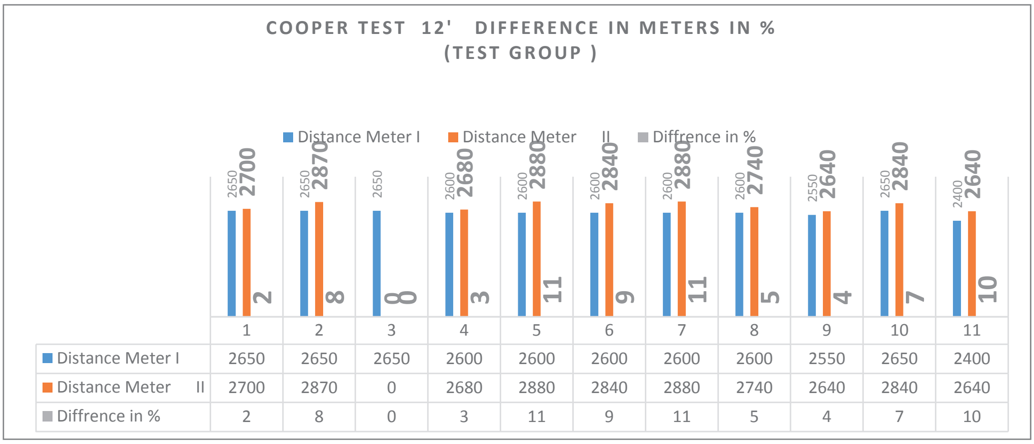


Figure 5. Difference in meters in % Test Group

The percentage in the distance covered in the Copper test (Table 5) increase with 7% average.

Table 5. Dissemination in % of subjects by increasing running distance

Increase of Running Disntance in %	Dissemination in % of subjects by increasing running distance
11	20
10	10
9	10
8	10
7	10
5	10
4	10
3	10
2	10

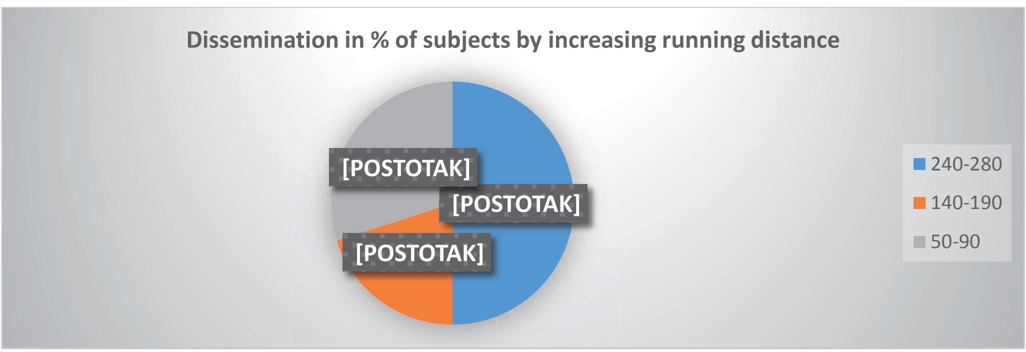
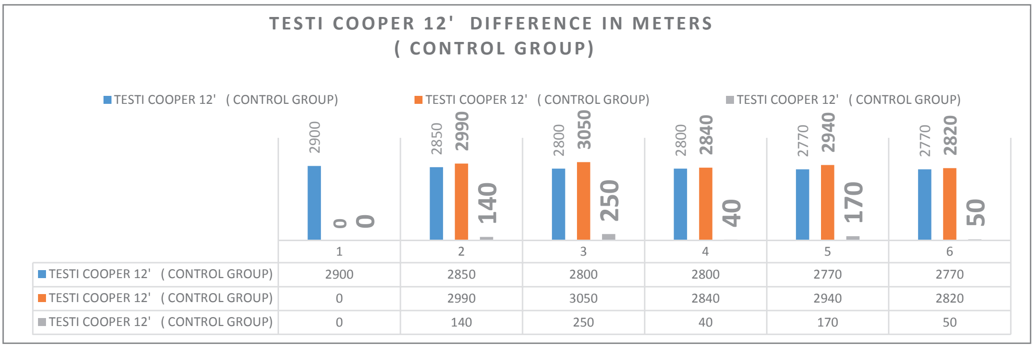


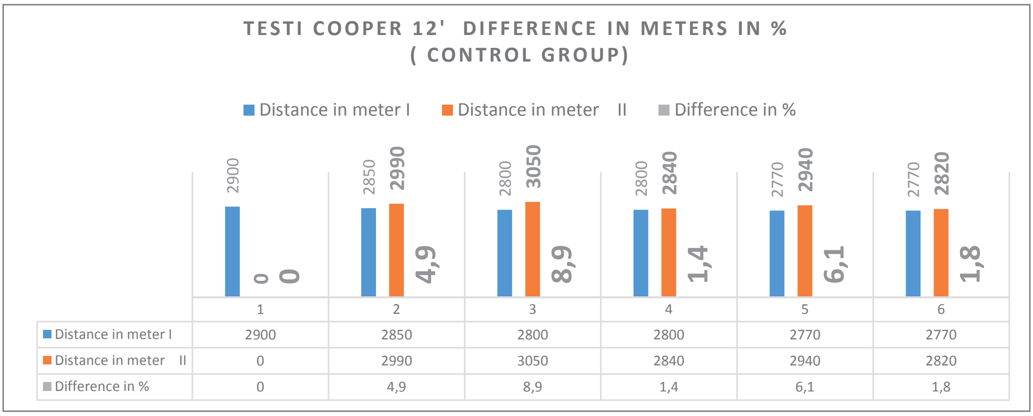
Figure 6. Dissemination in % of subject of Test Group by increasing running distance

In the control group there were improvements as well, but they were smaller (Figure 7, 8) compared to the improvements seen by the subjects of the test group. The average increase in % of the control group was 4.5%.



	1	2	3	4	5	6
TESTI COOPER 12' (CONTROL GROUP)	2900	2850	2800	2800	2770	2770
TESTI COOPER 12' (CONTROL GROUP)	0	2990	3050	2840	2940	2820
TESTI COOPER 12' (CONTROL GROUP)	0	140	250	40	170	50

Figure 7. Difference in meters Control Group



	1	2	3	4	5	6
Distance in meter I	2900	2850	2800	2800	2770	2770
Distance in meter II	0	2990	3050	2840	2940	2820
Difference in %	0	4,9	8,9	1,4	6,1	1,8

Figure 8. Difference in meters in % Control Group

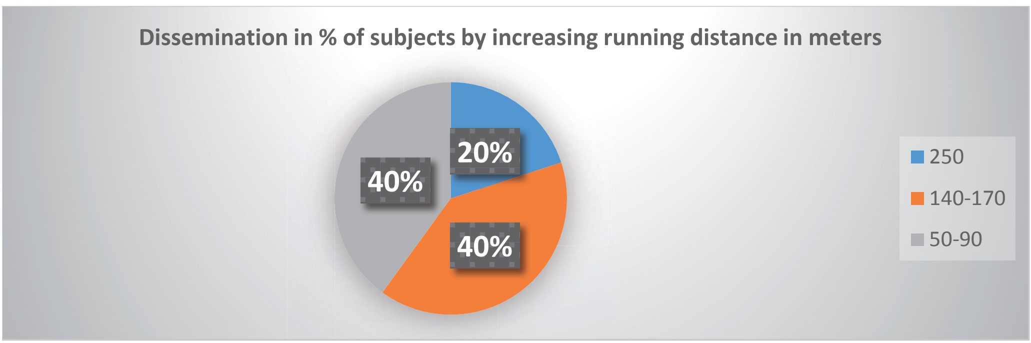


Figure 9. Dissemination in % of subjects of Control Group by increasing running distance in meters

In (Figure10) we have presented a comparison of the change in growth between the test group and the control group.

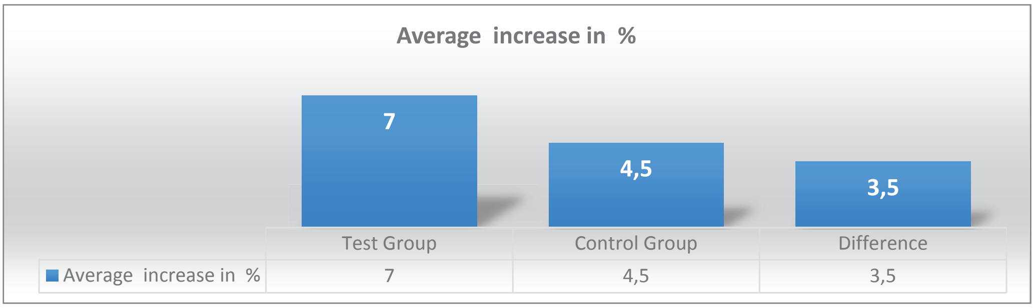


Figure 10. Difference average increase between Test and Control Group

Astrand Test 6' Ergo Metric Bicycle

The results of the Astrand test developed prior to commencement training and one after the 8 week training period (Figure 11, 12) showed that the subjects of the test group had a greater increase than the subjects of the control group.

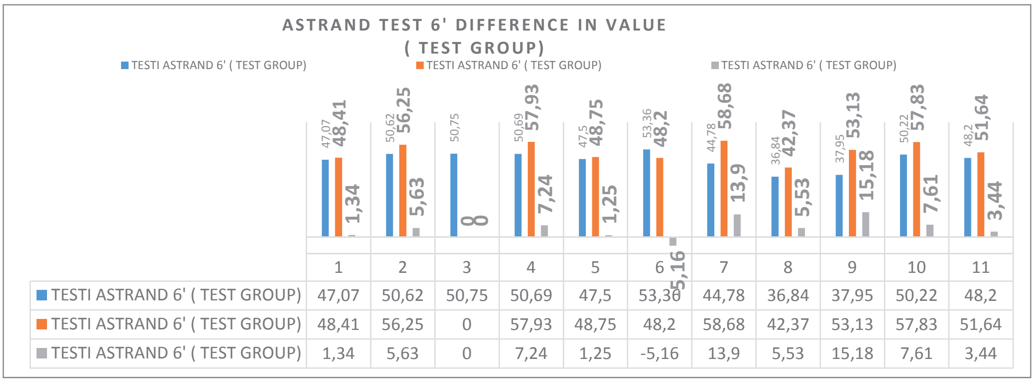


Figure 11. Astrand test 6' difference in value (Test Group)

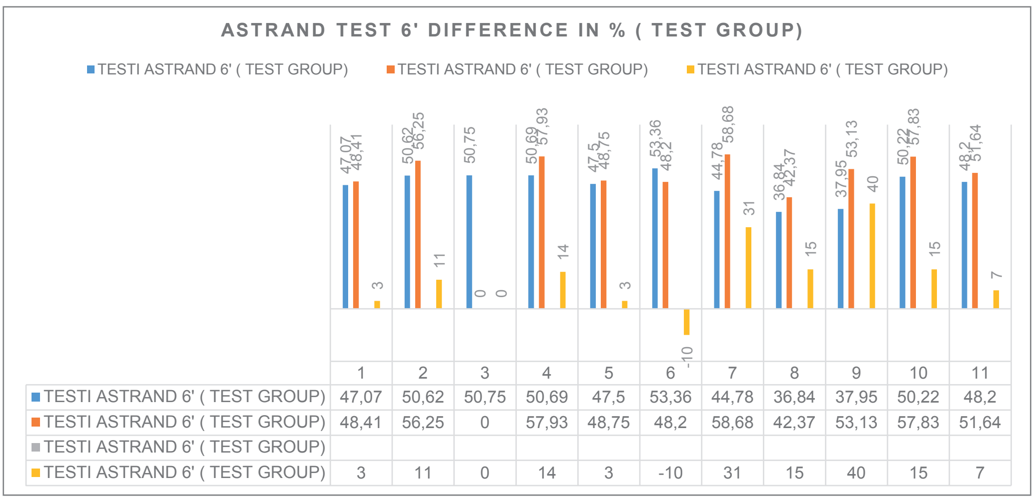


Figure 12. Astrand test 6' difference in % (Test Group)

Table 6. Increase VO2 max in% of Astrand Test and Distribution in % of subjects according to the growth of Vo2 max

40	10
31	10
15	20
14	10
11	10
7	10
3	20
-10	10

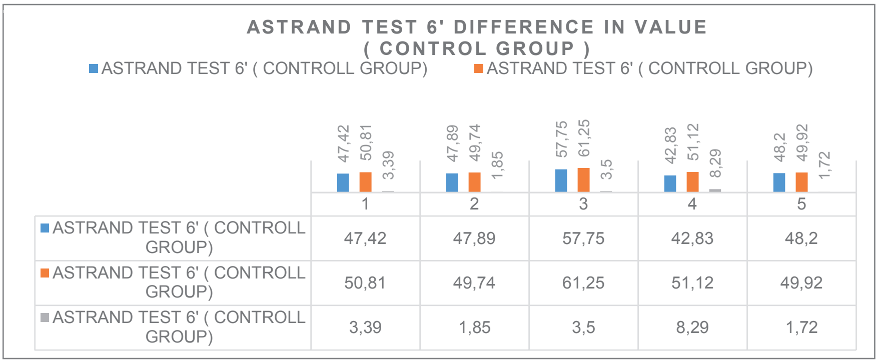


Figure 13. Astrand test 6’ difference in value (Control Group)

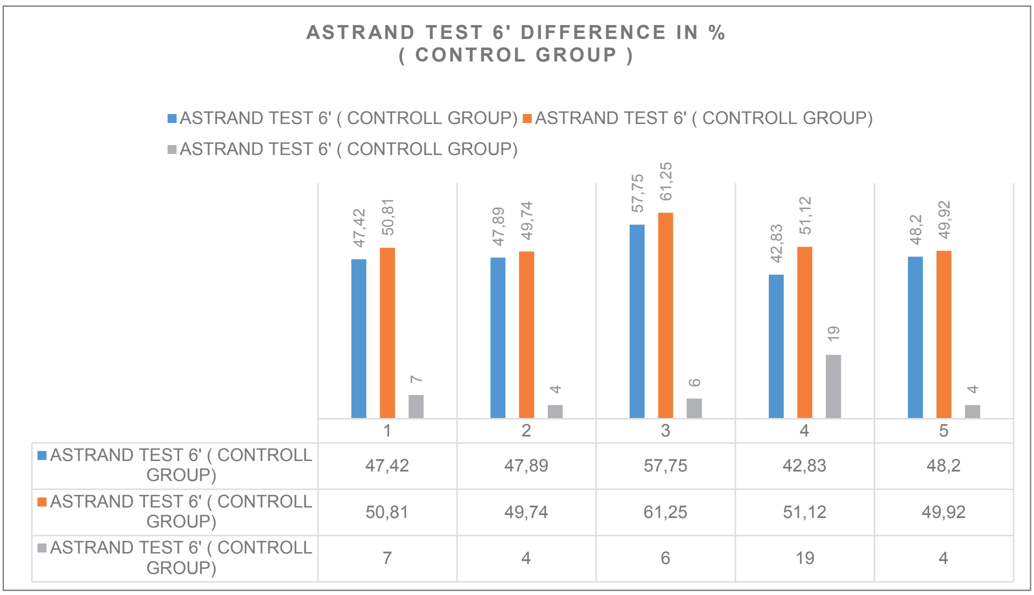


Figure 14. Astrand test 6’ difference in % (Control Group)

At the end of the intervention training, the results of the Astrand 6 min test on ergometric bicycles according to the protocol described above showed (Figure 15) that, the subjects of the test group had an average increase in VO2 max values of 12.9%. The control group also showed an average increase in VO2 max values of 8%.

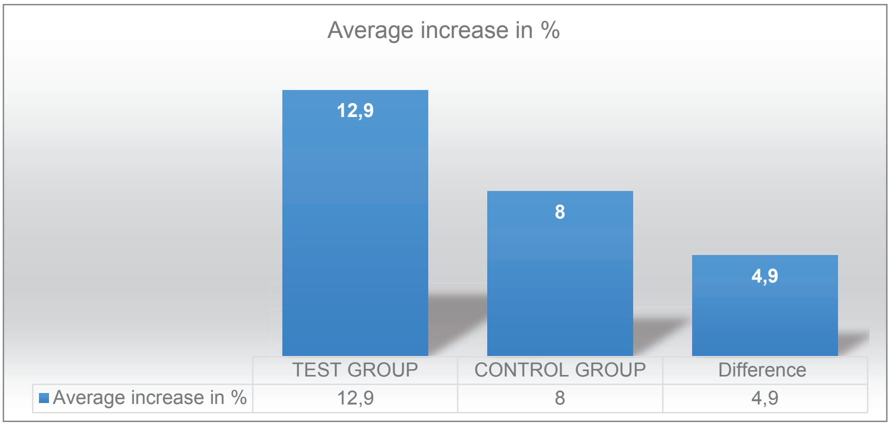


Figure 15. Difference in average increase in % between Test and Control Group

Discussions

Studies show that adult's footballers run in an average during the match approximately 10 to 12 km where the largest volume is caught by low intensity (Buchheit, M., Haydar, B., Hader, K., Ufland, P., Ahmaidi, S. 2011). But running where players get tired are those with high intensity which are much related to physical fitness and Vo2max. In 60 minute effective game, a footballer performs approximately every 12 minutes of acceleration, 11 rebounds and 14 runs with variations in directions at 0-360 degrees.

In the construction of this study, the idea was born precisely on the basis of previous study data which highlighted the nature and characteristics of running on the football field for youth category 16 year old (Atan, S.A., Foskett, A., Ali, A. 2014).The intervention training aimed to identify the volume and optimum intensity for improving Vo2max with low volume but HIIT Maximal Aerobic Speed (Wislkff, U, K. Ellingsen, and O.J. Kemi. 2009, Cornelissen,V A., Verheyden, B., Aubert, A E., & Fagard, R H. 2010). Training effects depend mainly on parameters such as intensity, duration and rest intervals as they are the key factors influencing.

The results from the study show that steady of the running intensity for 8 weeks and the gradual increase in running volume brought significant improvements to the Vo2 max of the subjects involved in the intervention exercise compared to the subjects involved in the traditional exercise (5).

Heartbeat monitoring is one of the ways to control the intensity of exercise.

The heart rate of subjects in the test group at the end of the 8 weeks decreased by 3%, which is also confirmed by previous studies related to high intensity aerobic training effects (Gibala, M.J. , Little, J,P., MacDonald M.J., Hawley, J.A. 2012). It should be noted that these effects on lowering heart rate in some cases were not achieved during exercise. From the questions we addressed to the subject that showed signs of fatigue or high heart rate, it turned out that the subject had slept too late, failing to meet the required hours for recovery, and therefore exhibited heartbeat at high rates by had difficulties in covering the running circuit within 30 seconds and recovery within the specified time of 4.30 minutes.

In studies where field tests and lab tests are used, there is always concern that subjects are giving the maximum in field tests. But benchmarking of laboratory labs with field tests

makes it possible to reach conclusions about the effectiveness of intervening training. The data show that subjects who underwent on interventional training increased by 7% at the distance covered in the second Cooper test and also increased by 12.9% in the Vo2 Max values in the second Astrand lab test on ergo metric bicycles.
In Sports Performance = Fitness - Fatigue
In the study, we did not have the ability to perform direct measurements on the playing field with GPS devices to monitor performance in relation to fitness and fatigue. But after the end of the fourth week we began to ask the subjects how they perceived their physical performance during the game.
In most cases, the subjects answered that at the end of the matches they did not feel too tired as they felt four weeks ago. Their perception was that they were more fit at the end of the game. So fatigue was coming later.

Conclusion
Drill with small volume with high intensity and with directional changes 120% speed of MAS may be an exercise for football sports for ages 15-16 years in improving the level of Vo2 max. The data in this study support the idea of the efficiency and the potential for using the circuit running with maximal aerobic speed high-intensity training.

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Some parental habbits as predictors of child BMI

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ABSTRACT
The aim of the study was to investigate the impact of parents' BMI, dietary and physical activity habits on the preschool child BMI. The survey was conducted on a sample of 148 parents and their children aged 3 to 7 (N=74; boys=43, girls=31). No significant differences have been determined between boys and girls in the values of body mass (girls: 20.39±4.50 kg, boys: 21.19±4.34 kg), body height (girls: 114.06±8.82 cm; boys: 117±7.70 cm) and BMI (girls: 15.21±1.62; boys: 15.32±1.56), why they have been considered as a unique sample. The results of forward stepwise multiple regression analysis have identified mothers BMI as a significant predictor of child BMI ($p<0.01$). Generally, the existence of child obesity risk factors, that arise from the dietary and sedentary habits of their parents, has been confirmed.

Introduction
The etiology of the child obesity is multifactorial, ie it reflects the complex interaction of genetic factors and environmental factors, including the availability of food and the time for leisure activities in the family. The researchers' attention is particularly directed to the complex interaction of genetic predisposition (which are responsible for approximately 70% of obesity cases) and environmental factors, since significant correlation have been established between obesity of parents and children (Epstein, Myers, Raynor, & Saelens, 1998; Johnson & Birch, 1994; Whitaker, Wright, Pepe, Seidel, & Dietz, 1997; Nguyen, Larson, Johnson, & Goran, 1996; Magarey, Daniels, Boulton, & Cockington, 2003; Salsberry & Reagan, 2005). Also, studies have determined the influence of parents attitude toward the model of child feeding; some attitudes ultimately lead to a greater body mass and greater weight changes of child during his childhood (Klesges et al., 1983; Fisher & Birch, 1999; Birch, Fisher, & Davison, 2003; Francis & Birch, 2005). For the children with more permissive parents, higher BMI values have been determined compared with children of more authoritative parents (Hughes, Power, Orlet Fisher, Mueller, & Nicklas, 2005). In the families with obese children more permissive feeding styles have been found compared to families with non-obese children (Moens, Braet, & Soetens, 2007). Previous becomes additionally worrying when known that early eating habits, a pattern according to which a child grows during childhood, can affect the appearance of obesity in adolescents and adults (Bošnjak & Grgurić, 2007; Hoppe, Christian Mølgaard, & Michaelsen, 2006).
Beside different eating habits, the predominantly sedentary lifestyle is also considered to be the problem of today, because it consequently leads to obesity. Together, those two problems accumulate acute and chronic negative effects on health (increased risk of cardiovascular diseases, organ systemic cancers, type 2 diabetes mellitus, metabolic syndrome, respiratory illness, locomotor system disease, gastrointestinal disease, disorder urogenital system; Treuth et al., 2007; Katzmarzyk, Church, Craig, & Bouchard, 2009; Owen, Bauman, & Brown, 2009; Medanić & Pucarin-Cvetković, 2013; Skinner, Perrin, Moss, & Skelton, 2015). The most frightful is a number of 2.8 million adults who

die per year from overweight (European Association for the Study of Obesity-EASO; http://easo.org/education-portal/obesity-facts-figures/).

Apart from adults, the percentage of children with overweight body mass and obesity is globally increased, but more disturbing information is that nutrition and living habits of children are getting worse with the increase of their age. According to the World Health Organization (WHO) and the International Obesity Task Force (IOTF), more than 155 million (10%) of children and adolescents in the world have overweight body mass and about 40 million (3%) are obese (https://www.worldobesity.org/data/child-obesity/). Except for schoolchildren, the frequency of obesity is an increasing problem in pre-school age, especially in the Middle East, North and Latin America, with an average prevalence of 3.3% (De Onis & Blössner, 2000). Some researchers show a higher cumulative incidence of malnutrition and the obesity of preschool children from socially deprived environment compared to children who grow up in the environment with appropriate social and economic opportunities (9.5% compared to 6.9%; Armstrong, Dorosty, & Reilly, 2003). Cunningham, Kramer and Venkat Narayan (2014) have reported that in the year of 2010. a 43 million (or 6.7%) of worldwide children (by the age of 5) had overweight body mass, and have estimated that by the year 2020. a 60 million of children (9.1%) (up to the age of 5) will be fat or will have overweight body mass. According to the data published in the United States (leading country in the number of overweight and obese population) by the year 2014., at the age of 5.6 years, 14.9% of children had overweight body mass, and 12.4% were obese (Cunningham, Kramer, & Venkat Narayan, 2014). In 2016. the Croatian Institute for Public Health (2016) conducted a European Health Interview Survey (EHIS) on a sample of 5000 people. The obtained data show that in Croatia 41.9% of the population has a normal body mass (body mass index ranging from 18.5-24.9kg/m^2), for 37.7% of the population the index of body mass was ranging from 25-29.9 kg/m^2 (overweight body mass), for 18.0% of the population body mass index was higher than 30 kg/m^2 (considered to be obese), and for 2.3% of the population a body mass index was found to be lower than 18.5 kg/m^2 (considered to be under-represented). According to the results of Kuzman, Pavić Šimetin and Pejnović Franelić (2012) in Croatia 33% of boys and 20% of girls have overweight body mass or are obese at the age of 11. However, despite the widespread and a significant number of obese children worlwide, it is surprising how much the overall population is generally very little informed about health problems that arise from it (West, 2007).

A screening tool that is mostly used to indicate whether a person is underweight, overweight, obese or a healthy weight for their height is value of Body Mass Index (BMI). Its values are age-independent and the same for both sexes, but may not correspond to the same degree of fatness in different populations due to different body proportions (https://www.medicalnewstoday.com/info/obesity/what-is-bmi.php). Because of child fat tissue change with the age, also because gender differences in fat tissue during a childhood, for children, a somewhat different calculation method is used for calculating BMI, compared to adults. For children and young people, the BMI is calculated according to their age and gender and is highly specific because of their growth and development. Namely, after calculating the BMI for children and adolescents, its numerical value is denoted on the CDC BMI Growth Chart for a specific age and gender in order to determine the percentile rank to which child belongs to (http://www.cdc.gov/growthcharts/data/set1clinical/cj41l023.pdf; http://www.cdc.gov/growthcharts/data/set1clinical/cj41l024.pdf). The BMI on percentile chart shows the relative position of the child among children of the same sex and age. The child is considered underweight if the BMI values are below the 5th percentile, the child has a normal body weight if the BMI is between 5th and 85th percentile, the child is overweight if the BMI is between 85th and 95th percentile, and the child is obese if the value of his BMI is equal to or greater than 95th percentile (https://www.cdc.gov/nccdphp/dnpao/growthcharts/training/bmiage/index.html)

Methods

Subject sample

The study was conducted on a sample of 74 children from two kindergartens aged 5.22±1.20 years, average body mass of 20.85±4.34 kg and mean body height of 116.24±8.13 cm. Out of the total number of children, 31 children were girls (average body mass of 20.39±4.50 kg (kg), average body height of 114.06±8.82 cm (cm) and average BMI of 15.21±1.62) and 43 children were boys (average body mass 21.19±4.34 kg, average height of 117.00±7.70 cm and average BMI value of 15.32±1.56). Significant differences have not been determined in body mass, body height and body mass index (BMI) between the genders and they were analyzed as a single sample (average body mass of 20.85±4.34 kg, average body height of 116.00±8.00 cm, BMI average 15.40±1.58). BMI of children under age of 5 has been calculated by using the WHO Anthro program (version 3.2.2, January 2011; http://www.who.int/entity/childgrowth/software/WHO_Anthro_setup.exe?ua=1) while the BMI for childer above age of 5 has been calculated by using the WHO Anthro Plus program (http://www.who.int/growthref/tools/WHO_AnthroPlus_setup.exe). The research was conducted in full in accordance with the Helsinki Declaration. All parents, the research participants, were informed about the research goal and signed a statement of consent for themselves and their child's participation in the research. The research gained the permit by the Ethics Committee and the entire research was fully realized in accordance with the Helsinki Declaration.

Variable sample

A sample of variables is presented by 7 items (from the original 21 items) of the modified Family Eating and Activity Habits Questionnaire (Golan & Weizman, 1998) questionnaire: 1) How many hours per week do you watch TV and/or play video games? (variable: *TV and/or game time during the week*); 2) How many hours per week do you spend on the following activities (cycling, walking, swimming, exercise, dancing, tennis, running and the other (variable: *Different cyclic activities during the week*); 3) In average, how many hours per week do you attend some leisure activities (including exercise groups)? (variable: *Weekly average number of hours spent in leisure activities*); 4) When you are alone at home, are you bored? (variable: *Frequency of boredom*); 5) For each of the following situations, write down how often they happen for each member of the family (eating directly from the pot, eating when bored, eating when angry, eating out in the afternoon, eating while standing, eating late at night and eating while watching TV/read/work)? (variable: *Frequency of unhealthy feeding*); 6) How often do you repeat the same food sequence? (variable: *Frequency of the same food sequence*; 7) How often do you or your husband/spouse eat with your child (dinner, lunch, snack, and breakfast)? (Variable: *Frequency of meals with a child*).

Information about parents body height and body mass (from which the BMI was calculated by the formula: weight (in kilograms) divided by height (in meters) per square) have been collected through a questionnaire. Measurements of children body mass and body height have been taken during morning hours in kindergartens by the same measurer. All data has been collected during June 2017.

Statistical Analysis

For all applied variables, basic descriptive statistical parameters have been calculated: arithmetic means, standard deviation, minimum and maximum values, Skewness and Kurtosis. T-tests for independent samples analyzed gender differences between parents in the following variables: AGE, body mass, body height and BMI, TV and/or game time during the week, different cyclic activities during the week, weekly average number of hours spent in free activities, frequency of boredom, frequency of unhealthy feeding and in frequency of the same food sequence. The impact of different living habits of parents (physical activities and nutrition) on the child BMI have been analyzed by multiple regression analysis using the forward algorithm of selecting variables in the model. For all applied statistical analyzes, the error of the first type is set to α=5%. All data have been calculated at the Faculty of Kinesiology in Split, using statistical analysis software Statistics 13.0. (Dell Inc., Tulsa, Oklahoma, USA).

Results and discussion

Descriptive parameters of all applied variables are shown in Table 1.

Table 1: Descriptive parameters of some anthropometric characteristics, physical activities and nutritional habits of different family members (N=74)

	Mean	MIN	MAX	SD	Skew	Kurt	p
Body mass mother (kg)	66.46	50.00	92.00	9.40	0.61	0.06	**<0.01**
Body mass father (kg)	91.61	70.00	187.00	15.06	3.64	22.05	
Body height mother (cm)	171.12	160.00	182.00	4.84	0.27	-0.26	**<0.01**
Body height father (cm)	182.50	93.00	198.00	12.62	-5.07	35.84	
BMI mother	22.69	17.43	30.39	3.02	0.54	-0.06	**0.01**
BMI father	29.35	20.78	216.21	22.46	8.34	70.35	
TV and/or game time during the week MOTHER	7.13	0.00	24.00	4.71	1.01	1.45	**0.05**
TV and/or game time during the week FATHER	9.26	0.00	35.00	7.65	1.43	2.41	
TV and/or game time during the week CHILD	8.06	0.00	25.00	5.58	1.23	1.31	
Different cyclic activities during the week MOTHER	10.84	0.00	41.00	7.53	1.28	2.66	0.60
Different cyclic activities during the week FATHER	11.61	0.00	45.00	10.23	1.44	1.92	
Different cyclic activities during the week CHILD	13.18	1.00	58.00	9.70	1.59	5.07	
Weekly average number of hours spent in free activities MOTHER	1.22	0.00	4.00	1.45	0.49	-1.54	0.77
Weekly average number of hours spent in free activities FATHER	1.31	0.00	10.00	2.17	1.87	3.56	
Weekly average number of hours spent in free activities CHILD	1.96	0.00	10.00	2.23	1.48	2.96	
The frequency of boredom MOTHER	1.27	0.00	3.00	0.56	1.49	2.15	**0.04**
The frequency of boredom FATHER	1.53	0.00	4.00	0.93	1.62	1.86	
The frequency of boredom CHILD	1.91	0.00	5.00	1.00	0.71	0.02	
The frequency of unhealthy feeding MOTHER	13.43	7.00	26.00	4.49	0.67	0.32	0.42
The frequency of unhealthy feeding FATHER	12.85	0.00	21.00	4.29	-0.43	0.89	
The frequency of unhealthy feeding CHILD	10.95	7.00	17.00	2.73	0.41	-0.76	
The frequency of the same food sequence MOTHER	2.79	1.00	4.00	0.81	-0.76	0.41	0.46
The frequency of the same food sequence FATHER	2.88	1.00	4.00	0.72	-0.56	0.66	
The frequency of the same food sequence CHILD	2.87	1.00	5.00	0.89	0.01	0.48	
The frequency of meals with a child	13.38	4.00	20.00	3.00	-0.21	1.16	

Legend: Mean - arithmetic mean, MIN - minimal value, MAX - maximal value, SD - standard deviation, Skew - Skewness, Kurt - Kurtosis, BMI - Body Mass Index

Significant differences between heights and weights of parents probably caused the difference between their BMI. Since in all those variables mothers values are significantly lower than fathers values, it is apparent that they don't belong in the same BMI category:

the average mothers BMI (22.69) is in the category of ideal values and the average fathers BMI (29.35) in the high BMI category. Compared to parents, children are conducting more time in cyclic and leisure activities and have the lowest values of the frequency of unhealthy eating. Despite child's higher vaules of frequency of boredom compared to parent, significant difference in this variable has been obtained only between parents.
The impact of some family habits on child BMI is shown in Table 2.

Table 2. The results of multiple regression analysis with forwarding algorithm of selection of variables in the model, over predictor variables of nutritional and sedentary habits of both parents and BMIs of the child

$R=0.56$; $R^2=0.31$; $F(7,59)=3.84$; $p<0.01$; $SE=1.377$						
		SE(β)	b	SE(b)	t(48)	p
Intercept			9.77	1.63	6.00	0.00
BMI MOTHER	0.42	0.11	0.21	0.06	3.69	0.00
The frequency of boredom MOTHER	-0.14	0.12	-0.42	0.34	-1.22	0.23
The frequency of the same food sequence FATHER	0.13	0.11	0.30	0.25	1.19	0.24
The frequency of unhealthy feeding FATHER	0.21	0.14	0.08	0.06	1.46	0.15
The frequency of unhealthy feeding MOTHER	-0.19	0.13	-0.06	0.05	-1.41	0.16
Different cyclic activities during the week MOTHER	0.23	0.14	0.05	0.03	1.64	0.11
Different cyclic activities during the week FATHER	-0.18	0.14	-0.03	0.02	-1.29	0.20

Legend: R - coefficient of multiple correlation, R2 - coefficient of multiple determination, p – the level of statistical significance

A set of all 7 selected variables have a value of correlation with the child BMI variable of R=0.56, respectively, explaining 31% of the variance of the criterion (R2), which is statistically significant. Of all 7 selected variables, only the mothers BMI have a significant influence ($p<0.01$) on the child BMI.

Discussion

Because the parents are mostly creators of preschool children routines, obtained results point to the conclusion that parents are aware of the importance of implementing the more active way of life and of the healthy way of diet for their child, even though they do not follow the same in the same amount.

Results obtained by T-tests for independent samples revealed significant differences between some characteristics and life habits of parents. Partially expected, due to gender differences in anthropometric characteristics, significant differences have been found between the body height and the body mass of the parents (fathers have been significantly heavier and significantly higher than mothers, and had a significantly higher value of BMI). The obtained result could be explained and "justify" through significantly higher values of body mass and height of fathers, also throughout the combination of longer time that fathers spent in sitting activities and higher values of frequency of boredom (both probable fulfill with the consumption of different (probably unhealthy) snack), compared to mothers. However, if we take into account the results of the time spent in leisure activities, which suggests that fathers weekly spend more time both in cyclic and other sports activities, then fathers BMI result is somewhat unexpected since participation in such activities generally lead to lower BMI values (Cameron et al., 2017, Cassidy, Chau, Catt, Bauman, & Trenell, 2017). There are two possible reasons for high values of father BMI. The first reason for the obtained result can be that time, which fathers spent in different physical activities, is not sufficient to annul the negative effect which the frequency of boredom and time of sedentary activity have on their BMI. The second reason could be “possible mistake” of BMI calculation, ie that a sample of fathers has an increased muscular mass, which increases overall body mass and finally increases values of BMI. Considering the time spent in various physical activities, such a conclusion is more possible than the previous one. However, since these possible conclusions are rather contradictory, further research is needed to determine the true cause of increased values of fathers BMI.

According to a sign of the beta coefficient of this parameter, obtained by multiple regression analysis, can be concluded that the increased/decreased values of mothers BMI are positively associated with the increased/decreased values of the child BMI. Similar to obtained results, a positive influence of mothers BMI on child BMI, since mothers (predominantly) are obliged to prepare family meals and feed children, have been confirmed in recent studies (Whitaker et al., 2000; Patsopoulou et al., 2015; Yeung et al., 2017). Since BMI relies on the body mass, which is partly dependent on the amount of subcutaneous fat produced by consuming larger quantities of unhealthy food, from the results can further be infer that the dietary habits of children with higher BMI are very similar to their mothers’ eating habits. Such deliberation is consistent with the results of Patsopoulou et al. (2015), obtained on a sample of adolescents, who found that obesity and overweight body mass of adolescents were related: to maternal obesity, lower maternal education, with eating even if not feeling hungry, with eating in different rooms at home and with the life with a father who cares for failure.

Conclusion

In the analyzed sample was found that there are obesity risk factors that arise and are related with the dietary and sedentary habits of parents, primarily of the mother. Consequently, in the interest of effective preventing of child obesity, it is important to continuously educate parents about the importance of their healthy eating habits and active lifestyles, encourage them to live that way of life, since children use parents as behavioral models. Also, taking into account fathers physical activity (which has been determined as significantly higher compared to the physical activity of mothers) and its non-significant impact on the child BMI, the recommendation would be to encourage joint leisure (physical) activities of this parent and child. With the ultimate goal of generalizing influences of nutritional and physical activity habits of different family members on the child BMI, additional research is needed as these relationships are likely to be bi-directional (obviously parental habits affect the diet and BMI of children, but it is possible that nutrition and BMI of children also have an impact on parents habits) which have not been analyzed by this research.

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Functional abilities among young Croatian soccer players

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ABSTRACT
The main objective of this study was to determine functional abilities during treadmill protocol of young soccer players of different age categories. Sixty six players from the first Croatian soccer league for young players participated in this study. Players were divided into three age groups by 22 players (Pioneers U-15, Cadets U-17 and Juniors U-19). Maximum oxygen intake VO_2max for U-15 age group was 4.1 l/min while the U-17 and U-19 had 4.22 l/min and 4.61 l/min respectively. Relative maximum oxygen intake RVO_2max was also highest at the oldest group with 62.3 ml/min/kg what was higher then cadets (60.3 ml/min/kg) and pioneers (58.76 ml/min/kg, $p<0.01$). Maximum blood lactate concetration was measured with cadets 12.06 mmol/l what was just slightly higher then juniors (11.79 mmol/l). Both groups had statisticaly higher results when compared with pioneers (9.81 mmol/l, $p<0.05$). It is evident that functional abilities improve with age and training experiance.

Introduction
During a soccer match, players perform a variety of different activities and movements with and without ball. During the time spent in the game there are unplanned changes of high and low intensity work intervals as well as their duration. For example, during a soccer match, professional players perform on average 1200 to 1400 different change activities by changing them every 4-6 seconds (Reilly et al 2000, Reilly and Williams 2003). As a global indicator of the physical requirements of a football game, the total distance traveled during the match is often used. Results between 10 and 13 kilometers that player run during the match is a modern standard for succesfull players. In addition, only 2% of the time spent in the game is with the ball. For comparison, the best soccer players in the 1960's run around 4 kilometers per game (Weineck 1999). Soccer evolved dramatically in the last couple of decades, especially in functional capacities domain and distance covered which can be seen in scientific lecture. Increased aerobic endurance for soccer players improves the quality of the game by increasing the distance covered, increasing the number of sprints and the number of ball contacts during the match (McMillan et al., 2005). Reilly (1997) reported that adult footballers run anywhere between 8,680 - 11,527 meters in the match. As the time goes and soccer develops, young players also develop in a such way so that they could be competitive in their respective age category. In order to do so they need to have high aerobic abilities which can be indirectly evaluated through distance covered over the corse of a match. Top level young junior soccer players run between 9,5 km and 11,5 km per match. During a 60 minutes game (under-12 and under-15) and a 80 minutes game (under-17) players usually run 6,2 km, 7,1 km and 8,6 km respectively. If the data would be transferred to a 90 minute game results would be 8,5 km, 10 km, 10,5 km respectively. Percentage wise, amount of time spent walking, jogging, running and sprinting in total distance covered is similar to the results

of senior players. It is important to emphasize that appropriate adaptation of young players body and abilities are possible only if the appropriate training is given. In order to make valid and reliable training periodisation it is neccesary to determine individual performance of every player. Aerobic and anaerobic capacities are different of players with different playing positions in the same age group, let alone between players of different age categories. With cardio pulmonary load tests under controlled conditions coaches can have accurate indicators of current cardiovascular and respiratory system of their players. So the main objective of this study was to determine functional abilities during treadmill protocol of young soccer players and to determine differences between different age groups.

Methods

Sixty six players from the first Croatian soccer league for young players volonteered for this study. Players were divided into three age categories: 22 players from Under-15 (mean height 176.40 ± 5.60 cm, mean weight 63,52 ± 7,41 kg), 22 players from Under-17 (mean height 178.04 ± 4.98 cm, mean weight 69.00 ± 6.53 kg) and 22 players from Under-19 age group (mean height 181.88 ± 4.72 cm, mean weight 75.05 ± 6.07 kg). Soccer players that volunteered for this study had training sessions four times per week and soccer matches on weekends. Children parents signed written consent forms specifically approved by the "Scientific committee of University of Split" (University of Split, Faculty of Kinesiology, Croatia). Scientific comitee approved the study which was conducted according to the principles expressed in the Declaration of Helsinki. Inclusion criteria to participate in the study were: i) participation in at least 85% of the training sessions, ii) regularly participating in the previous competitive season, iii) having a valid sport medical certification, and iv) being healthy (no pain or injury) and clear of any drug consumption. All players had Croatian Soccer Federation identity card signed and were fully healthy and medically examined by a sport specialist doctor. Participants refrained from drinking caffeine-containing beverages or alcohol for 24 hours and did not eat for 2 hours prior to testing to reduce any possible interference on the experiment.

Experimental design

Participants were evaluated during progressive treadmill protocol which started with inaction during first minute. All metabolic parameters were measured. After the first minute participants walked 3 km/h for 2 minutes. After the walking protocol continues with running (8 km/h) and is increased by 1 km/h every minute until exhaustion. During the protocol incline was constant at 2%. For the evaluation purposes in this resarch following equipment was used: a)anthropometric set (GPM, Switzerland), b) Quinton TM65 Treadmill (Cortex, USA, treadmill length 229 cm, width 76 cm, possible speed between 1 - 25 km/h), c) Quark PFT 4ergo (COSMED, Italy), automatised system for continuos (breath by breath) gathering of information for graphical representation, printing, storage and analysis of metabolic parameters, d) T 31 coded transmitter (Polar Electro, Finland), telemetric system for heart rate monitoring, e) Accutrend lactate analyser (Roche), to detrermine lactate concetration during inaction time and after protocol, f)respiratory mask (Hans Rudolph, SAD), g) Nafion Permapure® capillary tube (removes moisture without influnce on gas concentration). After the end of the protocol anaerobic ventilatory threshold was determined with V-slope method (increase in VCO_2 in relationship to VO_2) and with changes in VE/ VO_2, VE/ VCO_2 parameters (Walsh et al., 1990). Maximum oxygen intake VO_2max was recorded in the peak of VO_2during any 30 seconds of the protocol. Protocol was conducted in closed room with constant conditions (18-21°C and 40-60% humidity). Prior to every other participant turbine was calibrated with 3litres pump while the analysers were calibrated with known gas mixture

(16,1 % O_2 i 5,2 % CO_2, NO_2 rest). Ventilatory-metabolic oparamters were obtained with breath by breath method but because of the very large amount of information, data was merged to 30 seconds intervals. Lactate concetration was measured with artery blood (2 μl) from the finger inserted into lactate analyser. Differences in metabolic parameters of young soccer players were determined using Factorial ANOVA with Fischer LSD-post hoc analysis.

Results

Table 1. Metabolic parameters of U-15 soccer players

	U-15 pioneers (N = 22)			
	M	**Min**	**Max**	**SD**
L_{st} (mmol/L)	1,96	1,50	2,60	0,34
L_{max} (mmol/L)	9,81	5,70	13,80	2,84
HR_{max} (1/min)	189,70	176,00	202,00	9,47
RR_{max} (1/min)	53,68	42,20	69,40	8,08
VE_{max} (L/min)	142,28	104,50	171,40	21,99
VO_{2max} (L/min)	4,10	3,89	4,78	0,37
RQ_{max} (1/min)	1,04	0,91	1,16	0,06
RVO_{2max} (mL/min/kg)	58,76	52,00	65,00	3,52
HR_{VT} (1/min)	158,00	151,00	178,00	7,95
RR_{VT} (1/min)	43,74	32,00	59,00	7,55
VE_{VT} (L/min)	88,07	66,90	114,30	19,31
VO_{2VT} (L/min)	3,02	2,71	3,73	0,41
RVO_{2VT} (mL/min/kg)	43,04	36,00	52,00	5,77

Legend: **M** – mean, **Min** – minimum result, **Max** – maximum result, **SD** – standard deviation, L_{st} – blood lactate concetration in stillness, L_{max} – maximum blood lactate concetration, HR_{max} – maximum heart rate frequency, RR_{max} – maximum respiration frequency, VE_{max} – maximum minute ventilation, VO_{2max} – maximum oxygen intake, RQ_{max} – maximum respiratory coefficient, RVO_{2max} – relative maximum oxygen intake, HR_{VP} – heart rate on ventilation threshold, RR_{VP} – respiratory frequency on ventilation threshold, VE_{VT} – maximum minute ventilation on ventilation threshhold, VO_{2VT} – maximum oxygen intake on ventilation threshhold, RVO_{2VT} – relative maximum oxygen intake on ventilation threshhold.

Segers et al. 2002. gathered 3.84 L/min maximum oxygen intake with pioneers what is a little bit lower when compared to results of this study (4.10 L/min). Pioneers from Spain (Gravina et al. 2008.) had 57,74 mL/min/kg relative oxygen intake what was similar to theese results. However, other studies like the one from Chamari et al. from 2005. in Tunisia recorded higher values of 65,3 and 66,5 mL/min/kg. Also, in that research, speed of running during anaerobic threshold was similar but the maximum lactate concetration was lower (10 mmol/L) than in this study (13,8 mmol/L). Heart rate frequencies during VO_2max were similar to previous studies (Chamari et al. 2005, Segers et al. 2002), but Segers et al. 2002 had lower minute ventilation parameters during VO_2max (131,2 L/min) when compared to this study (142,3 L/min).

Table 2. Metabolic parameters of U-17 soccer players

	U-17 cadets (N = 22)			
	AS	**Min**	**Max**	**SD**
L_{mir} (mmol/L)	2,54	1,50	3,50	0,52
L_{max} (mmol/L)	12,06	7,10	17,60	2,98

HR_{max} (1/min)	188,33	161,00	202,00	9,84
RR_{max} (1/min)	59,18	42,30	70,70	6,45
VE_{max} (L/min)	141,83	106,60	164,10	16,72
VO_{2max} (L/min)	4,22	3,45	4,78	0,26
RQ_{max} (1/min)	1,07	0,97	1,23	0,06
RVO_{2max} (mL/min/kg)	60,40	52,00	65,00	3,80
HR_{VP} (1/min)	162,71	147,00	181,00	10,94
RR_{VP} (1/min)	42,43	25,00	59,00	7,74
VE_{VP} (L/min)	83,95	54,70	106,00	12,01
VO_{2VP} (L/min)	3,23	2,27	3,73	0,32
RVO_{2VP} (mL/min/kg)	46,30	35,00	53,00	5,48

Legend: **M** – mean, **Min** – minimum result, **Max** – maximum result, **SD** – standard deviation, L_{st} – blood lactate concetration in stillness, L_{max} – maximum blood lactate concetration, **HR_{max}** – maximum heart rate frequency, **RR_{max}** – maximum respiration frequency, **VE_{max}** – maximum minute ventilation, **VO_{2max}** – maximum oxygen intake, **RQ_{max}** – maximum respiratory coefficient, **RVO_{2max}** – relative maximum oxygen intake, **HR_{VP}** – heart rate on ventilation threshold, **RR_{VP}** – respiratory frequency on ventilation threshold, **VE_{VT}** – maximum minute ventilation on ventilation threshhold, **VO_{2VT}** – maximum oxygen intake on ventilation threshhold, **RVO_{2VT}** – relative maximum oxygen intake on ventilation threshhold.

With an average of 60.4 mL/min/kg RVO_2max (relative maximum oxygen intake) results from cadets in this study are similar to ones from Japanese and Tunisian players (Chamari et al. 2004, Tahara et al. 2005). However, players from McMillan et al. study (2005) from Ireland recoreded slightly higher values of RVO_2max (63,4 mL/min/kg). Heart rate frequencies were similar to previous studies (Chamari et al. 2004, McMilan et al. 2005, Tahara et al. 2006) and minute ventilation parameters during VO_2max were also similar to Tahara et al. 2006.

Table 3. Metabolic parameters of U-19 soccer players

	U-19 Juniors (N = 22)			
	AS	**Min**	**Max**	**SD**
L_{mir} (mmol/L)	3,12	1,90	4,70	0,78
L_{max} (mmol/L)	11,79	6,70	17,80	2,46
HR_{max} (1/min)	183,53	171,00	197,00	7,01
RR_{max} (1/min)	57,06	45,40	72,90	6,76
VE_{max} (L/min)	149,29	106,10	186,10	21,70
VO_{2max} (L/min)	4,61	3,62	5,66	0,56
RQ_{max} (1/min)	0,98	0,90	1,15	0,06
RVO_{2max} (mL/min/kg)	62,30	52,00	71,00	5,06
HR_{VP} (1/min)	162,25	147,00	173,00	6,96
RR_{VP} (1/min)	45,25	33,20	61,70	8,44
VE_{VP} (L/min)	102,66	77,80	136,50	16,53
VO_{2VP} (L/min)	3,77	2,67	5,06	0,55
RVO_{2VP} (mL/min/kg)	50,65	41,00	58,00	5,35

Legend: **M** – mean, **Min** – minimum result, **Max** – maximum result, **SD**-standard deviation, L_{st} – blood lactate concetration in stillness, L_{max} – maximum blood lactate concetration, **HR_{max}** – maximum heart rate frequency, **RR_{max}** – maximum respiration frequency, **VE_{max}** – maximum minute ventilation, **VO_{2max}** – maximum oxygen intake, **RQ_{max}** – maximum respiratory coefficient, **RVO_{2max}** – relative maximum oxygen intake, **HR_{VP}** – heart rate on ventilation threshold, **RR_{VP}** – respiratory frequency on ventilation threshold, **VE_{VT}** – maximum minute ventilation on ventilation threshhold, **VO_{2VT}** – maximum oxygen intake on ventilation threshhold, **RVO_{2VT}** – relative maximum oxygen intake on ventilation threshhold.

In table 3. it can be seen that relative maximum oxygen intake for junior players is 62.30 mL/min/kg what corresponds to previous studies (Silva et al. 1999, Balikian et al.2002). Heart rate frequency during VO_2max are somewhat lower when compared to results from Chamari et al. 2004, Aziz et al. 2005, McMilan et al. 2005 and Metaxas et al. 2005. Maximum lactate concetration for U-19 players in this study (11.79 mmol/L) are similar to findings from previous studies from Chamari et al. 2004, Metaxas et al. 2005 and Aziz et al. 2005. Aditionally, results of ventilation (VEmax) during VO_2max in this research (149,3 L/min) are higher than results from Aziz et al. 2005 (124 L/min) and results from Metaxas et al. 2005. (135.1-145.9 L/min). Respiratory frequency during VO_2(57.06) were similar to Metaxas et al. 2005 (55.3-59.8) while the respiratory coefficient was lower (0.98) than in Aziz et al. 2005 (1.05-1.16).

Table 4. Differences in metabolic parameters of young soccer players (Factorial ANOVA with Fischer LSD-post hoc analysis)

	U-15	U-17	U-19
	AS (SD)	**AS (SD)**	**AS (SD)**
L_{mir} (mmol/L)	**1,96 (0,34)****	**2,54 (0,52)††**	**3,12 (0,78)³**
L_{max} (mmol/L)	**9,81 (2,84)***	12,06 (2,98)	**11,79 (2,46)¹**
HR_{max} (1/min)	189,70 (9,47)	188,33 (9,84)	**183,53 (7,01)¹**
RR_{max} (1/min)	**53,68 (8,08)***	59,18 (6,45)	57,06 (6,76)
VE_{max} (L/min)	142,28 (21,99)	141,83 (16,72)	149,29 (21,70)
VO_{2max} (L/min)	4,10 (0,37)	**4,22 (0,26)††**	**4,61 (0,56)²**
RQ_{max} (1/min)	1,04 (0,06)	**1,07 (0,06)†††**	**0,98 (0,06)¹**
RVO_{2max} (mL/min/kg)	58,76 (3,52)	60,40 (3,80)	**62,30 (5,06)²**
HR_{VP} (1/min)	158,00 (7,95)	162,71 (10,94)	162,25 (6,96)
RR_{VP} (1/min)	43,74 (7,55)	42,43 (7,74)	45,25 (8,44)
VE_{VP} (L/min)	88,07 (19,31)	**83,95 (12,01)†††**	**102,66 (16,53)²**
VO_{2VP} (L/min)	3,02 (0,41)	**3,23 (0,32)†††**	**3,77 (0,55)³**
RVO_{2VP}(mL/min/kg)	43,04 (5,77)	**46,30 (5,77)††**	**50,65 (5,35)³**

Legend: M – mean, Min – minimum result, Max – maximum result, SD – standard deviation, L_{st} – blood lactate concetration in stillness, L_{max} – maximum blood lactate concetration, HR_{max} – maximum heart rate frequency, RR_{max} – maximum respiration frequency, VE_{max} – maximum minute ventilation, VO_{2max} – maximum oxygen intake, RQ_{max} – maximum respiratory coefficient, RVO_{2max} – relative maximum oxygen intake, HR_{VP} – heart rate on ventilation threshold, RR_{VP} – respiratory frequency on ventilation threshold, VE_{VT} – maximum minute ventilation on ventilation threshhold, VO_{2VT} – maximum oxygen intake on ventilation threshhold, RVO_{2VT} – relative maximum oxygen intake on ventilation threshhold.
*p<0,05; **p<0,01; ***p<0,001 – Significant differences between pioneers (U-15) and cadets (U-17)
†p<0,05; ††p<0,01; †††p<0,001 – Significant differences between cadets (U-17) and juniors (U-19)
¹p<0,05; ²p<0,01; ³p<0,001 – Significant differences between pioneers (U-15) and juniors (U-19)

All three groups of soccer players had higher concetration of lactates in inaction than expected. This type of results are probably repercussions of training activities before the sampling which corresponds to previous findings from Bangsbo, Nørregaard & Thørso 1991. Furthermore, cadets had the highest naximum lactates 12.06 ± 2.98 when compared to pioneers 9.81 ± 2.84 (p<0.05) and juniors (11.79 ± 2.46).

Discussion

In this research there is a visible increase and differences in lactate concetration toward older age groups. Differences are statistically significant between age categories. It is interesting that the juniors, before the testing had higher blood lactate values but lower blood lactate values after the treadmill protocol when compared to cadets. At a lower intensity of activity, the organism is able to slow down the accumulation of acid by its buffer systems and circulation. At a time when the intensity increases so much that aerobic metabolism can not meet the energy needs of the body, there is an increase in anaerobic degradation of glucose and sudden accumulation of lactic acid. The rate of further deposition depends on the aerobic capacity that will oxidize lactic acid and on the ability of inactive muscles to make one part of the resulting lactate bind to itself. Obviously juniors have the ability to better adapt the body to the exercise load because they participate in soccer training longer then cadets that has a strong impact on the development of functional abilities. The assumption is that longer-term soccer training in juniors, compared to cadets (1-2 years), leads to increased muscular vascularization, respiratory adaptation, sports hypertrophy, and thus the improvement of the aerobic metabolism. Better motion performance can alter the ratio of inactive and active muscle fibers so that with better running economy participants can spend less energy. When looking at heart maximum rate frequencies (table 4.) there were significant differences between U-15 (189.70) and U-19 (183.53) category. The heart rate values at ventilation anaerobic thresholds are similar in all observed age groups of soccer players, and there are no statistically significant differences between them. However, these values are growing according to the older age group of soccer players. Cadets and juniors enter the anaerobic state later, at higher heart rate values, and will be able to perform sports activities longer and more effectively than pioneers. The obtained maximum heart rate values of the observed players of all age categories are lower than those of previous studies (Segers et al., 2002, Chamari et al 2005, McMillan et al 2005, Aziz et al 2005, Metaxas et al., 2005). The reason for this lies in the fact that in all these studies the maximum achieved heart rate was measured, while in this study, the heart rate measured at VO_2max. Heart rate frequency can be reduced as a result of endurance training, and since cadets and juniors are in training process longer then pioneers results obtained are in a way expected. Also, as expected, result of highest maximum relative oxygen intake RVO_2max is in the U-19 category and is significantly better than in U-15 category. Results of VO_2max shown statistical differences between U-19 and U-17 ($p<0.01$) group as well as in betwwen U-19 and U-15 group ($p<0.01$). The increase in absolute and relative VO_2max with the older age category of soccer players is largely due to increased body height reflecting on muscle mass. This means that aerobic work capacity is accompanied by bodily development which is in concurrence with the results of this research. Soccer training has a major impact on the development of functional abilities, and the results are progressively better towards the older age. Juniors (U-19 group) also had highest minute ventilation when compared to younger groups (cadets, pioneers) but the differences weren't statistically significant. The frequency of breathing is constantly decreasing during growth. The decline in breathing frequency with age is a sign of more economical breathing in older age groups of soccer players. In table 4. it can be seen that values of the heart rate frequency are decreasing with age category what is phisologically expected and related to previosus findings (Wilmore and Costill 1999). Heart rate frequencies on ventilatory threshold are similar at all given groups and there is no statistacaly significent differences. However, juniors and cadets had slightly higher values what could mean better overall conditioning when compared to pioneers. Because cadets and juniors enter in the anaerobic regime of work later than pioneers they can produce more activities and more efectively during match and training than pioneers.

Conclusion

Changes in functional capacities are evident among different age groups in soccer. With the growth of body dimensions, the growth and development of the bloodstream, muscle and respiratory system is apparent. This leads to an increase in aerobic and anaerobic capacity, and increases the maximum oxygen intake. By conducting soccer training over a longer period, there is a significant improvement in the oxygen transport system. Changes are also associated with the growth of the entire organism. As the size of the body increases, so does the oxygen requirement that is manifested by increasing the size and function of the lungs. The increase in absolute and relative VO_2max with the older age category of soccer players is largely due to increased body height. Increased muscle mass leads to an increase in absolute oxygen consumption, which is less visible through relative oxygen delivery that is standardized per unit of mass. This means that aerobic work capacity is accompanied by physical development. Juniors are better adapted to aerobic and anaerobic training load because they are longer involved with soccer training that has a big impact on the development of functional abilities.

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The construct validity of the standing long jump test in boys and adolescents

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ABSTRACT
The aim of this study was to determine the construct validity of the standing long jump test in boys and adolescents. The participant was 120 subjects equally divided into 5 experimental groups and one control group. Each group contained 20 respondents of boys and adolescents, and a control group was made of 20 students of second year from Faculty of Kinesiology. The sample of variables consisted of the standing long jump test, vertical jump test and the age of respondents. To determine the construct (convergent) validity of the standing long jump test with regard to age the correlation analysis was carried out. From the obtained Pearson's correlation coefficients, it can be concluded that the standing long jump test in boys and adolescents, as a measurement tool to assess explosive strength of lower limbs, have poor construct validity and thus has a lower utility value. The author suggests that vertical jump without arm swing (countermovement jump) is a more reliable test for measuring lower explosive muscular strength in younger age groups, as demonstrated in previous studies.

Key words: children, explosive strength, horizontal and vertical jump, motor assessment

Introduction
Strength tests are an important component of physical fitness tests in many countries and regions in the current world (Yin et al. 2018). For the assessment of explosive strength respectively lower-body muscular power in children, students, athletes and adults the standing long jump test is most commonly used (Popeska et al., 2009; Fernandez-Santosa et al. 2018). However, one of the main limitations when using the standing long jump as a test for the assessment of an individual physical fitness is that the standing long jump is a very complex movement (Harrison & Keane, 2007; Labiadh et al., 2010; Szerdiova et al., 2012). Specifically, to achieve the best performance of the standing long jump the subject must perform a complex motion. That includes a bend, half squat, simultaneously arm swing, two leg take-off, inclination, and landing (Nagano et al., 2007; Lee & Cheng, 2008). Therefore, the success of the jump depends on the coordination of the upper and lower segments of the body (Bartlett, 2007; Mackala et al., 2013; Espinosa-Sánchez, 2017). The fact is that if the standing long jump test is using for assessment of motor abilities, this movement has to be technically correct performed in order to give the appropriate results for further scientific knowledge and to provide adequate conclusions of measurement. Many authors have been concerned with the metric characteristics of the tests to determine the explosive strength of the lower limbs in children. Precisely because the result in the standing long jump performance is not the consequence of only one factor (in this case the explosive strength) but also of the motor skills, coordination, growth, maturation, and therefore its validity is questionable (Bobbert et al., 1996; Eston & Reilly, 2004). Therefore, the aim of this study was to determine the construct validity of the standing long jump test in boys and adolescents. Considering the objective of this research, the established hypothesis is that construct validity of the

standing long jump test is not satisfactory in boys and adolescents between the ages of 4 and 18, as opposed to the students of the second year from Faculty of Kinesiology.

Methods

Participants

In accordance with the aim of this study, a 120 male participants was divided into five experimental groups made of 20 respondents for each age group of boys and adolescents, and one control group composed of 20 students of the second year from the Faculty of Kinesiology. The first experimental group includes boys from 4 to 6 years, their average age was 5.00, body height 115.15 cm, body fat 21.25 kg, while average body fat was 17.23%. The second experimental group includes boys from 7 to 9 years, their average age was 8.10, body height 134.99 cm, body mass 34.15 kg, while average body fat was 23.43%. The third experimental group includes boys from 10 to 12 years, their average age was 11.05, body height 150.35 cm, body weight 42.98 kg, while average body fat was 22.81%. The fourth experimental group includes boys from 13 to 15 years, their average age was 14.05, body height was 170.31 cm, body mass was 64.06 kg, mean body fat was 25.78%. The fifth experimental group encompasses adolescents from 16 to 18 years, their average age was 16.95, body height 180.02 cm, body weight 73.02 kg, while average body fat was 23.65%. The control group included students from 20 to 22 years, their average age was 20.35, body height 182.99 cm, body weight 82.43 kg, while average body fat was 23.83%.

Variables

The sample of variables consisted of the age of the respondents, the standing long jump test and the vertical jump test on the platform without arm swing.
The standing long jump test was carried out on the mat with a marked start line and a measuring scale in centimeters (Figure 1). Respondents had three test attempts, and then three times in a row performing the test. During the performance, it was important to use arm swing, two feet take-off and two feet landing. Respondents also performed three vertical jumps without arm swing at Kistler's *Quattro Jump* (9290AD) platform for measuring the reaction force under the standard *Quattro Jump Bosco Protocol* for the *Countermovement Jump* (Figure 2).

Figure 1. Mat for standing long jump test

Figure 2. Vertical jump without arm swing (Countermovement Jump) at Kistler's Quattro Jump platform

Measurement protocol

The research was conducted in kindergartens, schools and faculty in the area of Zagreb. All respondents voluntarily participated in the research, and the parents' consent was collected for each child. Data collection took place in the morning hours, always at the same time, with the same instruments, and the measurements were carried out by the same persons, educated surveyors.

Statistical Analysis

For the analysis of the collected data, the Statistical for Windows Version 9 software package was used. For all variables, the central and dispersive parameters are calculated: arithmetic mean (AM) and standard deviation (SD). The normality of the distribution of variables was tested by Kolmogorov-Smirnov test. The construct (convergent) validity of the standing long jump test according to age was determined by Pearson's correlation coefficient.

Results

According to the aim of this study, correlation analysis was performed. Based on Pearson's correlation coefficient, the construct validity of the standing long jump test with regard to different age groups of respondents is determined.
The construct validity was obtained by correlation of standing long jump test with a vertical jump on the platform without the arm swing (Countermovement jump). This jump has been confirmed in previous studies to have better metric characteristics than other tests used to estimate explosive power, especially in younger age (Bosco, 1983; Vitasalo, 1988; Marković et al., 2004; Acero et al., 2011).
Based on the obtained Pearson's correlation coefficient (Tables 1. to 6.) it can be seen that in respondents aged 4 to 6 years there was no statistically significant association in either of the items of mentioned jumps. A statistically significant association between almost all items was gathered in the 7-to-9-year-old boy group, with the exception of item SLJ1 with the items VJ1 and the VJ3. In the mentioned group of boys the coefficient of correlation is lower than in the students, their variance moves around 40% but according to Mejovšek (2008) is a sufficient reason to consider them statistically significant. Considering the obtained results, it is to be assumed that in the group 7 to 9 year olds there were several very well trained boys who achieved excellent results in both measured tests and thus influenced on the common variance (Table 2.). Furthermore, in a group of 10 to 12 year olds and 13 to 15 years, a statistically significant Pearson's correlation coefficient was obtained only between two items (Tables 3. and 4.). Therefore, it can be established that the construct validity of the standing long jump test is not satisfactory with these groups of respondents.

Table 1. Pearson's correlation coefficient of standing long jump test and vertical jump in boys 4-6 years.

	Standing long jump 1-SLJ1	Standing long jump 2-SLJ2	Standing long jump 3-SLJ3
Vertical jump 1-VJ1	0,43	0,19	0,44
Vertical jump 2-VJ2	0,37	0,12	0,38
Vertical jump 3-VJ3	0,29	0,19	0,33

Legend: SLJ1, SLJ2, SLJ3= the first, second and third items of standing long jump test; VJ1, VJ2, VJ3= the first, second and third items of vertical jump; * = marked correlations significant with p≤ 0,05

Table 2. Pearson's correlation coefficient of standing long jump test and vertical jump in boys 7-9 years.

	Standing long jump 1-SLJ1	Standing long jump 2-SLJ2	Standing long jump 3-SLJ3
Vertical jump 1-VJ1	0,53	***0,66**	***0,61**
Vertical jump 2-VJ2	***0,68**	***0,62**	***0,66**
Vertical jump 3-VJ3	0,58	***0,67**	***0,68**

Legend: SLJ1, SLJ2, SLJ3= the first, second and third items of standing long jump test; VJ1, VJ2, VJ3= the first, second and third items of vertical jump; * = marked correlations significant with $p \leq 0,05$

Table 3. Pearson's correlation coefficient of standing long jump test and vertical jump in boys 10-12 years.

	Standing long jump 1-SLJ1	Standing long jump 2-SLJ2	Standing long jump 3-SLJ3
Vertical jump 1-VJ1	0,54	***0,61**	0,50
Vertical jump 2-VJ2	0,46	0,59	0,44
Vertical jump 3-VJ3	0,47	0,56	0,45

Legend: SLJ1, SLJ2, SLJ3= the first, second and third items of standing long jump test; VJ1, VJ2, VJ3= the first, second and third items of vertical jump; * = marked correlations significant with $p \leq 0,05$

Table 4. Pearson's correlation coefficient of standing long jump test and vertical jump in boys 13-15 years.

	Standing long jump 1-SLJ1	Standing long jump 2-SLJ2	Standing long jump 3-SLJ3
Vertical jump 1-VJ1	0,52	0,45	0,47
Vertical jump 2-VJ2	***0,63**	***0,64**	0,58
Vertical jump 3-VJ3	***0,61**	0,57	0,57

Legend: SLJ1, SLJ2, SLJ3= the first, second and third items of standing long jump test; VJ1, VJ2, VJ3= the first, second and third items of vertical jump; * = marked correlations significant with $p \leq 0,05$

Table 5. shows the obtained Pearson's correlation coefficient of standing long jump test and vertical jump test in the group of adolescents aged 16 to 18 years. It is evident that statistically significant correlations have been obtained between standing long jump and vertical jump in almost all items except with item VJ1. The results suggest that in a group of adolescents there is no results variation in items of vertical jump, while in test standing long jump there is a variations during the performance of the first attempts, and in the following items, the stabilization of the results is achieved. Therefore, in the observed group a more acceptable test for assessing the explosive strength of lower limbs is vertical jump, as opposed to the students of the Faculty of Kinesiology, where high positive correlation was obtained in all the items of the measured test (Table 6). Based on the obtained, it can be stated that the common variance of the group of students is about 60% and that is a sufficient reason to claim that it is the same or similar construct.

Table 5. Pearson's correlation coefficient of standing long jump test and vertical jump in adolescents 16-18 years.

	Standing long jump 1-SLJ1	Standing long jump 2-SLJ2	Standing long jump 3-SLJ3
Vertical jump 1-VJ1	0,59	0,53	0,59
Vertical jump 2-VJ2	***0,62**	***0,60**	***0,69**
Vertical jump 3-VJ3	***0,62**	***0,61**	***0,68**

Legend: SLJ1, SLJ2, SLJ3= the first, second and third items of standing long jump test; VJ1, VJ2, VJ3= the first, second and third items of vertical jump; * = marked correlations significant with $p \leq 0,05$

Table 6. Pearson's correlation coefficient of standing long jump test and vertical jump in second-year students of Faculty of Kinesiology.

	Standing long jump 1-SLJ1	Standing long jump 2-SLJ2	Standing long jump 3-SLJ3
Vertical jump 1-VJ1	***0,79**	***0,77**	***0,75**
Vertical jump 2-VJ2	***0,79**	***0,76**	***0,75**
Vertical jump 3-VJ3	***0,79**	***0,77**	***0,75**

Legend: SLJ1, SLJ2, SLJ3= the first, second and third items of standing long jump test; VJ1, VJ2, VJ3= the first, second and third items of vertical jump; * = marked correlations significant with p≤ 0,05

Discusion

From the obtained Pearson's correlation coefficient of standing long jump test and vertical jump test between boys and adolescents from 4 to 18 years old and a group of students from the Faculty of Kinesiology, it can be established that the construct (convergent) validity of standing long jump test is not satisfactory in the observed younger age group. In the group of respondents of boys and adolescents more acceptable test for assessing explosive strength is vertical jump, in contrast to the students where were obtained high positive correlation in all measured items. Thomas, Nelson and Silverman (2005) also state that standing long jump and vertical jump are the most common tests to estimate the explosive strength. They claimed that the tests often use commonly to evaluate the same capability but they appeal to the correlation between these two tests which is between r = 0.70 to r = 0.80, and sometimes less. At a correlation coefficient of 0.70 between standing long jump and vertical jump with only 49% of variance one test is related to the other. It means that 51% of variance is unexplained and there can not be claimed that they measure the same construct. In support to the above-mentioned go and research results of Marković et al. (2004). They aimed to determine the reliability and factorial validity of seven tests to assess the explosive strength (5 different vertical jumps: Sargent jump, Abalakow jump with and without arm swing, Squat jump and Countermovement jump; and 2 tipes of horizontal jump: Three connected both feet jump and Standing long jump). As a result of the factor analysis, one factor of explosive strength projected, which explains 66.43% of the total variance of all seven tests. Based on the correlation of the tests with the extracted factor, they concluded that the vertical jump without arm swing (countermovement jump) has the highest correlation r = 0.87 and thus the highest factor validity, while the other tests have less correlation while standing long jump has the smallest coefficient of correlation r = 0.76 with extracted factor. Ayan-Perez et al. (2017) assessed the test-retest reliability of the Sargent jump (VJ) for vertical jumping performed by 4 and 5 years old preschoolers. The results were compared with those obtained in the standing long jump test. Pearson's correlation coefficients were used to examine the degree of association. The VJ showed a higher correlation and agreement in the selected subjects. Their findings suggest that VJ is reliable when executed by 4-and 5-year-olds.

Based on the obtained results in this study, it is possible to accept the hypothesis that the construct (convergent) validity of standing long jump test is not satisfactory in boys and adolescents, as opposed to the second year students from the Faculty of Kinesiology.

Conclusion

For the purpose of verifying the hypothesis resulting from the aim of this research, a sample of 120 male subjects was divided into 5 experimental groups and one control group. Each experimental group contains 20 respondents of boys and adolescents; also a control group was made of 20 students of the second year from Faculty of

Kinesiology. The sample of variables consisted of the standing long jump test, the age of the respondents and the vertical jump test without the arm swing (countermovement jump). From the obtained Pearson's correlation coefficients of the standing long jump test and the vertical jump test of boys and adolescents and a group of students from the Faculty of Kinesiology, it can be concluded that the construct (convergent) validity of the standing long jump test is not satisfactory in the observed younger age groups. For boys and adolescents, the vertical jump test is a more applicable to assess the explosive strength of lower limbs. The results of this study indicate high positive correlations in all the items of the measured tests for explosive strength of lover limbs in older respondents (students). This fact, the low association between the standing long jump test and the vertical jump test, should be taken into account at the time of choosing the most appropriate test to assess lower explosive muscular strength in younger age groups.

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Anthropometric characteristics in female youth volleyball players of different situational efficacy

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ABSTRACT
The aim of the study was to analyze anthropometric characteristics in female youth volleyball players of different situational efficacy. On a sample of 204 youth players from all parts of Croatia, whose mean *body height* was 170.10±7.41 cm, *body mass* 58.92±9.28 kg, *body mass index* 20.31±2.67 kg/m^2, *chronological age* 14.11±0.84 years, and *training age* 42.14±16.76 months, 10 anthropometric characteristics were measured following the ISAK protocol, on the dominant side of the body. The players were divided based on the criterion of team placement and individual player quality within a team on less successful (N=119), and more successful (N=85). All the anthropometric characteristics measured had high level of relative and absolute reliability and good homogeneity, and their distribution did not deviate significantly from normal distribution. By discriminant analysis, it was determined that more successful volleyball players had higher values of body height and body mass, and somewhat lower values of subcutaneous fat tissue. It can be assumed that such body build makes the performance of all volleyball elements easier, especially spike and block, which are executed above the net.

Key words: body build, discriminant analysis, less successful and more successful volleyball players

Introduction
Anthropometric characteristics are often investigated in sports games, especially in volleyball, in which teams play over a net. Morphological anthropometrics can offer some information on primary selection of candidates for volleyball, but also information which could be used in secondary selection – specialization, i.e., determination of specific player roles with specific player tasks (Đurković et al., 2011).
Conclusions about the importance of pronounced body height and less pronounced subcutaneous fat tissue in volleyball can be indirectly drawn from comparisons of volleyball players to non-athletes (Morrow et al., 1980), as well as comparisons of volleyball players to athletes in other team sports (Bayios et al., 2006). Similar results have been obtained by comparing young female volleyball players to non-athletes (Milić et al., 2012a). In this study, young female volleyball players aged 10-12 years had more pronounced measures of longitudinal skeleton dimensions, higher body mass, but also lower abdominal and calf skinfold values in comparison to their peers who were non-athletes.
In the area of anthropometric characteristics, the most frequently used variables which have been successful in differentiating male and female volleyball players of different player quality and playing at different positions are *body height* and *body mass* (Gualdi-Russo & Zaccagni, 2001; Bayios et al., 2006; De Hoyo et al., 2008; Grgantov, 2005; Malousaris, et al., 2008; Milić et al, 2011; Ayan, et al., 2012; Milić et al., 2013; Gaurav,

M. Singh, & S. Singh, 2014, Milić, 2014; Grgantov et al, 2017; Milić et al, 2017). In almost all studies, pronounced body height and low values of subcutaneous fat tissue were positively correlated with competitive success or were good in differentiating more successful from less successful volleyball players. Such body build enables high reach above the net, which is an important precondition for successful execution of all elements performed in a jump, and primarily of spike and block, which ultimately win most points in volleyball (Grgantov, Nedović & Katić 2007).

However, most of these studies have been conducted on a sample of male and female volleyball players in junior and senior age group, whereas studies which analyze differences in anthropometric characteristics of more successful and less successful female youth volleyball players are relatively rare. In a review study, Lidor & Ziv (2010) also point out that more studies are needed to assess the contribution of physical attributes to actual performance in volleyball.

Therefore, the aim of this study is to analyze anthropometric characteristics of female Croatian youth volleyball players of different situational efficacy.

Methods

The subject sample included 204 female youth volleyball players from all parts of Croatia, who participated at the open Croatian volleyball championship 2014 in Rovinj. To make the sample as representative as possible, young volleyball players from all Croatian regions were included, especially members of the best teams at the national level.

Out of the 9 best-ranked teams, 8 teams participated in this study. The second group included players from 5 clubs that were ranked between the 10th and the 19th place, whereas the third group included 3 volleyball teams who were ranked between the 20th and the 30th place at the youth national championship.

Mean height of the participants was 170.10±7.41 cm, their mean body mass was 58.92±9.28 kg, and mean *body mass index* was 20.31±2.67 kg/m^2. Mean *chronological age* of the participants was 14.11±0.84 years, and mean *training age* was 42.14±16.76 months.

All participants had an identity card issued by the Croatian volleyball federation, certified by an authorized sports physician.

The following 10 anthropometric characteristics were measured: *body height*, *body mass*, *elbow diameter*, *knee diameter*, *upper arm circumference flexed*, *calf circumference*, *triceps skinfold*, *back skinfold*, *abdominal skinfold* and *calf skinfold*.

From these measures, *body mass index* (BMI) was calculated as body mass (kg) divided by body height squared (m^2).

All measurements were taken following the ISAK protocol on the dominant side of the body (Stewart, Marfell-Jones, Olds & De Ridder, 2011).

The measurements were taken twice, and mean value was used as final result. The exception were sporadic high variabilities in skinfolds, in which case the third measurement was taken.

Players were divided into two subgroups based on the criterion of competitive efficacy, which was determined on a five-point Likert scale. A grade of 1 to 5 was assigned to each player based on two criteria (Table 1):

1. <u>Team ranking in the competition</u>: All teams (16 volleyball clubs) participated in the open Croatian championship and, based on their ranking in the championship, they were classified into 3 categories (1th-9th place; 10th-19th place; 20th-30th place).
2. <u>Player quality within the team</u> (assessed by the coaches). Each coach divided the players of her/his team into three groups (*the most successful* – the most efficient players, *average* – other members of the starting line-up and reserves who contribute to game quality; *the least successful* – players who very rarely or never enter the game)

All players who were assigned grades of 1 to 3 were categorized into the less successful group, and all players who were assigned grades 4 and 5 represented the group of more successful players (Grgantov, 2005; Grgantov et al., 2006; Milić et al., 2012a, 2012b; Grgantov et al., 2012; Milić et al., 2013; Grgantov et al. 2013; Milić, 2014; Grgantov et al. 2017; Milić et al., 2017).
Categorization of individual player quality is presented in Table 1.

Table 1. Categorization of individual player quality

	Individual player quality			
Team placement at the national championship	Members of the national team	The most successful players in a team	Average players in a team	The least successful players in a team
(1-9)	5	5	4	3
(10-19)	5	4	3	2
(20-30)	5	3	2	1

In the first phase of the study, time and place (sports halls) of testing was arranged with authorized persons from volleyball clubs. Coaches talked to the parents of volleyball players and explained the reasons for the study and obtained a written consent for underage children to participate in the study. Aside from the parents' consent, an approval from the regional volleyball associations and the umbrella organization of the Croatian Volleyball Federation was also obtained. All measurements were taken at the same time of day (in the morning between 8 and 12 a.m.), and two days before the measurement volleyball players' training sessions did not include high training load so that fatigue had no influence of the test results.
In the second phase of the study, anthropometric characteristics were measured by a single measurer.
In the final phase of the measurement, players' coaches assessed player's quality within their teams. Team quality was assessed based on the results at the youth Croatian volleyball championship 2014 (Official web page of the Croatian volleyball federation).
In the third phase of the study, the obtained data were entered and analyzed by the *Statistica Ver. 12.0* software.
Methods of data analysis included determining the metric characteristics of all the applied anthropometric measures (reliability, homogeneity, and sensitivity) on a sample of female youth volleyball players.
Calculation of descriptive statistical indicators of distribution for the 10 anthropometric measures included: arithmetic mean (AM), central value, median (M), minimum result (Min), maximum result (Max), standard deviation (SD), and MaxD value to determine significant deviation from normal distribution of variables by Kolmogorov-Smirnov test (KS).
Discriminant analysis was applied to analyze the differences between less successful and more successful young volleyball players regarding their anthropometric characteristics, with the level of significance of $p \leq 0.05$.

Results
Pearson's correlation coefficient (r) was used to determine linear inter-item correlation between the results of the two measurements of anthropometric set of 10 measures.
For direct comparison of inter-item variability of several different anthropometric variables, coefficient of variability (CV) was calculated, whereas t-test was used to determine homogeneity.

The results of inter-item reliability and homogeneity of the applied anthropometric measures are presented in Table 2.

Table 2. Metric characteristics of anthropometric measures

Anthropometric measures	r	CV	$AM_1 \pm SD_1$	$AM_2 \pm SD_2$	t-test
Body height (cm)	0.99	0.00	170.09±7.41	170.11±7.42	-0.91
Elbow diameter (cm)	0.97	0.01	8.73±0.66	8.72±0.65	1.08
Knee diameter (cm)	0.97	0.01	5.67±0.42	5.68±0.42	-0.41
Body mass (kg)	0.99	0.01	59.00±9.29	58.90±9.29	1.00
Upper arm circumference flexed (cm)	0.99	0.00	27.15±2.25	27.24±2.25	-0.73
Calf circumference (cm)	0.99	0.00	36.28±2.65	36.30±2.65	-1.80
Triceps skinfold (mm)	0.99	0.01	16.29±5.29	16.31±5.30	-0.56
Back skinfold (mm)	0.99	0.02	12.66±5.94	12.72±5.97	-0.11
Abdominal skinfold (mm)	0.99	0.02	17.85±8.93	17.90±8.97	-1.34
Calf skinfold (mm)	0.99	0.02	17.77±6.50	17.43±6.49	0.88

Legend: **r** – Pearson's coefficient of inter-item correlation, **CV** – coefficient of inter-item variability, **AM_1** – arithmetic mean of the first measurement, **AM_2** – arithmetic mean of the second measurement, **SD_1** – standard deviation of the first measurement, **SD_2** – standard deviation of the second measurement, **t-test** – test value when testing the significance of differences between AMs of the first and the second measurement, * – significant difference at the level of $p \leq 0.05$.

High values of inter-item correlation and low values of coefficient of variation indicate that all anthropometric variables had high level of relative and absolute reliability (consistency of results in the repeated measurement). Considering that no significant differences between the 1st and the 2nd measurement were determined by an independent samples t-test in any of the variables, it can be concluded that all anthropometric measures had good homogeneity.
Consequently, the final result of anthropometric variables was defined as mean value of the two measurements.
The results of descriptive statistics are presented in Table 3: arithmetic mean (AM), median (M), minimum (Min) and maximum (Max) result, and standard deviation (SD) of ten morphological variables, as well as the variable *body mass index* (ratio of body mass in kilograms and squared body height in meters).
Sensitivity was tested by coefficients of asymmetry (Skew) and peakedness (Kurt) of distribution. Normality of distribution was tested by Kolmogorov-Smirnov test with critical value of 0.12, which represented the maximum allowed size of maximum difference between cumulative observed and theoretical relative frequencies.

Table 3. Descriptive indicators and sensitivity of anthropometric variables of female youth volleyball players (N=204)

Variables	AM	M	Min	Max	SD	KS	Skew	Kurt
Body height (cm)	170.10	170.03	144.35	189.50	7.41	0.04	0.06	0,33
Elbow diameter (cm)	8.73	8.68	6.10	11.10	0.65	0.06	0.03	1,50
Knee diameter (cm)	5.67	5.65	4.85	9.00	0.42	0.06	2.69	1,94
Body mass (kg)	58.92	58.30	35.35	100.70	9.28	0.11	0.85	2,50
Upper arm circumference flexed (cm)	27.19	27.10	22.20	35.90	2.24	0.08	0.55	1,43
Calf circumference (cm)	36.29	36.35	30.40	47.25	2.65	0.06	0.39	1,50
Triceps skinfold (mm)	16.30	15.70	5.80	34.50	5.30	0.05	0.49	0,08

Back skinfold (mm)	12.69	11.20	5.60	45.60	5.95	0.06	2.50	2,40
Abdominal skinfold (mm)	17.88	15.50	5.50	51.70	8.94	0.12	1.12	1,22
Calf skinfold (mm)	17.76	17.10	6.40	45.65	6.49	0.12	1.06	1,93
Body mass index	20.31	19.87	15.06	33.26	2.67	0.12	1.31	3,78
							KS test = 0.12	

Legend: **AM** – arithmetic mean, **M** – median, **Min** – minimum result, **Max** – maximum result, **SD** – standard deviation, **KS** – Kolmogorov-Smirnov test, **Skew** – coefficient of asymmetry of distribution, **Kurt** – coefficient of peakedness of distribution.

Analysis of distribution indicators of the total sample of female Croatian youth volleyball players showed that there were no significant deviations from normal distribution in any of the variables, which means they were suitable for further multivariate parametric statistical analysis.

Somewhat lower distribution characteristics, although within the statistical tolerance limits, were found in the variables *abdominal skinfold*, *calf skinfold*, and *body mass index*. Variables *knee diameter*, *abdominal skinfold* and *body mass index* showed positive asymmetry of result distribution, whereas their coefficients of kurtosis indicated reduced sensitivity of the test.

Descriptive indicators, i.e., arithmetic means and standard deviations of anthropometric variables for less successful and more successful volleyball players, and the results of discriminant analysis (discriminant function, canonical correlation coefficient, Wilks' lambda coefficient, degrees of freedom, test of significance of discriminant function and group centroids) of the defined subgroups of subjects are presented in Table 4.

Table 4. Discriminant analysis of anthropometric variables of less successful and more successful female youth volleyball players (N=204)

Variables	**Less successful N=119**	**Successful N=85**	**DF**
	AM±SD	**AM±SD**	
Body height (cm)	167.33±6.58	173.99±6.77	0.84
Elbow diameter (cm)	8.63±0.63	8.87±0.66	0.31
Knee diameter (cm)	5.63±0.47	5.73±0.33	0.21
Body mass (kg)	56.3940±8.66	62.47±9.02	0.58
Upper arm circumference flexed (cm)	26.84±2.20	27.68±2.21	0.32
Calf circumference (cm)	35.79±2.53	36.99±2.65	0.39
Triceps skinfold (mm)	16.22±5.29	16.41±5.34	0.03
Back skinfold (mm)	12.93±6.36	12.31±5.33	-0.09
Abdominal skinfold (mm)	18.58±9.25	16.89±8.45	-0.16
Calf skinfold (mm)	17.55±6.35	18.04±6.71	0.06
Centroids	-0.50	0.70	**CanR** = 0.51
Wilks' lambda = 0.74	χ^2 = 59.20	**SS**=10	**p** = 0.00

LEGEND: **N** – number of subjects, **AM** – arithmetic mean, **SD** – standard deviation, **DF** – correlation coefficients of discriminant function and variables, **CanR** – canonical correlation coefficient, **Wilks' lambda** – Wilks' lambda coefficient, χ^2 – test value when testing significance of discriminant function, **SS** – degrees of freedom, **p** – level of statistical significance of discriminant model.

By examining the results of discriminant analysis of differences in morphological space between less successful and more successful female youth volleyball players presented in Table 4, it can be seen there was one significant discriminant function which accounted for 25% of total variability of variables.
Based on the size and sign of group centroids, as well as the size and sign of projections of separate variables of anthropometric characteristics on discriminant function, it can be concluded that more successful volleyball players had more pronounced variables *body height* and *body mass*, as well as the measures assessing voluminosity and transverse dimensionality of the body, whereas they had somewhat less pronounced core subcutaneous fat tissue of the trunk in comparison to the less successful players.

Discussion
The main aim of this study was to analyze the differences in anthropometric characteristics between successful and less successful female youth volleyball players. By discriminant analysis it was determined that successful volleyball players had more pronounced body height and body mass, and somewhat less pronounced subcutaneous fat tissue in comparison to less successful players. The obtained results are congruent with most of the previous studies that have investigated this problem and found that more successful male and female volleyball players had higher values of body height and body mass as compared to the less successful players (Gladden & Colacino, 1978; Morrow et al., 1979; Spence et al., 1980; Gualdi-Russo & Zaccagni, 2001; Grgantov, 2005; Barnes et al., 2007; Malousaris et al., 2008). Similar results have been obtained in studies conducted on a sample of female youth volleyball players. Grgantov et al., (2007), on a sample of 246 female volleyball players divided into four age groups ranging from 12 to 19 years, determined that in all age categories longitudinal skeleton dimensionality showed significant positive correlation with situational efficacy. Milić et al., (2017) also determined that more successful female youth volleyball players in all positions had a lower body mass index, were less mesomorphic and endomorphic, and more ectomorphic than less successful players, which confirms the results of the present study.
In studies comparing adult female volleyball players to non-athletes (Morrow et al., 1979), as well as in studies comparing adult female volleyball players to basketball and handball players (Bayios et al., 2006), it has been determined that female volleyball players have more pronounced body height and fat-free body mass. Very similar results have been obtained by comparing beginner female volleyball players aged 10-12 years to their peers who do not train volleyball (Milić et al., 2012), which indicates that in initial selection for volleyball, great attention is paid to adequate body build characterized by longitudinal skeleton dimensionality. There has been only one study (Fleck et al., 1985) that did not determine significant differences between female volleyball players playing for the national team and collegiate players at university games level. The reason for this might be the high level of quality in both subsamples as players are already homogenous, i.e., selected based on the required anthropometric characteristic, so some other, primarily technical-tactical and psychological skills become more relevant. The obtained results are expected considering volleyball is a sport in which two teams compete over a relatively high net (224 cm for women, i.e., 243 cm for men). Pronounced longitudinality of the skeleton helps in achieving greater reach in play over the net, which in turn allows more diverse and efficient spiking in attack and counter-attack, which wins most points in volleyball (Grgantov et al. 2013). High jump reach is also very important when blocking the opponents' spikes. During block performance, it is allowed for players to cross the net with their arms into the opponents' field, which allows players with very high jump reach to cover a much larger area. This makes it harder for the opponents' spikers to play in attack, and easier for teammates to play field defense as the area they have to cover is decreased (Grgantov et al., 2017; Milic et al., 2017). Both jump set and jump

serve are volleyball elements in which it is also an advantage if contact with the ball is made as high as possible above the net. From this it can be concluded that in all phases of the volleyball game, except in serve reception and field defense, pronounced longitudinality of the skeleton represents an important precondition for successful competitive performance. Except for longitudinal skeleton dimensionality, successful youth volleyball players in this study are characterized by more pronounced body mass. This is probably partly a suppressor effect of body height, but values of group centroids and size and sign of projections of variables assessing voluminosity and subcutaneous fat tissue on discriminant function indicate that more successful volleyball players have higher muscle mass and lower subcutaneous fat tissue. As volleyball is a sport in which the body is moved in the space, such body build allows better horizontal and vertical acceleration, which is very important for successful performance of all technical-tactical elements during competition (Nešić, 2006).

Conclusion

The results of this study confirm that pronounced longitudinal skeleton dimensionality and voluminosity of the body based on muscle mass differentiates successful from less successful female youth volleyball players. However, the obtained results should not be interpreted by saying that players with lower body mass and higher subcutaneous fat tissue cannot be successful in volleyball. Even though at some player positions, primarily middle hitter, it is very hard to make up for lower body height, at all other player positions, especially libero and setter, players with above average body height can also achieve top performance level. Both more pronounced subcutaneous fat tissue and the lack of muscle mass can be regulated by a high-quality training program and adequate diet. It is very important to mention that in younger age groups biological age influences body build and therefore players' competitive efficacy. Previous training experience (training age) also influences the quality of performance of all volleyball elements. Thus, coaches should take all these factors into account during selection for player positions, especially when drawing conclusions about maximum player potentials of youth volleyball players. Selection for competitive teams should not be a one-time procedure, but rather a long-term process. In this process, every child who wants to play volleyball should be allowed to do so, regardless of their player quality.

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Relationship between certain kinematic parameters during the jump shot and their effect on shooting efficiency in basketball

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ABSTRACT
The aim of this research was to analyse relationships between key kinematic parameters during the performance of the jump shot and to analyse prediction of shooting efficiency based on the observed kinematic parameters.
The participants in the research were twenty-five (25) basketball players, candidates for Croatian Men's U16 National Team.
Based on the obtained results, the conclusion can be made that correlation between certain key kinematic parameters exists and that they can have statistically significant effect on shooting efficiency during the performance of jump shot in basketball.

Key words: jump shot, Xsens system, kinematic parameters

Introduction
According to the structural analysis of basketball, the jump shot represents an element of basketball technique that allows players to shoot the ball towards the basket from greater distances (Krause, Meyer, Meyer, 2009). Upon observing the jump shot as a segment of motor performance, the conclusion can be made that it represents an extremely complex specific motor movement that requires quality instruction during the process of acquisition and improvement. Over the course of basketball history, the jump shot has become one of the most common types of shots in basketball (Hess, 1980; Hay, 1985), and as such, it has also become the subject of numerous scientific research.
In the beginning, the above-mentioned research was primarily directed on analysis of basic biomechanical parameters during the performance of the basketball jump shot, whereas later on, the emphasis shifted towards various other segments.
One of these segments was certainly the analysis of differences between biomechanical parameters with regard to the distance between the player and the basket during the performance of a jump shot. It was thus established that the height at which the player released the ball decreases as the distance between the player and the basket was increased. Similar results were determined for the angle at which the ball was released towards the basket during the jump shot (Miller, Bartlett, 1996; Okazaki and Rodacki, 2012). Another kinematic parameter which demonstrated an increase in its value was the speed at which the ball was released, which is explained as a result of increased angular velocities in the lower, and thus also in the upper extremities (Satern, 1993). A recent research by Rupčić et al. (2016) established that by increasing the distance from

the basket resulted in decreasing the duration of contact with the surface, as well as the duration of the shot.
On the other hand, numerous authors also studied the effect of the defensive player on differences in certain biomechanical parameters while performing the jump shot in basketball (Rojas, Cepero, Ona and Gutierrez, 2000). A similar research conducted by Borović, Rupčić and Antekolović (2016) also determined that the shooter partially alters his performance of the jump shot in certain kinematic parameters under the influence of the defensive player.
Basketball is a game during which a player must perform various technical and tactical tasks in high intensity. The above-mentioned is proved in the research performed by Ben Abdelkrim et al. (2007) with young U19 basketball players in Tunisia that determined an average heart frequency of 171 beats per minute during a basketball game. Further confirmation can also be found in a research by Rubén Dehesa et al. (2015) with professional elite basketball players, which showed that during situational 5 on 5 drills performed on the entire basketball court players' heart frequencies varied between 166,06 and 172,10 beats per minute. In 2010, Montgomery, Pyne and Minahan measured highest heart frequencies of 188 beats per minute, i.e. 99±1% of the maximum heart frequency. On the basis of all the above-mentioned, the conclusion can be made that basketball players perform the jump shot while under high physiological load, and therefore, many research also studied and established the effects of the afore-mentioned physiological load on changes in biomechanical parameters during the performance of the jump shot (Erčulj and Supej, 2009; Rupčić, Knjaz, Baković, Devrnja, Matković, 2015).
As basketball is a game with numerous changes of direction and, therefore, full of different situations in which players perform the jump shot, the primary aim of this research was analysing certain relationships between kinematic parameters that are considered to have a high predictive value in relation to shooting efficiency. A secondary aim of this research was analysing the prediction of shooting efficiency on the basis of the observed kinematic parameters.

Methods

Sample of examinees

This research included the participation of twenty-five (25) basketball players, potential Croatian U16 national team members, with their average age at 15,24±0,66 years, average body height of 194,62±6,24 cm and average body weight of 84,63±9,56. Each of the examinees performed four (4) jump shots (2x left side, 2x right side), which resulted in an overall of one hundred (100) performed jump shots.

Sample of variables

The following kinematic parameters were observed as part of this research:

1. *Maximum point of releasing the ball on the vertical axis (IZB_L_max)* – implies the height at which players release the ball during the performance of a jump shot – Xsens AWINDA system;
2. *Angle of the shoulder joint at the moment of releasing the ball (KUTram)* – implies the angle of the shoulder joint of the shooting arm at the moment when the player releases the ball during the performance of a jump shot – Xsens AWINDA system;
3. *Movement of the general centre of gravity on the X axis (OCTTxosi)* – implies the movement of the general centre of gravity between the point of rebound and the point of landing during the performance of a jump shot – Xsens AWINDA system;
4. *Angle formed by the downward line of the basketball and the horizontal plane of the rim (KUTlopte)* – implies the angle formed by the downward line of the basketball in relation to the horizontal plane of the rim – 94 Fifty Smart Sensor Basketball.

All biomechanical parameters obtained from the Xsens AWINDA system were further analysed by using the MVNanalyze_2018 programme.

Measurement procedure

The player is first situated under the basket; he then runs along the endline and receives the ball in the corner of the basketball court, after which he performs a jump shot for a three-point field goal. Each player performs two (2) jump shots from each side of the basketball court.

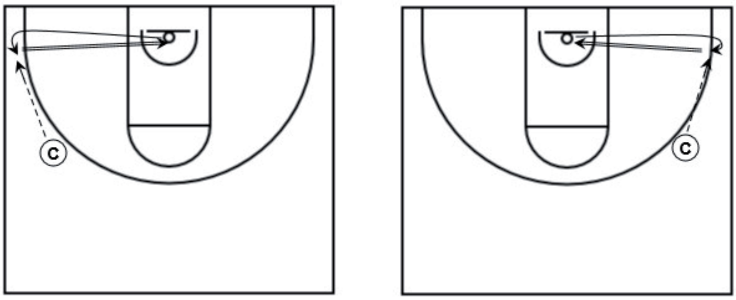

Diagram 1 and 2. Description of the player's movements and the positions for performing the jump shot for a three-point field goal.

Data processing procedure

The basic descriptive statistical indicators for the observed variables (arithmetic mean, standard deviation, minimum and maximum value) were calculated by using the programme package STATISTICA, ver. 13.3. Correlation was used for the purpose of determining the relationship between the results of the observed kinematic parameters. The prediction of the effects of the observed kinematic parameters on shooting efficiency for three-point shots in basketball was performed by applying the regression analysis.

Results

The basic descriptive statistical parameters for the observed variables are demonstrated in Table 1. The average value for the variable *Maximum point of releasing the ball on the vertical axis (IZB_L_max)* was 225,91±10,81 cm, while the average value for the variable *Angle of the shoulder joint at the moment of releasing the ball (KUTram)* was 113,37±13,34 degrees. The variable *Movement of the general centre of gravity on the X axis (OCTTxosi)* was on average 14,48±10,68 cm, whereas the *Angle formed by the downward line of the basketball and the horizontal plane of the rim (KUTlopte)* showed an average of 42,44±6,12 degrees.

Table 1. Basic descriptive statistical parameters for the observed variables.

	Descriptive statistics				
Variables	**N**	**AS**	**Minimum**	**Maximum**	**SD**
IZB_L_max	100	225,91	192,90	250,00	10,81
KUTram	100	113,37	92,40	150,90	13,34
OCTTxosi	100	14,48	-18,00	39,00	10,68
KUTlopte	100	42,44	26,00	68,00	6,12

Legend: IZB_L_max – maximum point of releasing the ball on the vertical axis; KUTram – angle of the shoulder joint at the moment of releasing the ball; OCTTosi – movement of the general centre of gravity on the X axis; KUTlopte – angle formed by the downward line of the basketball and the horizontal plane of the rim.
N – number of analysed jump shots; AS – arithmetic mean; Minimum – lowest analysed value; Maximum – highest analysed value; SD – standard deviation.

Table 2. Correlative relationships between the analyzed kinematic parameters.

	Correlative relationships; p< ,05000; N=100					
Variable	**AS**	**SD**	**IZB_L_max**	**KUTram**	**OCTTxosi**	**KUTlopte**
IZB_L_max	225,91	10,81	1,00	0,32	-0,06	0,23
KUTram	113,37	13,34	0,32	1,00	-0,15	0,15
OCTTxosi	14,48	10,68	-0,06	-0,15	1,00	-0,23
KUTlopte	42,44	6,12	0,23	0,15	-0,23	1,00

Legend: IZB_L_max – maximum point of releasing the ball on the vertical axis; KUTram – angle of the shoulder joint at the moment of releasing the ball; OCTTosi – movement of the general centre of gravity on the X axis; KUTlopte – angle formed by the downward line of the basketball and the horizontal plane of the rim.

Table 3. Summary of regression analysis – prediction of the effect of the observed kinematic parameters on shooting efficiency for three-point field goals in basketball.

	Regression analysis; R= ,331; R2= ,110; F(4,95)=2,9397; p< ,0244					
N=100	b*	Std.Err. of b*	b	Std.Err. of b	t(95)	p-value
Intercept			0,89	0,95	0,93	0,36
IZB_L_max	-0,18	0,10	-0,01	0,00	-1,73	0,09
KUTram	0,04	0,10	0,00	0,00	0,34	0,73
OCTTxosi	-0,01	0,10	-0,00	0,00	-0,14	0,89
KUTlopte	0,32	0,10	0,02	0,01	3,12	0,00

Legend: IZB_L_max – maximum point of releasing the ball on the vertical axis; KUTram – angle of the shoulder joint at the moment of releasing the ball; OCTTosi – movement of the general centre of gravity on the X axis; KUTlopte – angle formed by the downward line of the basketball and the horizontal plane of the rim.
R – multiple correlation; R^2– coefficient of determination of multiple correlation; F – value used for testing the significance of all the variables in a model; p – significance level of the coefficient of multiple correlation; Std.Err. – standard error of estimate; b* – standardized regression coefficient; Std.Err. of b* – standard error of estimate for standardized regression coefficients; Std.Err. of b – standard error of estimate for non-standardized regression coefficients; t(95) – value for df=n-m-1=95 degrees of freedom when testing the significance of regression coefficients.

Discussion

Based on the obtained correlative relationships demonstrated in Table 2, the conclusion can be made that there is a statistically significant correlation between the following variables: *Maximum point of releasing the ball on the vertical axis (IZB_L_max)* and *Angle of the shoulder joint at the moment of releasing the ball (KUTram)* (r=0,32; p<0,05); *Maximum point of releasing the ball on the vertical axis (IZB_L_max)* and *Angle formed by the downward line of the basketball and the horizontal plane of the rim (KUTlopte)* (r=0,23; p<0,05); *Movement of the general centre of gravity on the X axis (OCTTxosi)* and *Angle formed by the downward line of the basketball and the horizontal plane of the rim (KUTlopte)* (r=-0,23, p<0,05).

The obtained results demonstrated in Table 2 point to the fact that the angle of the shoulder joint increases as does the height at which the ball is released, whereas consequently the angle at which the ball falls towards the basket decreases. Thus it is precisely the angle at which the ball is released and the angle at which the ball falls towards the basket that are consequently correlated, while also representing the parameters with high predictive values with regard to shooting efficiency in basketball (Miller and Barlett, 1996).

During the performance of the jump shot, it is particularly important that the player performs the rebound in a vertical line, with a slight tendency of moving the body towards the front. It is assumed that if the player would move towards the back in relation to the point of rebound, he would then also distort other kinematic parameters which would in turn consequently also effect the shooting efficiency. Precisely by analysing the values demonstrated in Table 2, it can be noticed that the variables of the body's movement on the X axis and the angle at which the ball falls towards the basket are in a correlative relationship, i.e. that the body's movement towards the back would result in a decreased angle at which the ball falls towards the basket, whereas previous research determined the relevance of an increased angle at which the ball falls towards the basket (Fontanella, 2006).

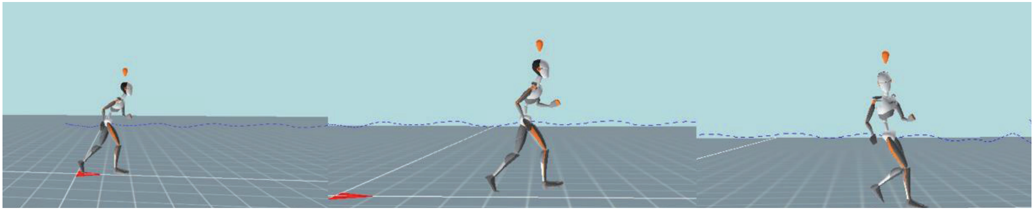

Diagram 3. Animation of the player's movements while opening for receiving the ball.

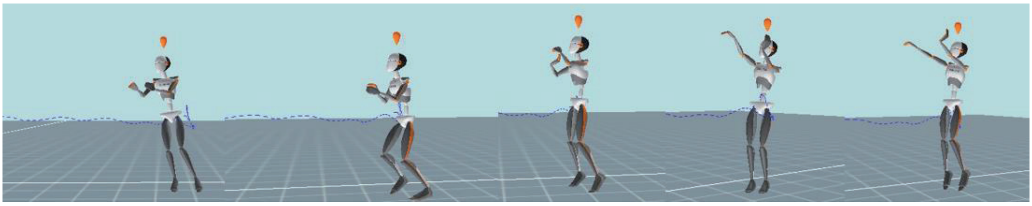

Diagram 4. Animation of the jump shot – receiving the ball, rebound phase, central position phase, release phase, final phase.

Table 3 demonstrates the results of the regression analysis between independent predictive kinematic parameters while performing the three-point field goal jump shot in basketball, and the dependent criteria variable – shooting efficiency. The coefficient of multiple correlation (R) was 0,331, while the coefficient of determination (R^2) was 0,110 and at a level of significance of $p<0,0244$. The standardized regression coefficients were as follows: IZB_L_max (b*=-0,18, p-level=0,09); KUTram (b*=0,04, p-level=0,73); OCTTxosi (b*=-0,01, p-level=0,89); KUTlopte (b*=0,32, p-level=0,00). On the basis of the calculated coefficient of multiple correlation (R=0,331) and its coefficient of significance ($p<0,0244$), the conclusion can be made that there is a statistically significant relationship between the analysed kinematic parameters while shooting for three-point field goals and shooting efficiency in basketball. Based on the standardized regression coefficients and their levels of significance, the conclusion can also be made that the kinematic parameter *Angle formed by the downward line of the basketball and the horizontal plane of the rim (KUTlopte)* (p=0,00) has a statistically significant effect on shooting efficiency for three-point field goals. The above-mentioned values confirm that the angle at which the ball falls towards the basket represents one of the most important predictive kinematic parameters for efficient shooting in basketball, assuming that the ball has a proper trajectory.

Conclusion

The results obtained in this research reaffirm the complexity of motor movements such as the jump shot in basketball. Consequently, it is extremely important to pay adequate attention to the researched kinematic parameters during the process of acquisition and improvement in order for the process of instruction to be as successful as possible. Parameters such as: position of the centre of gravity at the moment of receiving the ball, movement of the body on the horizontal axis, position of the ball at the moment of catching it, height of rebound, angle of the shoulder joint, angle of releasing the ball and consequently, the angle at which the ball falls towards the basket, represent parameters that greatly affect the situational efficiency of basketball players.

On the other hand, the importance of proper jump shot performance is also evident in the fact that if the mentioned parameters are not correctly acquired on a satisfactory performance level, the process of automatization in learning motor skills shall result in an inaccurately acquired performance, and that shall ultimately result in poor shooting technique, as well as lower shooting efficiency.

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Effects of small-sided games on passing accuracy and explosive power in primary school children

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ABSTRACT
Purpose: The aim of our research was to determine the effects of small-sided games on passing accuracy and explosive strength in primary school children. The authors hypothesized that this program might significantly improve passing and explosive power in children.
Methods: Forty-eight primary school children participated in this study (12,26±1,01). They were tested for lower body explosive power and passing accuracy. Players were randomly allocated into a small-sided games group (n = 24) and instructional group (n = 24). Each player participated in a 12-week training program that included 2 organized court training sessions per week.
Results: There was statistically significant difference pre- to post-training ($p < 0.01$) in Block and Spike jump after 12 weeks of SSG training. In SJ and CMJ results revealed a statistically significant difference between groups pre- to post-training ($p < 0.05$). Both groups made significant increases in passing accuracy with significant interaction effect between the groups.
Conclusion: Small-sided games implemented in primary school education appears to be an effective way of improving explosive strength and passing accuracy. The results of this study indicate that SSG method was more effective for improving passing and lower body explosive power than traditional instructional school programme.

Key words: game-based, conditioning, impact, power, technique

Introduction

Most of adolescents often find it difficult to participate in traditional classes, because of a lack of enjoyment. Therefore, an approach called small-sided games training has been developed in order to combine the skill and conditioning elements in a coordinated approach (Gabbett, 2003). The use of small-sided games as training drills offers the simulation of movement patterns in team sports, while maintaining a competitive environment in which athletes must perform under pressure and fatigue (Gabbett, 2002). Moreover, the important consideration is the optimization of skill development in team sport while still obtaining appropriate conditioning levels. Simply put, according to Magill (2007), transfer of practice to the game environment depends on the extent to which practice or training resembles the game. Moreover, small-sided games as a training method are very popular because it replicates the technical skills and decision making, whilst also representing the competitive match physiological demands (Sheppard, Gabbett, & Stanganelli, 2009). According to Sampaio et al, (2009) decrease in space and number of players in game allow greater intensity in game. In addition, Rampinini et al. (2007) confirmed aforementioned statement that the intensity of sided games increases while the number of players decreases.

Gabbett, Georgieff, Anderson, Cotton, Savovic, and Nicholson (2006) have concluded that skill-based volleyball training improves speed and agility performance, spiking, setting, passing accuracy, spiking and passing technique, but has little effect on the physiological and anthropometric characteristics of players. They also stated that skill-based training programs should be supplemented with an appropriate amount of energy system training to enhance the physiological and anthropometric characteristics of talented junior volleyball players.

Having in mind that volleyball has some unique skills, novice players find it difficult to master it due to small amount of transfer from other sports, except for footwork. Therefore, children require a great deal of repetition before they are able to consistently execute the fundamental skills. However, volleyball is often taught to children with little opportunity for skill practice, no lead-up games, and with full-sided teams. The advantages of small sided games are reduced number of players which equals a higher number of ball contacts and more quality decisions during the game. Moreover, children become more physically efficient in the smaller area, with more opportunities to lean tactical skills. However, the most important is that children may benefit from this fun and dynamic approach to learning the game of volleyball. Therefore, the aim of our research is to determine the effects of small-sided games training on explosive strength and passing accuracy in primary school children.

Methods

Participants

Forty-eight primary school children participated in this study (12,26±1,01). Two of the participants in instructional training group didn't complete the program. Inclusion criteria were regular participation in classes, and the absence of injury in the past 6 months. Prior to the start of the study, subjects undertook several tests to determine their baseline fitness and technical skill levels. Players were then randomly allocated into a small-sided games group (n = 24; Height: 165.16±7.62cm; Body mass: 47.69±8.79 kg) or instructional group (n = 24; Height: 163.16±5.46 cm; Body mass: 48.13±9.95 kg). All subjects received a clear explanation of the study, including the risks and benefits of participation, and written parental or guardian consent was obtained before players were permitted to participate. The protocol of the study was approved by the Ethical Committee of the Faculty of sport and physical education, University of Novi Sad, and according to the revised Declaration of Helsinki.

Procedures

Beside the results, basic anthropometric parameters (body height and body weight) were registered in the study protocol. Maturity was determined by self-assessment of Tanner stage (Weeks and Beck, 2010). The initial testing took place in the beginning of the school year while the final testing was performed after 12 weeks of small-sided games training method and instructional training. At the time of the study, subjects were having 2 volleyball practice sessions and 1 match weekly, with no additional strength and conditioning. All study procedures took place at a school athletic facility. All participants took part in one introductory week during which time proper form and technique on each fitness test were reviewed and practiced. During this session research assistants demonstrated proper testing procedures and participants practiced each test. Participants were asked not to perform any vigorous physical activity the day before or the day of any study procedure. Moreover, all participants were instructed to have a good night's sleep (≥ 8 hours) before each testing day, to avoid drinking, or eating at least 2–3 hours before testing. Also, the participants were motivated to give their maximum effort during performance measurements. The same researchers tested the same participants and the fitness tests were performed in the same order with identical equipment, positioning, and technique. Before each testing, the participants performed a standard 20-minute warm-up. Standard warm up protocol consisted of 10 min of warm up running and 10 min of dynamic stretching and 5 x 30m of running exercises.

Countermovement and Squat Jump Performance

For the purpose of the explosive strength assessing, a device "Myotest" was used. Subjects performed two vertical jumps, Countermovement Jump (CMJ) and Squat jump (SJ). The sample of the variables, processed and mistreated by the device "Myotest" consisted of the: Height (expressed in cm); Power (expressed in W/kg); Force (expressed in N/kg) and Velocity (expressed in cm/s). Subjects carried a belt around their lower trunk, on which was positioned a wireless device "Myotest" (safely attached to a belt). All subjects performed three vertical jumps (CMJ), in the following way: from the initial position, i.e., normal standing position and the hands placed on the hips, through the flexion in the articulations of the knee up to 90º, after the audio signal of the device, the subjects performed the maximum vertical take-off, and landed with affable flexion (up to 110º) in the articulations of the knee and finally, went back into a starting standing position, while waiting for the new sound signal, when the specified jump technique was repeated. In the case, when the CMJ was not well performed, double audio signal, informed the subject, to repeat properly specified jumping technique.
The squat jump (SJ) allows measurement of "non-plyometric" displacement and the ability to develop a great deal of strength within a very short space of time (explosiveness). This test consisted of the person jumping as high as possible with their hands on their hips from a half-squat position (i.e. 90° bending of the knees). This position was maintained for about 1s. The subjects were then instructed to extend the lower limbs as explosively as possible with the aim of performing a squat jump. Three attempts were made at this exercise. The best result was retained for analysis.

Spike and block jump performances

For the standing reach, while wearing their normal volleyball footwear, players were requested to stand with their feet flat on the ground, extend their arm and hand, and mark the standing reach height while standing 90° to a wall. Players were encouraged to fully extend their dominant arm to displace the highest vane possible to determine their maximum standing reach height. The measurement of the standing reach height allowed for a calculation of the relative jump heights on each of the jumping tasks (absolute jump height (cm) – standing reach height (cm) = relative jump height) (Sheppard, et al., 2009). Spike and block jump performances for volleyball players depend heavily on the height at which these skills are performed above the net and are determined by not only the capacity of the athlete to raise vertically his center of gravity, but also his stature and standing reach. In this particular case, specific tests would provide a further understanding of the training-induced adaptation. For the spike jump, the standing reach was determined as the maximal distance between the fingertip of the attack hand and the ground, while standing 90° to a wall. The spike jump was measured from a running lead (2- or 3-step approach) by using a basketball backboard marked with lines 1 cm apart with a 1-minute rest interval between them (Hasegawa et al., 2002 Fry, Kraemer, and Hakkinen, 2002). For the block jump, the standing reach was determined as the maximal distance between fingertips of the block hands and the ground, while facing the wall. The block jumps started from a standing position with the hands at shoulder level and arms raised from the start position without extra swing. All tests used the same observer who was situated on a volleyball referee stand placed 2 m from the backboard. Both jumps were recorded as the best of the 3 attempts (Stanganelli, Dourado, Oncken, Mançan, & da Costa, 2008 Mançan, da Costa, 2008).

Passing

The passing ability of the players was evaluated by determining their ability to return a pass to a target positioned at the net, 2 m from the right-hand sideline. The target dimensions were 1.6 m long and 2.3 m wide. A coach, positioned in the service position, approximately 1 m above the ground and 10 m from the receiving player, threw an overhead pass to the receiving player. Players were required to pass (dig) the ball to another player standing with arms extended above their head, in the target area. Players were awarded 2, 1 and 0 points if a pass did not reach either of the target areas. The aggregate from 6 trials was recorded as the player's accuracy score. More detailed explanation of the test could be found in Gabbett & Georgieff (Tim Gabbett, et al.).

Training program

Training program lasted for 12 weeks. SSG and instructional training program were performed in the beginning of the school year and added to the usual classes two times a week. SSG and IT were always performed at the middle of a class, after a standardized warm-up. In the first part of the class children were involved in low intensity drills and after that, SSG and IT were used. The goals of the small-sided games program were to increase the intensity of sport-specific training, and attention was given to volleyball skills and play. In addition, children were introduced with small-sided games rules. None of the players was performing any additional resistance or aerobic training outside of the 2 training sessions. The duration of training sessions was recorded, with sessions typically lasting 40-45 min. For this purpose we used games 2v2 (7m x 3m) and 3v3 (12m x 6m). This configuration was chosen because of the greater intensity experienced in this type of drill compared to SSG involving more players (Sampaio, et al., 2009). Another reason for using smaller court is because more players can exercise simultaneously (up to 12 players performing 3v3 drills at the same time). Drills were played like a competition. Instructional training program was designed to develop volleyball technique in traditional school settings. All skills were taught by using blocked practice, so that all trials for each skill were completed before moving onto the next skill (T. J. Gabbett, 2008). A typical instructional training session consisted of children performing individual skills against a wall or to a partner in a noncompetitive environment, multiple repetitions, and practice of technique in a closed-skill environment.

Statistical analysis

Statistical analysis included descriptive analyses (means and standard deviations for the sample as a whole, and separately for the SSG and ITG) for the pre- and post-training status. Normality and homoscedasticity assumptions for all data before and after intervention were checked respectively with Shapiro-Wilk and Levene's tests. Training effects were analyzed using a two-way analysis of variance (ANOVA) (2 x 2) with repeated measures. Factors included training groups (SSG and ITG) and time (pre- and post-training). When a significant F ratio was found, Tukey post hoc tests were used for pairwise comparisons. A criterion α level of $P<0.05$ was used to determine statistical significance.

Results

The Shapiro-Wilk test has shown that all data was normally distributed. The repeated measures ANOVA revealed a statistically significant difference pre- to post-training ($p < 0.01$) in Block and Spike jump after 12 weeks of SSG training. In SJ and CMJ there were statistically significant differences between groups pre- to post-training ($p < 0.01$). SSG group experienced significant increase in both, CMJ and SJ pre- to post-testing, whereas IT group had no significant changes in the same period (Table 1).

Table 1. Power performance at pre- and post-training

	SSG group *(n=24)*		**IT group** *(n=24)*	
	pre (Mean ± SD)	post (Mean ± SD)	pre (Mean ± SD)	post (Mean ±SD)
Block jump	34.10± 7.48	36.33± 5.67*	35.02± 5.33	36.42± 5.65
Spike jump	43.63± 8.70	47.63± 8.72*	42.73± 7.30	44.16± 8.66
SJ	20.29± 4.65	22.21± 3.91*†	21.59± 4.19	21.30± 4.74
CMJ	26.16± 6.59	30.87± 5.62*†	26.04± 4.86	26.66± 4.84

* Significant difference $p < 0.05$ between pre and posttraining testing; † Significantly greater improvement than in IT group ($p < 0.05$)

The changes in passing accuracy are shown in Figure 1. Small-sided games training induced significant ($p<0.01$) improvements in overhand passing (32.6%) and forearm passing (45.7%) accuracy. Instructional training induced improvements in passing accuracy also. However, in comparison to the instructional training group, the improvements in overhand passing and forearm passing were greater ($p<0.01$) in the small-sided games group.

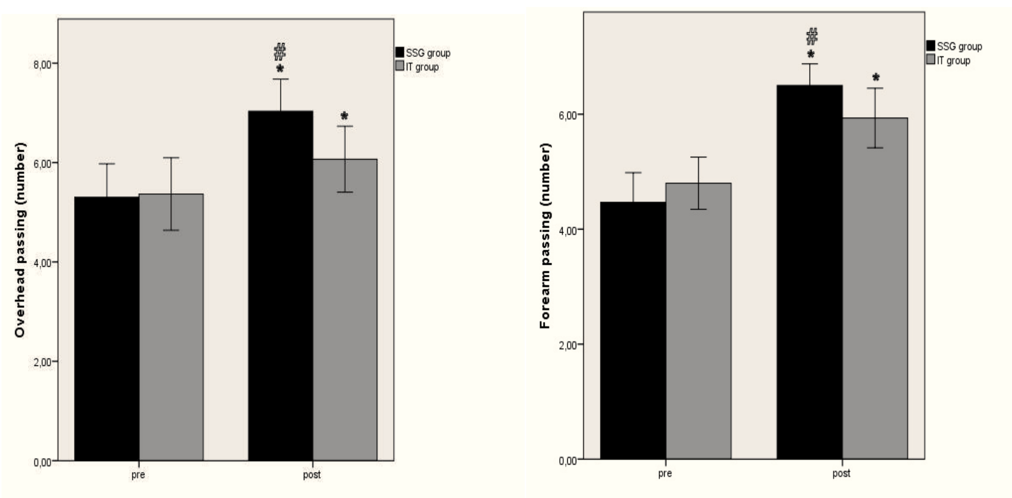

Figure 1. Changes in overhead and forearm passing at pre- and post-training. Values are mean ± SD.* significantly different from pretraining; # significantly different from IT group, $p<0.001$

Discussion

The present study investigated the effect of a small-sided games training program on lower body explosive power and passing accuracy in primary school children. Our results showed that SSG training was more effective at increasing most performance parameters in primary school children compared to instructional training and suggest that SSG training should be used preferentially due to their higher quantity of game-based specificity. Significant improvement was observed in all jumping tests for SSG group. In similar studies, however with young male volleyball players Gabbett (2008) stated that skill-based conditioning games have induced improvements in speed, vertical jump, spike jump, agility, upper-body muscular power, and estimated maximal aerobic power. In addition, Gabbett et al. (2006) have concluded that skill-based volleyball training improves speed and agility performance, spiking, setting, passing accuracy, spiking and passing technique, but has little effect on the physiological and anthropometric characteristics of players.

SSG group showed significant improvement in spike jump. This is not surprising, since training program uses the similar technique during the game. Therefore, the drills (i.e., service, attack, and block) and matches during training programs have contributed significantly to the improvement of the performance in such a specific type of test (Stanganelli, et al., 2008 Mancan, and da Costa, 2008).

Ziv and Lidor (2010) concluded that most recent studies in volleyball involve the effects on squat jump and countermovement jump showing that plyometric training should be included in volleyball training. In our study, results for SJ and CMJ test showed a statistically significant difference between groups pre- to post-training ($p < 0.05$). In volleyball, a squat and countermovement jump are usually performed in a fast spike and in a static block jump (BJ). Volleyball players use two different BJ techniques, starting from an upright position or starting from a squat position, with a countermovement being performed in both cases (Amasay, 2008). Therefore, improvement in SJ and CMJ following game-based training was logical.

After 12 weeks of SSG training, there were increases in two passing accuracy tests, overhand and forearm passing (Figure 1). It is interesting that SSG group showed better results compared to IT group having in mind that almost all instructional training sessions were designed to develop volleyball technique and accuracy. We can speculate that children benefit more from this fun and dynamic approach during SSG. In similar study, two 4-week training programmes consisting of SSG or mixed training both resulted in improvements in various technical skills ranging from 17 % to 27 % (Bogdanis et al. 2007). This is consistent with Delextrat et al, (2014) who showed a significantly better improvement in basketball shooting skills after SSG than HIT, while passing skills were similarly increased by both training methods. Gabbett, et al (2006) showed that skill-based training improves spiking, setting, passing accuracy, spiking and passing technique. Our results show a tendency for better improvement in passing skills in the group undertaking SSG training. Possible explanation could be found in the fact that players in the SSG training always had a target during games, which is similar to the target during the passing tests. Moreover, short shuffling moves in SSG, associated with tests, which involve leg coordination in addition to passing ability could significantly contribute to better results.

Conclusion

To conclude, small-sided games implemented in primary school education appears to be an effective way of improving explosive strength and passing accuracy. The results of this study indicate that this method was more effective for lower body explosive power than traditional instructional programme in school. Many teachers and coaches do not use the approach described in this article to the training process because they fear that the level of skills could decrease in children.

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Relations of fitness parameters and morphological characteristics of nine-year -old obese children

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ABSTRACT
The aim of this research was to determine the relations of fitness parameters and morphological characteristics of nine-year-old obese children. The sample of participants consisted of 122 obese children (22 girls and 100 boys), third grade students (mean age 9,07 years) of elementary schools in Nis. The following fitness parameters were measured: HR in load, VO2max (ml), HR in peace, bend forward - bend backward - throw test, hand taping, 20m dash with a standing start, Abalakov test and forward bend on the bench test. Morphological characteristics were determined by measuring 13 parameters of longitudinal and transversal dimensions of skeleton, volume and body weight, as well as subcutaneous fat tissue (body height, leg length, arm length, shoulder width, pelvic width, hip width, body mass, thorax volume, upper arm volume, thigh volume, upper arm skinfold, back skinfold and abdominal skinfold). For all of the data we calculated the Mean and standard deviation (SD). Canonical correlation analysis was used to determine the relations between the set of variables representing fitness parameters and the set of variables of morphological characteristics. Based on the coefficients of canonical correlation analysis, it can be concluded that the spaces of morphological characteristics and fitness parameters are interconnected with two pairs of statistically significant canonical factors ($p<.01$). The analysis of the relations between the first pair of canonical factors suggests that obese subjects with lower body mass, transversal and circular dimensionalities of the body tend to have better results in the parameters of cardiorespiratory fitness.

Key words: physical fitness, obesity, physical activity, younger school age

Introduction

Physical fitness is considered to be a significant factor in children's growth and development and it is usually defined as set of attributes that are either health- or skill-related. The term health-related physical fitness covers an entire range of motor activities, usually defined as those specific components of physical fitness that have a relationship with good health (ACSM, 2007). According to the given source, health-related physical fitness elements are: cardiorespiratory fitness, muscular strength, muscular endurance, flexibility and body composition. There is also a set of abilities that are not exclusively related to human health, but primarily with sports achievement (Sport/Skill-Related Physical Fitness). These are agility, balance, coordination, speed, reaction time, power, etc.

Physical fitness components have a decreased secular trend. According to the studies, aerobic fitness decreases ~0.4% and muscular strength ~2.0% per year (Cadenas-Sánchez, Artero, Concha, Leyton, & Kain, 2015). On the other hand, obesity records higher rates every year. WHO reports that there have beenover 340 million children and adolescents aged 5-19 who were overweight or obese in 2016 (WHO, 2017). The global increase in childhood overweight and obesity has become a worldwide epidemic. The data indicate that the prevalence of excessive nutrition and obesity has increased from 4% (1975) to over 18% (2016) (WHO, 2016). There were 18% of girls and 19% of boys who had a body mass categorized as higher than normal in 2016 (WHO, 2017). Research from Serbia (Đorđić, Radosavljević, Milanović, Božić, Grbić, Jorga i Ostojić, 2016) reports 23,1% overweight and obese children in total, and 6,9% obese younger school age students.

Obesity is related to many health complications. These complications arise in the cardiovascular system, the articulations and skeleton system and the endocrine system (type 2 diabetes), and obesity is increasingly associated with various types of malignancies recently (WHO, 2016). In younger school age, which is characterized as a sensitive developmental period, a child's organism is exposed to various influences, the effects of which are manifested in the later period. If obesity occurs in childhood, it very often continues in adulthood and presents a risk factor for many mass non-communicable diseases (WHO, 2016) and result in significant health and socioeconomic consequences. The childhood obesity has been associated with obesogenic factors such as intake of energy-dense foods and very low levels of physical activity (Maffeis, Zaffanello, & Schutz, 1997), which favours impaired physical fitness (Tomkinson, Leger, Olds, & Cazorla, 2003). Previous studies of fitness parameters and morphological characteristics highlights a decline and a stagnancy in the levels of motor performance and an increase of BMI values (Graf, Koch, Kretschmann-Kandel, Falkowski, Christ et al. 2004; Kopecký & Pridalová, 2008).

Cardiorespiratory fitness has previously been emphasized as the primary factor supporting good health, but musculoskeletal fitness is recently identified as a decisive component in preserving overall health (Thivel, Ring-Dimitriou, Weghuber, Frelut, & O'Malley, 2016). Smith et al. (Smith, Eather, Morgan, Plotnikoff, Faigenbaum, & Lubans, 2014) emphasised possible physiological and psychological assets attributed to muscular fitness in children and adolescents. Their studies provided direct confirmation for an inverse connection between muscular fitness and adiposity (total and central), cardiovascular disease or metabolic risk factors; and a positive association with bone health and self-esteem. Muscle strength and muscular fitness play an important role in daily life and are essential for performing everyday activities (Thivel et al., 2016).

Furthermore, the studies imply that obesity does have a negative impact on speed, agility, endurance, lower limb power and balance but does not influence flexibility handgrip and upper body strength (Ceschia, Giacomini, Santarossa, Rugo, Salvadego, Da Ponte et al., 2016). According to Podstawski & Boryslawski (2012), body height is positively correlated with almost all motor abilities, while the body mass is in a variable correlation. A statistically significant positive correlation of BMI was with the frequency of the movement, the arm strength and the shoulder band, and the negative with the shuttle run test and the flexed-arm hang test. The results from a large number of studies indicate that flexibility is independent from the nutritional status (Tokmakidis, Kasambalis, & Christodoulos, 2006; Leskošek, Strel, i Kovač, 2007).

The aim of this paper was to determine the relationship between fitness parameters and morphological characteristics of nine-year-old obese children.

Methods

Subjects were 122 obese children (22 girls and 100 boys), third grade students (mean age 9,38±0,69 girls and 8,75±0,69, boys) of elementary schools in Nis, Serbia. After measuring body height and body weight and calculating BMI values according to Cole, Bellizzi, Flegal, & Dietz (2000), students whose body weight indexes indicated obesity were isolated from the larger sample. The following fitness parameters were measured: HR in load, VO2max (ml), resting HR, bend forward - bend backward – throw test, hand taping, 20m dash with a standing start, Abalakov test and forward bend on the bench. Morphological characteristics were determined by measuring 13 parameters of longitudinal and transversal dimensions of skeleton, volume and body weight, as well as subcutaneous fat tissue (body height, leg length, arm length, shoulder width, pelvic width, hip width, body mass, thorax volume, upper arm volume, thigh volume, upper arm skinfold, back skinfold and abdominal skinfold). Measurements were made according to the method recommended by the International Biological Program, IBM (Weiner & Lourie, 1969).

Measurements and tests were conducted in the schools during the course of physical education in the premises for the physical education classes and in training halls. All respondents were healthy on the day of testing and had a written consent from their parents and school principals.

Relationships between fitness parameters and morphological characteristics were determined by canonical correlation analysis. The structure of isolated canonical factors in the examined spaces was also determined.

RESULTS

Table 1.The descriptive statistics of the morphological characteristics and fitness parameters

	I grade boys		I grade girls	
	Mean	SD	Mean	SD
Age (yrs)	8,75	0,69	9,38	0,69
BMI (kg/m2)	24,88	2,04	25,87	2,35
Body height (cm)	142,72	5,92	148,15	6,40
Leg length (cm)	79,16	4,36	84,43	4,61
Arm length (cm)	60,07	3,38	63,69	3,26
Shoulder width (cm)	33,78	1,92	34,93	2,50
Pelvic width (cm)	25,82	1,60	26,83	1,69
Hip width (cm)	27,19	1,51	28,47	1,57
Body mass (kg)	50,81	6,25	57,00	8,04
Average circumference of the chest (cm)	78,03	4,99	78,23	6,47
Upper arm volume (cm)	24,69	1,99	26,24	2,33
Thigh volume (cm)	47,48	4,23	50,15	4,27
Upper arm skinfold (mm)	22,85	7,02	27,59	7,13
Back skinfold (mm)	21,97	6,33	22,69	7,61
Abdominal skinfold (mm)	27,00	6,71	27,85	5,47
BF	38,72	5,63	41,03	5,21
HR in load	158,57	9,75	170,64	4,72
VO_2 max (ml)	42,61	1,81	40,05	2,50
Resting HR	92,09	11,43	98,59	7,54
Bend forward-bend backward-throw (dm)	57,91	21,83	50,36	19,46
Hand tapping (reps in 20s)	27,62	4,88	26,27	4,85
20m dash (s)	4,91	0,67	5,03	0,52
Abalakov test (cm)	18,48	4,42	17,64	4,79
Forward bend on the bench (cm)	31,15	5,96	35,27	9,50

The connection between a set of variables of fitness parameters and variables of morphological characteristics wasestablished bycanonical correlation analysis (Table 2).

Table 2.Coefficients of canonical correlation of morphological and fitness parameters of nine-year-old obese children

	R	R^2	Chi-sqr.	df	p
0	0,70	0,49	201,84	120	0,000**
1	0,65	0,42	140,11	98	0,003**
2	0,54	0,30	89,01	78	0,185
3	0,49	0,24	56,48	60	0,605
4	0,37	0,14	31,06	44	0,929
5	0,27	0,08	17,09	30	0,971
6	0,26	0,07	9,81	18	0,938
7	0,18	0,03	3,08	8	0,929

Key: R – canonical coefficient of correlation; R^2 – canonical coefficient of determination or square of canonical correlation; χ^2 – Bartlett chi square test of canonical correlations' significance; df – number of degrees of freedom p – statistical significance

The first pair of canonical factors explains 49% (R^2= .49) of common variability, second couple explains 42% (R^2= .42) of remaining common variability to the level of significance of .01.
The structure of isolated canonical factors in the examined spaces (fitness parameters and morphological characteristics) are defined in order to explain the structure of the canonical dimensions.

Table 3. Factor structure

	Root 1	Root 2
HR in load	-0,35	-0,54
VO2max (ml)	0,62	0,55
Resting HR	-0,23	-0,31
Bend forward-bend backward-throw (dm)	0,20	-0,36
Hand tapping (reps in 20s)	0,36	-0,38
20m dash with a standing start (s)	-0,31	-0,15
Abalakov test (cm)	0,30	-0,34
Forward bend on the bench (cm)	-0,01	0,23
Body height (cm)	-0,48	-0,48
Leg length (cm)	-0,33	-0,47
Arm length (cm)	-0,40	-0,37
Shoulders span (cm)	-0,60	-0,21
Pelvis span (cm)	-0,62	-0,01
Hips span (cm)	-0,64	-0,34
Body weight (kg)	-0,73	-0,40
Average circumference of the chest (cm)	-0,03	-0,68
Upper arm circumference (cm)	-0,68	-0,42
Thigh circumference (cm)	-0,41	-0,23
Upper arm skinfold (mm)	-0,40	-0,29
Back skinfold (mm)	-0,37	-0,11
Abdomenal skinfold (mm)	-0,17	-0,28
BMI (kg/m2)	-0,60	-0,14
BF	-0,39	-0,31

Table 4 shows the factor structure of fitness parameters and morphological variables. By analyzing the results it can be noticed that the largest projections from the set of physical fitness variables on the first isolated canonical factor have VO2max (ml) (0,62). Projections of the negative direction recorded all morphological variables. The largest projections from the set of morphological variables have body weight (-0,73), upper arm circumference (-0,68), hips span (-0,64), pelvis span (-0,62) shoulders span (-0,60), and BMI (-0,60).
The largest projections on the second isolated canonical factor have VO2max (ml) (0,55) and HR in load (-0,54). Variables average circumference of the chest (-0,68) and body height (-0,48) had the highest projections from the morphological group, as well as leg length (-0,47), body weight (-0,40) and arm length (-0,37).

Discussion
The spaces of morphological characteristics and fitness parameters are interconnected with two pairs of statistically significant canonical factors, at the level of significance .01. The first pair of canonical factors explains 49% (R^2= .0,49) of common variability, at a significance level of .01. The other couple explains 42% (R^2= .042) the remaining common variability. The analysis of the relations between the first pair of canonical factors suggests that obese subjects with lower body mass, transversal and circular dimensionalities of the body tend to have better results in the parameters of cardiorespiratory fitness. The overage VO2max in boys was 42,61ml/kg/min, and girls 40,05ml/kg/min, which is less than non-obese children's values. When expressed relative to body mass, in normal nourished children, VO2max values are essentially stable in boys across the childhood years at about 50 ml/kg/min, while girls tend to show a progressive decline. This decline is approximately 20% between years 8 and 13 (Ostojic, Stojanovic, Stojanovic, Maric, & Njaradi, 2011). VO2max rises progressively during childhood, with greater values in boys than girls. The studies state that the obese children have lower relative VO2max (Berndtsson, Mattsson, Marcus, & Larsson, 2007), and therefore, have lower aerobic fitness than their non-obese peers (Marinov, Kostianev, & Turnovska, 2002). Previous studies have also shown that cardiorespiratory fitness measures have a negative correlation with BMI in children (Monyeki, Awotidebe, Moss, Sparks, Wushe, et al., 2017; Sandercock, Voss, Mcconnell, & Rayner, 2009), so there is an assumption that a decrease in cardiorespiratory fitness in children may occur due to an increase in obesity (Mota, Flores, Ribeiro, & Santos, 2006; Stratton, Canoy, Boddy, Taylor, Hackett, & Buchan, 2007). Results from this study suggest that even obese children, with lower body weight and dimensionalities, have better measures in VO2max. Such findings should have practical appliance in working with obese children. By lowering their weight, cardiorespiratory fitness should be increased.
The second factor in the fitness parameters area is defined by positively oriented variable VO2max (0,55) and negatively oriented variable HR in load (-0,54). The second canonical factor is also defined by positively oriented measures of longitudinal dimensionality, volume of the chest and body mass, from the group of morphological variables. The highest projection from the group of the fitness parameters had variables of cardiorespiratory fitness.
Relations of the second pair of canonical factors indicate that subjects with lower dimensions of longitudinal dimensionality of the skeleton with lower volume of the chest and lower body weight, have higher oxygen consumption and better HR in load. Previous studies reported that HR values in the load are higher in obese children (de Sousa, Hussein, Trowitzsch, Andler, & Reinehr, 2009).
The relationships obtained may be interpreted on the basis of some other factors beyond the control of this research (e.g. neurological, functional and mental development of the respondents, previous motor experience, etc.).

CONCLUSION

The general analysis of the relationships between the both first and second statistically significant canonical factors suggests that obese subjects with lower weight, adiposity and body mass tend to have better results in cardiorespiratory fitness, VO2max and HR in load. Such findings should have practical appliance in working with obese children. Every obese child should be included in some form of physical activity, primarily to improve cardiorespiratory fitness and provide a good health in future.

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Speed, change of direction speed, and reactive agility of junior soccer players according to the level of competition

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Purpose: It is well documented that physical, technical and tactical skills successfully discriminate soccer players by competitive level. However, the majority of studies have focused on adolescent soccer players with biggest individual differences in growth and biological maturation. There is limited information for older adolescent players. Moreover, information regarding the potential level differences between elite and sub-elite soccer players in reactive agility are insufficient. Therefore, the purpose of this study was to compare speed, change of direction speed and reactive agility of junior soccer players by level of competition.

Methods: Sixty-four Serbian U19 soccer players were selected and divided into an elite group (n = 29) competing in the first division of the national U19 league, and a non-elite group (n = 35) competing in a regional division. The running speed of players was determined using a 20-m sprint effort with photocell gates (Microgate, Polifemo Radio Light, Italy) placed 0.4 m above the ground, with an accuracy of 0.001 ms. The timer was automatically activated as participants crossed the first gate at the starting line with split times at 5 m, and 10 m. Change of direction speed was measured with illinois agility test. The reactive agility test was performed according to the protocol described previously by Chaouachi et al. (2014), however, this time the Witty SEM lights were used instead the testers. When the participants past the first gate the signal shows right or left direction. The participants must react to visual signal, change direction and past the third gate.

Results: There was no significant difference between competitive level in speed and change of direction speed ($p > 0.05$). However, large differences, favouring elite players, were observed for reactive agility time ($p=0.001$) and for the players' reaction ($p=0.001$).

Conclusion: We found no clear differences in speed and change of direction speed between elite and non-elite junior soccer players in Serbia which was probably due to differential selection criteria or exposure to training. However, it can be concluded that reactive agility appeared to distinguish elite from non-elite junior soccer players.

The temporal characteristics of the jump shot in a condition of imitation and regular performance among youth basketball players

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Purpose: The purpose of this study was to compare the temporal variables of the jump shot in three conditions: regular performance and imitation with and without visual information.

Methods: Twenty youth male basketball players (age 15,9 ± 0,7 yrs., experience 7,7 ± 1,8 years) voluntarily participated in this study. 300 jump shots at 6 meters from the basket were taken for each of three different conditions: regular jump shot after receiving a pass; imitation with open- and covered eyes. A sleeping mask was used to blindfold the shooter. According to the shooting accuracy of the regular jump shot performance players were split into three groups: 1) >50%; 2) 30-50% and 3) <30% shooting accuracy. All attempts were videotaped from the side view with a Nikon D7100 camcorder set at 60 Hz frame rate. The duration of jump shot phases (Catching, Sitting down, Jumping up, Shooting, Follow throw) and the whole activity were measured by „Kinovea" program (0.8.26) and Microsoft Excel 2016 were used for data processing. The data obtained were analyzed using descriptive statistics (Mean, Standard Deviation, Coefficient of Variation). The equality of variation and significance of the differences was controlled by F-test and T-test.

Results: The main results indicate that the duration of the „Sitting down" phase decreased significantly (p< 0,001) under imitation conditions with open (0,15 s +/- 0,05) and closed (0,14 s +/- 0,06) vision compared with regular performance (0,19 s. +/- 0,06) while the duration of the „Jumping up" phase was reliably (p< 0,001) extended from 0,15 s +/- 0,04 in regular performance to 0,19 s +/- 0,08 at imitation with open and covered 0,19 +/- 0,07 eyes. Conditions of both shooting imitations highlighted statistically significant difference between the first (>50%) and third (<30%) group in „Catching", „Sitting down" and „Shooting" phases (p <0.05). A group with higher shooting accuracy performed the above mentioned phases with longer temporal indicators and a lower coefficient of variation.

Conclusion: On the basis of the results we can conclude that youth male basketball players with higher shooting accuracy are more stable in the imitation of jump shot technique and show longer duration in „Catching", „Sitting down" and „Shooting" phases in comparison with players showing lowest accuracy.

Key words: shooting phases, accuracy comparison, video analysis, variability analysis

Characteristics of the attack from under-18 to under-22 players in men's and women's beach volleyball categories

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Purpose: In beach volleyball, attacks can be subcategorized into *spikes* and *shots*. By definition, the *spikes* are executed with maximum power and the ball trajectory after hand contact follows a straight line. On the other hand, the *shots* are relatively softly attacked balls, which are used to place the ball into unprotected areas of the curt. Currently, there is hardly any information in literature related to the way of the execution of the attack in relation to gender and age group. Therefore, the purpose of this study is to determine types of attack used in categories from under-18 to under-22 according to gender in order to have a deeper knowledge about the game in the lower categories of beach volleyball.

Methods: A total of 1.518 attacks from men's games (33 sets) and 1.504 attacks from women's games (36 sets) were analysed. The sample included 40 teams from under-18 to under-22 that qualified for the semi-finals and finals of the 2016 World Championships and the 2016 European Championships.
An observational, descriptive, and correlational design was used, together with a notational analysis in order to assess the different features of the attack execution. The free software used to analyse the videos was LongoMatch 1.0. The variables studied were: type of attack, efficacy, area and place of attack, gender and age group.

Results: The results show that for both genders: women clearly favour shots (56%) over spikes (44%) as long as men lightly favour spikes (52%) over shots (48%). Moreover, while cross-court spikes are the popular in men (35%), women play about 30% cross-court spikes as well as line shots. There was a similar attacking quality in both genders: 51% positive, 34% neutral and 15% negative. In both genders, there is a clear tendency to attack by zone 2 (58%). And finally, the areas of attack most used were Z5 and Z1 (the corners), least used were Z3 and Z6 (the middle).

Conclusion: The present study shows that women and men use differently the types of attacks, although the placements, effectiveness and areas of attack are quite similar in both genders. Coinciding with Koch et. al. (2009) and Medeiros et. al. (2014) men use more spikes than women, and the use of the spike in the lower categories is fewer than in the senior category. According to Mesquita et. al. (2004), spike is more effective than shot in men. In conclusion, the results of the study provide coaches and researchers new information about performance indicators of the attack.

Time of day effects on speed, change of direction speed and reactive agility in adolescent soccer players

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Purpose: Most of the studies consistently reported higher performance in the afternoon than the morning. However, data examining the effect of time-of-day on agility performances appear to be equivocal. This study investigated the effects of time-of-day on speed, change of direction speed and reactive agility in young soccer players.

Methods: Fifty-one soccer players from Serbia (age: 17.4±0.7 yr; weight: 72.4±4.3 Kg; height: 182.3±4.4 cm; experience: 6±1 yr) volunteered to participate in this study. Soccer players participated in the testing at two times a day: 08:00 and 18:00 h in a randomized order over two days with a minimum recovery period of 36 h. The running speed of players was determined using a 20-m sprint effort with photocell gates (Microgate, Polifemo Radio Light, Italy) placed 0.4 m above the ground, with an accuracy of 0.001 ms. The timer was automatically activated as participants crossed the first gate at the starting line with split times at 5 m, and 10 m. Change of direction (COD) speed was measured with illinois agility test and Y test to the left and to the right side. The reactive agility test (RAT) was performed according to the protocol described previously by Chaouachi et al. (2014). During RAT, the tester had 4 options for each condition: preplanned and randomly ordered (i.e., 8 trials). All these conditions were provided to each player in 2 series (5–8 minutes between sets rest) in a random order. Players were instructed to recognize the cues as soon as possible. Running time was recorded using photocell gates (Microgate, Polifemo Radio Light, Italy) placed 0.4 m above the ground, with an accuracy of 0.001 ms. The same conditions were used for another reactive agility test but this time the Witty SEM lights were used instead the testers. When the participants past the first gate the signal shows right or left direction. The participants must react to visual signal, change direction and past the third gate.

Results: There were no significant differences between morning and evening testing for speed in adolescent soccer players ($p>0.05$). Reactions on both signals in RAT tests were significantly higher in the evening than the morning ($P<0.05$). However, results for Illinois ($p=0.001$) and Y test (left: $p=0.006$ and right: $p=0.001$) were significantly better in the morning than in the evening.

Conclusion: The present study confirms daily variations in change of directions and agility performance in trained young Serbian soccer players. However, the present results indicate that the samples of junior soccer players displayed an optimum for selected soccer-specific skills in the evening, which is in contrast to change of direction speed results. Nevertheless, the coaching staff should be aware of these rhythms and plan activities accordingly.

Technical testing and match analysis statistics as predictors for age-specific talent development in an English football academy

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Purpose: Current research within professional football has shown; 1) technical demands have significantly increased (Barnes *et al.,* 2014), 2) a positive association between greater ball possession and successful results (Liu *et al.,* 2016), and 3) players from successful teams complete more technical actions (Rampinini *et al.,* 2009). Therefore, from a talent development perspective, it is proposed that it is important to assess both unopposed technique and skill behaviours, to support the development strategies of these fundamental technical attributes in elite youth football. Although there are some studies that demonstrate elite youth football players elicit superior technical skills compared to their non-elite counterparts (Vaeyens *et al.,* 2006), there is no research surrounding technical characteristics within an academy environment that predict developmental outcomes. Therefore, the aim of this study was to assess technical attributes and skill behaviours to determine, over two consecutive football seasons, what outcomes support greater age-specific development within the Foundation Development Phase (FDP; under-9 to 11s) and Youth Development Phase (YDP; under-12 to 16s) in an English football academy.

Methods: A total of four football-specific technical tests were used to assess technical ability. Eight match analysis statistics from competitive match-play were also observed to examine skill behaviours. A total of 87 players (aged 8 to 17 years) were analysed within their respective phase; FDP (n=36) and YDP (n=51). Development was measured by comparing the delta change between overall player profile scores from two seasonal player reports. Stepwise regression analyses were conducted to assess the predictive capability of these variables on overall development, with statistical significance set at p=0.05.

Results: Within the FDP, average total touches per game change explained 7.4% of the variance (r^2=0.074, p=0.003), whilst lob pass ability explained a further 2% of the variance (r^2=0.094, p=0.011). Within the YDP, lob pass ability explained 11.7% of the variance (r^2=0.117, p=0.020), pass completion percentage change explained a further 8.3% of the variance (r^2=0.200, p=0.031), whilst reliability in possession percentage change explained a further 8.2% of the variance (r^2=0.282, p=0.024).

Conclusion: Interestingly, lob pass ability was the only technical test that was associated with increased development in both age phases. Additionally, in possession skill behaviours were the attributes that were associated with superior development in both

age phases. Together this research supports the proposition that professional football academies should emphasise developing passing accuracy and ability, through planning and delivering both unopposed technical practices and unpredictable game-based situations. Furthermore, it is suggested that strategies are incorporated to increase ball contact time during competitive match-play within the FDP. For example, competing with reduced player numbers during competitive match-play, to increase individual total touches, could subsequently enhance development opportunities.

The role of 0–10 m sprint ability as a predictor for holistic talent development in an english football academy

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Purpose: Physical performance characteristics, such as sprinting, jumping, and agility, have been found to influence elite youth football development towards professional status in European countries such as Austria (Gonaus & Muller, 2012), Belgium (Deprez *et al.* (2015), Finland (Forsman *et al.,* 2016), Germany (Honer & Votteler, 2016), Holland (Huijgen *et al.,* 2014), Portugal (Coelho-e-Silva *et al.,* 2010), Serbia (Mirkov *et al.,* 2010), Spain (Gil *et al.,* 2007), and Switzerland (Zuber *et al.,* 2016). However, little is known what physical performance factors influence talent development within an English context. Subsequently, the aim of this study was to determine, over two consecutive football seasons, what fitness testing outcomes were associated with greater holistic development within the Youth Development Phase (YDP; under-12 to 16s) in an English football academy.

Methods: A total of 51 players (aged 11 to 17 years) completed a collection of five football-specific fitness tests twice across two seasons to observe physical performance; 0–10 m sprint, 0–30 m sprint, 10–30 m sprint, countermovement jump (CMJ), and L-agility. Holistic development was measured by comparing the delta change between overall player profile scores from two seasonal player reports, including psychological, physiological, technical, and tactical attributes. Stepwise regression analyses were conducted to assess the predictive capability of these variables on overall development, with statistical significance set at p=0.05.

Results: Only 0–10 m sprint ability was negatively associated with holistic development (r^2=0.092, p=0.031), explaining 9.2% of the variance. Thus, 0–30 m sprint, 10–30 m sprint, CMJ, and L-agility results had no association with holistic development.

Conclusion: Whilst these findings were dissimilar from previous studies (Forsman *et al.,* 2016; Zuber *et al.,* 2016; Gonaus & Muller, 2012; Mirkov *et al.,* 2010), they coincide with others who also found shorter sprint ability as a significant feature within the talent development process in elite youth football (Honer & Votteler, 2016; Deprez *et al.,* 2015; Huijgen *et al.,* 2014; Coelho-e-Silva *et al.,* 2010; Gil *et al.,* 2007). The importance of 0–10 m sprint ability in the modern game is illustrated by Barnes *et al.* (2014), who reveal the number of sprints has increased by 35% in the English Premier League, whilst the proportion of explosive sprints has also improved, alongside sprint distance becoming shorter, over a seven season period between 2006/07 and 2012/13. Additionally, Faude *et al.* (2012) highlight the importance of straight line sprinting at senior professional level, as it's the most frequent physical action used in goal situations in professional football. Therefore, it is proposed the measurement of 0–10 m sprint ability is included in a batch of testing procedures to identify, and subsequently monitor, athlete development within an English football academy setting. In addition, 0–10 m sprints should be incorporated into football-specific training strategies within the YDP to facilitate holistic development.

Effect of an individual skills specific coaching education programme on the skill level of mini-rugby players

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Purpose: The purpose of the current study was to determine the effect of a skills specific coaching education programme on the skill level of mini-rugby players in the in the Western Province Rugby Union.

Methods: The participants of this study and coaches (N=6) and players (N=181) from different primary schools in Cape Town. The schools were selected based on the mini-rugby structure at the schools, to ensure a uniform environment between the experimental and control groups. Two of the four schools were randomly allocated to the experimental group (n=84) and the other two schools were randomly allocated to the control group (n=97).

Results: After being exposed to the 16-week skills programme for the entire season, the experimental group showed significant improvements ($p<0.05$), in passing; catching; picking up the ball; tackling; and taking the ball into contact. Although the experimental group did display improvement in evasive running, the improvement was not significant ($p=0.32$). The control group displayed varied results in that the group as a whole deteriorated in three of the six skills and improved in the remaining three skills.

Conclusion: A major finding of this study was that the specific skills intervention programme significantly enhanced the skill level of the players.

Role of age in attacking tactical knowledge among soccer school players

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Purpose: Based on the notion that a player must know what to do and how to do in order to determine his actions in the games, the aim of current study was comparison of declarative and procedural knowledge of soccer among soccer school players with different age groups.

Methods: 456 players of soccer school from U-10 (95 players), U-13 (225 players) and U-16 (136 players) age groups completed Soccer Tactical Knowledge Test (STKT) (Serra-Olivares and Garcia-Lopez, 2016). This instrument with taking two basic pedagogical principles outlined by the game based approaches (Mitchell et al., 2006) into account, the importance of the specific vocabulary-language and the individual differences of each learner, in comparison with other tools does not only evaluate "knowing what and how to do" in terms of declarative and procedural knowledge of the invasion games, but also "knowing why to do" in relation to the tactical principles for attacking proposed by Bayer (1992). In current study, declarative tactical knowledge (36 items) with subscales include specific knowledge on technical-tactical individual and collective elements when attacking for invasion games and roles and positions in soccer, and procedural tactical knowledge (15 items) with subscales include specific knowledge in situations of keeping the ball, moving forward to the opposite goal and scoring in soccer were assessed by STKT.

Results: Results showed significant differences in total, declarative and procedural tactical knowledge ($F_{(2,453)}$= 16.54, $F_{(2,453)}$= 15.22 and $F_{(2,453)}$= 9.57, p= 0.000, respectively) among U-10, U-13 and U-16 groups. Bonferroni post hoc revealed these significant differences just between U-10 with U-13 and U-16 groups in total (p= 0.000, both), declarative (p= 0.000, both) and procedural (p=0.000, both) tactical knowledge. In declarative knowledge, U-13 and U-16 groups in all technical and tactical mentioned subscales were significantly better than U-10 group (p=0.000, all), but in the roles and positions in soccer subscale, U-16 was just significantly better than U-13 and U-10 groups (p= 0.000, both). In procedural knowledge, U-13 and U-16 groups in situation of keeping the ball subscale were significantly better than U-10 group (p= 0.005, both), but in the situations of moving forward to the opposite goal and scoring subscales the significant difference was just observed between U-16 and U-10 groups (p= 0.013, p= 0.009, respectively).

Conclusion: One of the essential capability for soccer players to perform successfully is to possess high tactical knowledge (Williams and Davids, 1995). Agreement between our results and Americo et al. (2017) and Moreira et al. (2014) shows that not only the length of time to explore the sport-specific concepts, but also the age-induced biological maturation and psycho-physical development of children/adolescents (Toeldo et al., 2017), possibly duo to the experience level of soccer training (Goncalves et al., 2016), affect the acquisition of tactical knowledge (Auld, 2006). Furthermore, significant

differences between U-16 and U-10 players in declarative and procedural tactical knowledge confirms the statement that prior to age of 11/12, the cognitive development of players is not yet sufficient to understand the dynamics of cooperation and opposition and comprehend core tactical principles of the game in invasion team sports like soccer (Gonzalez-Villora et al., 2015; Piaget, 1964). As a result, given that the quality of learning process is influences by the tactical knowledge level, these findings suggest that improvement of declarative and procedural tactical knowledge in the initial years influences future soccer success.

Relationships between anthropometrics measure, motorical abilities and psychological factors in young tennis players

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Purpose: The classic observation of the differences in the anthropological characteristics of children by sex, involved in sports, is often caused by erroneous treatment. That is why the purpose of this work is to establish similarities and differences in the anthropological characteristics of young boys and girls tennis players.

Methods: From the data bank of testing, a group of 48 girls and 40 boys was drawn. In the anthropometric area 39 were measured, from which: BMI, percentage of fat mass and somatotype were calculated. Motorical abilities were measured using 19 tests. Endurance was measured using a Multistage fitness test (Beep), following a heart using rate monitor (Polar) and blood lactate concentrations was measured after maximal effort. For the analysis of psychological factors, three tests were conducted: general achievement motivation (Havelka & Lazarević, 1980), sports achievement motivation (Havelka & Lazarevic, 1984) and Eysenck's EPQ-J. Data processing, descriptive statistics as well as variance analysis were performed using statistical statistics package Statistica 13 (TIBCO Software Inc. (2017). Statistica (data analysis software system), version 13. http://statistica.io.).

Results: The obtained data shows a very small and expected difference in anthropometric space. The statistically significant difference is present in the percentage of body fat ($p < .00$), which presents the girls having a higher body fat mass. The same does not confirm the projection on the endomorphic component of somatotype ($p = .17$). In motorical abilities, the biggest difference is measured in the tests of flexibility ($p < .00$), which presents the girls as young athletes with a significantly higher degree of flexibility. The girls are presented statistically significantly more successful in the circulatory test ($p = .01$) and they also achieve a significantly higher concentration of lactate in the blood after the Beep test. Boys are statistically significantly more successful in performing agility tests ($p = .04$) and show higher aerobic power than girls ($p = .04$). The research did not confirm any significant difference in personality traits as well as in the area of motivation. Only the boys were projected statistically significantly more strongly on the scale of positive emotional responses in general achievement ($p = .04$), while the girls were projected statistically significantly higher on Lie scale ($p < .00$).

Conclusion: The research carried out has confirmed some previous insights into the differences between the sexes. Unlike much of the research done so far, the differences in personality traits have not been confirmed, especially in the projection of the extroversion. In a detailed analysis of the data obtained, special attention should be focused on the knowledge that girls in this chronological age can be biologically more mature for up to two years.

Comparative study of anthropometric measurement and body composition between junior basketball and volleyball players from Serbian national league

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Purpose: The purpose of this study was to describe anthropometric characteristics and body composition of elite junior basketball and volleyball players from national league and to make comparison between them.

Methods: Fifty-nine males were enrolled in the study divided into three groups: thirteen basketball players, fourteen volleyball players and thirty-two healthy sedentary subjects. All subjects were assessed for the anthropometric measures required for the calculation of body composition variables, using standardized procedure recommended by established literature. Data was analyzed using SPSS and the descriptive statistics were expressed as mean (SD) for each variable, while ANOVA and LSD Post Hoc tests were carried out to detect the effects of each type of sport.

Results: The results showed there was no significant difference in body mass index and bone content of body among the groups, while a significant difference was found for body height, body weight, muscle and fat contents of body among the groups. Basketball and volleyball players were significantly taller and heavier than the subjects of the control group, while there was not any significant difference between the body height and body weight of basketball and volleyball players. Muscle content of basketball players was significantly higher than control subjects, while a significant difference was not noticed between volleyball players and subjects of control group. Fat content in the body of basketball and volleyball players are significantly lower than the percent of fat content in the body of control group, while there was not found any other difference in this content.

Conclusion: These findings may give coaches from the region better working knowledge and suggest them to follow recent selection process methods and to be more careful during the talent identification.

Key words: sport, junior, basketball, volleyball, male

Levels of satisfaction in different actions and game situations in young badminton players

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Purpose: The new models of sports teaching indicate that it is necessary to know the levels of preferences of young players for the design of the exercises. The aims of the present study are: a) to analyze the levels of satisfaction of different technical-tactical actions in badminton players in training ages; b) to know what game situations are that players like to practice in the training; c) to know what extent players like to attack and defend.

Methods: The determined sample was composed of 207 badminton players, who participated in the Spanish Championship of Regional Selections under 14.

Results: The results indicate that: a) the technical-tactical action that the player likes to perform is to play a long point, and the least is to defend from the bottom; b) the preferred game situations in the training sessions are those of playing against the coach, and those of the match, whereas that the least are the related with the exercises without opposition; d) the player prefers to perform attack actions against those of defense.

Conclusions: These values must be taken into account by the coaches, when designing teaching sessions, as well as establishing game styles in the competition, with the aim of bringing their practical proposals to the needs and priorities of players in the early training stages.

Opinion of young badminton players about the possibility of making changes to the regulations

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Purpose: In order to ensure that the competition is a true formative medium, it is necessary that it be adapted to the needs, priorities and preferences of young athletes. In this sense, there are several authors who highlight the regulation as the key element to make the competition as a formative medium. There are few studies in which statutory changes are proposed in sport in general, indicating in all of them that an adequate regulatory modification allows an increase in their sport learning levels. However, most of the studies which are about on regulatory modifications propose the modifications after an only conceptual review. There are few studies that take into account the opinion of the coaches and experts on these possible modifications (Ortega, Castro, et al., 2008). These opinions should be essential criteria to decide which modifications to make. To a much lesser extent, the opinion of the athletes is taken into account in order to carry out said regulatory modifications. Therefore, the main purpose of the present study is to know the opinion that young badminton players have about possible regulatory modifications on the current regulations used by the Spanish Badminton Federation.

Methods: The determined sample was composed of 207 badminton under 14 players, who participated in the Spanish Championship by Autonomous Communities.

Results: The most significant results indicate that the majority of players find the current regulation very adequate, although some of them would propose: a) a greater number of points in each set with respect to the usual ones b) the shuttlecock would be slower; c) the net should be lower.

Conclusions: These values must be taken into account by the coaches and the sports federations, with the aim of being able to make regulatory adaptations which facilitate an adequate progress in the formation of the badminton player.

The relationship between FMS and functional single-leg hop stabilization test in team sport and martial arts young male athletes

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Introduction: The aim of this study was to investigate the correlations between two different functional tests: Functional Movement Screen (FSM) and dynamic postural stability test results of athletes from team sport (basketball, handball,volleyball) and martial arts (judo, taekwondo, karate).

Methods: 45 team sport (age =16,27 ± 1,7 years; height=183,2± 6,6 cm and BMI=23,5 ± 3,8) and 19 martial arts athletes (17,6±2,2a years; height=177,6±6,7cm and BMI=24,4±3,7). Participants were screened using the 100-point scale FMS™ protocol (Butler,R.J et al.,2010). The Dynamic Postural Stability Index (DPSI) and the directional components (medial-lateral, anterior-posterior, and vertical) after a jump landing was measured by Kistler force plates (Wikstrom, E. A et al.,2005).All statistical analysis was computed using the IBM SPSS Statistics (version 23.0).

Results: The mean composite FMS 100-point scale of martial arts athletes was 55,1±9,3 and team sports athletes 45,0±6,4. Martial arts athletes shows statistically significantly higher score in active straight-leg raise 4,4±3,1 vs 7,9±3,9 ($p<0,05$) and trunk stability push-up test 4,4±3,5 vs 7,1±4,5 ($p<0,001$). There was not statistically significant difference between other five tests. There was not significant differences between athletes groups stability test results. The team sport athletes shows slightly better medial- lateral stabilisations that martial arts athletes (4,4±0,53 vs 4,6±0,03) in 1 second trial duration and martila arts athletes anterior-posterior stabilisations (20,97±0,68 vs 22,2±0,15). There was moderate correlation between seven different FMS exercises scores and DPSI values of martial arts atheletes ($r= 0,51$) and team sports athletes ($r=0,47$).

Conclusion: The results of the study indicate low score both tests in groups. The team sport athletes have more problems with muscles of the hamstring and trunk muscles stabilizing than martial artists. Sport specifically shows team sport athletes better medial-lateral direction posture stabilisation and martial arts anterior-posterior posture stabilsation. The relationship between functional performance ability and sport injury risk has been established in many cases, but relationship between functional performance ability and sport- specific athletic performance needs more reseach.

Key words: functional performance, dynamic stability, young athletes

Describing physical activity profile of young Montenegrin females using the international physical activity questionnaire (IPAQ)

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Purpose: The purpose of this study was to describe the physical activity profile of young females living in Montenegro.

Methods: The data was collected from 340 randomly selected young Montenegrin females that were 20.90±1.41 years old (range 18-26). The International Physical Activity Questionnaire (IPAQ), self-administered long format, was used to describe the physical activity profile of selected population in five areas (job-related physical activity, transportation physical activity, housework, house maintenance, and caring for family, recreation, sport, and leisure-time physical activity and time spent sitting). A descriptive analysis was carried out to analyze the mentioned variables.

Results: Among variety of very interesting results reached by the mentioned protocol, it is important to highlight that just 17.4% of respondents currently have a job or do any unpaid work outside its home, 89.1% of them walked for at least 10 minutes at a time to go from place to place, but one fourth not more than three times during the last seven days. On the other hand, 15.6% of respondents did physical activities related to housework, house maintenance, and caring for family at least 10 minutes at a time, but just 1.5% more than five days a week. 7.9% of Montenegrin young females did not walk at least one day for at least 10 minutes at a time in its leisure time, but over 50% of active young women did walk more than five out of seven days in the week. Over 20% of respondents have usually spend sitting more eight four hours on a weekday.

Conclusion: The data reached in this project suggested that the prevalence of physical inactivity among young Montenegrin females was relatively high. From this reason, the physical activity promotion has to be more implemented in the national and international projects for the young females in Montenegro to reach, at least European standards. This abstract has been done within nation project under the title “Effects of Physical Activity on Social Inclusion of Young People” that was approved by Ministry of Sport in Montenegro (No.01- 553-691/2018 from 1 March 2018).

Key words: physical activity, youngsters, female, health

Analysis of the goals scored by U-12 players during 7 and 8 soccer a side games

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Purpose: The purpose of this study was to analyze the goals scored by U-12 players in the two common competition formats designed for them to play by the soccer associations at international level (7 and 8 a side soccer).

Methods: The characteristics of the goals scored by the players during 7 and 8 a side soccer games were analysed. The minute of the goal, the play duration, the number of passes of the play, the zone of the kick, and the distance from the kicking to the goal were registered. Data regarding the previous action developed by the players before the goal was also collected for analysis purposes. The numerical imbalance between attackers and defenders was analysed by registering the number of attacking teammates and defenders to the player who scored a goal in a radius of two distances (distance < 3 meters, and distance between 3 and 6 meters). Finally, the technical-tactical imbalance between the player who score the goal and his direct defender was analysed by registering the distance between them and using entropy.

Results: Significant differences were observed depending on the competition format played (7 or 8 a side soccer), the team level (regional or local), the age category (U-11 or U-12), the result of the game (victory, defeat or draw), and the kind of play (usual playing or set-pieces).

Conclusion: It was observed a lack of evidence about the mechanisms of scoring in young soccer. On the topic of the scoring teaching, the scoring strategies analysis will benefit a better understanding of the scoring skills acquisition process.

U-12 players space domain in 7- and 8-a side soccer games

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Purpose: An interesting research line about invasion games teaching has focused on the competition formats analysis in order to make the sport practice better and easier for children. However, in sports such as soccer research, is inconclusive about which competition format would be more appropriate to practice depending on the age and the player's characteristics (Lapresa et al., 2010, 2013). The purpose of this study was to analyze possible differences in the tactical domain of the space between two different competition formats (7 and 8- a side soccer) using a new approach based on GPS tactical assessments.

Methods: 280 U-12 youth footballers played one 30min-match of in each format (7 and 8- a side football). Team areas, centroids and distances were analyzed by using GPS devices. Realtrack WIMU and SPRO software were used to analyze data.

Results: Results show differences in all variables between the two formats, depending on the age and the level of the players. Differences were also observed depending on the game phase of play (attacking or defense).

Conclusion: On the topic of the tactical behavior development, the competition format analysis by using GPS devices will help to a better understanding for sport pedagogical purposes (Clemente, et al., 2014; Frencken et al., 2011; Serra-Olivares et al., 2017).

Small-sided games: 6v6 a positive progression for the development of junior netball?

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Purpose: The aim of this study was to understand the if the expected benefits of playing small-sided games with modified rules (more individual time on vaired tasks in a game and more opportunities to explore skills) actually exist.

Methods: Fifty-six participants from Year 5 & 6 were used in this study and came from the five zones within New Zealand. Each participant played the 6v6 modified game which has contrasting rules and equipment compared to the traditional game. The themes fast, change and focus were all coded for using SportsCode Elite™, and motivation was measured through a Basic Motivational Needs Questionnaire. All data were reported as mean ± standard deviations. Precision of estimation was indicated with a 95% confidence interval. The criteria for interpreting effect sizes were, < 0.2 (small), < 0.6 (moderate), and >1.2 (large) (Thalheimer & Cook, 2002). The frequency of whistle blows, passes completed and passes high/wide were measured and the one-way between group analysis of variance (ANOVA) was used to determine significance. A Kruskal-Wallis test was used to determine if the the frequency of transitions, passes intercepted, passes to nowhere, player engagement and distraction as well as successful and unsuccessful shots were significantly different. A *t* Test was performed on the basic motivational needs of all the players and the motivation among the zones to see if statistical differencs occur. Data was assessed for normality by inspecting the skewness, kurtosis and Shapiro-Willk statistic.

Results: Results show that pass completions by position ($F_{(2, 138)} = 8.321$; $p = 0.001$; $\eta^2 = .108$) and player distraction between zones (U=21.409; z=2.998; p = .002) were both significantly different.

Conclusion: The results of this study support the view that 6-a-side as a modified game can provide a viable supplement to Netball. The game modifications simplify it yet also speed it up creating pressure and decision making demands which appear to be consistent with the game at the higher level, all in a motivational context. As a developmental game 6-a-side is not perfect; passing and engagement data suggests that it favours link players, therefore variations or rule changes need to address this. The broad body of this research emphasises the value in modifying games for the benefit of developing players. This is not a goal exclusive to 6-a-side but rather a concept that merits greater emphasis in the development of coaches at all levels.

Other

Functional movement screen (FMS) as a support tool in the prevention of sports injuries

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ABSTRACT
This work aims to verify the validity of the Functional Movement Screen (FMS) as an injury prevention tool for professional soccer players. The study method is experimental with a group: through the analysis of a sample of 15 professional soccer players, who have undergone two screening sessions (august 2017 and december 2017) described in the Functional Movement Screen (FMS). A t-test for dependent group was conducted to check the differences between the means of group collected during the phase pre-season and season. The analysis of the data showed that there was a good adherence to the project by the players, on the 15 tested that have performed a personalized program. In general, there was an improvement in the results of the two screening tests performed. This study will attempt to highlight whether "specific" movement patterns predispose athletes to injuries and whether an FMS functional movement screening tool can be used to predict injuries. The purpose of this study is to determine whether motion patterns predispose players to injury and whether the FMS could be used to predict injury in this population during a competitive season.

Key words: soccer, muscle injuries, personalized program, performance

Introduction
Soccer is a sport with an high agonistic engagement such to require the development of all the motor skills and we play a sport to acquire general and specific motor skills (Altavilla et al, 2017). In professional sports, the problem of accidents affects so much that they force the athlete to withdraw from competitions. In football the incidence of injuries is high (18.6 per 1000 AEs in the match, 4.3 per 1000 A-Es in training). Obviously, epidemiological prospects and different incidences can occur when the extrinsic and intrinsic factors change, for example (Schmikli et al., 2009) state that the exposure to the injury of an adult male subject (18-34 years old) is twice that of incidence that is calculated in a child or a boy (4-17 years). Football is a sport that requires different skills (Altavilla & Raiola, 2018) such as speed, power, explosiveness, balance and neuromuscular coordination, and exposes players to direct contact with the opponent; in fact, most of the injuries in this sport are caused by contrasts, therefore defined as traumatic accidents (Stubbe et al, 2015; Tegner & Lorentzon, 1991). Despite the contact between players is the main cause of injuries occurred in the game, most of the injuries found in training have an indirect traumatic nature (Agel et al, 2005). It has been estimated that between 50% and 80% of these injuries are excessive in nature and affect the lower limbs confirm, Emery, & Meeuwisse (2010) through their study, that the tibio-tarsal joint and the knee joint are those most prone to injury in the practice of soccer. The main

causes are of a musculoskeletal nature is multifactorial, recent studies have recorded an increase in the recognition of muscular imbalances, poor neuromuscular control and instability of the nucleus as potential risk factors for athletic injuries; therefore the athletes must be subjected at exercitation with a high degree of postural instability, that stimulates the static and dynamic balance (Altavilla et al, 2014). It is possible to hypothesize that certain changes in motor control may result from lesions that can be detected using motion-oriented tests (Kiesel et al, 2007). One of these assessment tools is the Functional Movement Screen (FMS), whose use has increased in popularity in recent years. It is a screening system that attempts allow the professional to assess the fundamental movement patterns of an individual (Cook, 2011). Its low cost, its simplicity of application and its non-invasive qualities contribute to its use by professional and amateur athletes. Many athletes and individuals are performing high level activities despite being inefficient in their fundamental movements (Altavilla et al, 2018); thus, without knowing it, these individuals are attempting to add fitness to dysfunction (Cook et al, 2014). To perform the FMS, an examiner observes the subject while performs seven fundamental movements in order to identify non-functional movement patterns. A score of zero to three is given based on the quality of the movement. Muscle imbalances can lead to compensatory motion patterns, resulting in poor biomechanics, micro or macro lesions poor functional movement is a risk factor for injuries in soccer players. Players with dysfunctional movement patterns, those measured by the FMS, are more likely to suffer an injury than those who score higher on the FMS. (Lisman et al, 2013) examined a population of US Marines and found that a score of 14 or less on FMS showed limited ability to predict all traumatic musculoskeletal injuries. Chorba et al, (2010) have confirmed that with scores lower than 14 on the FMS there is an increase of about 4 times the risk of lower limb injuries in soccer players. This work aims to verify the validity of the FMS.

Materials and methods

Participants

The study was conducted on a sample of fifteen soccer players men, of ages between 18 and 28 years, they have voluntarily participated in the study. The order of execution of the tested items is the one dictated by the FMS manual (Functional Movement Screen) as well as the criteria for evaluating the quality of the movement. Inclusion criteria for this study included athletes who had not suffered an injury in the previous 30 days forbidding participation in the season preparation workouts. The exclusion criteria included an injury sustained in the 30 days prior to the test that excluded the athlete from the competition. Players have been tested within the first weeks of pre-season preparation; who have been asked to perform a series of movements (seven) using the FMS. After performing the analysis of the dysfunctional movements found in the items, we have developed an individual program consisting of seven exercises with the aim of providing an instrument through which the athletes could improve or to prevent. The players had to perform the proposed exercises, integrating them before the training session in the weekly organization, three times a week.

Procedures

The FMS consists of seven motion tests (Deep Squat, Hurdle Step, In-Line Lunge, Shoulder Mobility, Active Straight Leg Raise, Trunk Stability Push-Up e Rotary Stability), that are designed to quickly and easily identify restrictions or alterations in normal movements. According to Cook et al, the test was designed to challenge the interactions of the mobility and stability of the kinetic chain necessary for the execution of fundamental and functional movement patterns. The study method is experimental with a group of fifteen soccer players men, the group has been tested in august, trained with FMS exercises by Cook and then re-tested in december. The type of research is of the type test - intervention - re-test. The first screening session was carried out on a sample of 15 Italian second-division professional footballers, in August 2017 and then in December 2017. This allowed us to have a sufficient number of data to carry out our research. We used 2 video cameras, one with a frontal upturn and one lateral, in order to make a better analysis of the movement, so that we can make our observation even more precise. The only exclusion criterion: the injured athletes were excluded from the statistical analysis.

Statistical analysis

The fifteen soccer players men have been tested: mean ± standard deviation. Measures of central tendency and dispersion (mean ± standard deviation) of age, height, weight and BMI; age: 23,8 ± 4,6 years; height: 177.6 ± 4.1; body weight: 74.1 ± 3.9 and BMI: 23,5 (table 1). A t-test for dependent group (test-retest) was conducted to check the differences between the mean of group collected during the phase pre-season and season. The analysis covered basic statistics and percentages for the date considered. All statistical analyzes were conducted using Dell's statistical software 13.2.

Table 1.

Group (n=15)	M	SD
Age (year)	23,8	4,6
Height (cm)	178,6	4,1
Weight (Kg)	75,1	3,9
BMI (Kg/m²)		23,5

BMI: it value is an intervall of normality

Results

In tables 2-3-4 and figure 1, are summarized the results obtained in the present study.
In tables 2 and 3 are shown the data collected on several test, in august (test), and after a period of four mounths of training, in december (retest).

Table 2. Experimental group test (Pre-season)

Subjects	Deep Squat	Hurdle Step	Inline Lunge	Shoulder Mobility	Active Straight leg raise	Trunk stability push-up	Rotary Stability	Total
1	2	2	1	2	2	2	2	13
2	1	1	1	1	2	1	1	8
3	2	2	2	1	2	2	1	12
4	2	2	1	1	2	2	2	12
5	2	2	1	1	2	2	2	12
6	2	2	1	2	1	2	2	12
7	1	1	2	1	2	1	2	10
8	2	2	1	2	2	2	2	13
9	1	2	1	1	2	1	1	9
10	1	1	1	1	2	2	2	10
11	2	2	2	1	2	2	2	13
12	2	2	1	1	2	2	1	11
13	2	2	1	2	2	2	2	13
14	1	2	1	1	2	1	1	9
15	1	1	2	1	1	2	1	9
Averages	1,6	1,73	1,27	0,93	1,73	1,67	1,53	**11,06**

Table 3. Experimental group retest (Season)

Subjects	Deep Squat	Hurdle Step	Inline Lunge	Shoulder Mobility	Active Straight leg raise	Trunk stability push-up	Rotary Stability	Total
1	2	2	2	2	3	2	2	15
2	2	2	2	1	2	2	2	13
3	2	2	2	2	2	2	2	14
4	2	2	2	2	2	3	2	15
5	2	2	2	2	3	2	2	15
6	3	2	2	2	2	2	2	15
7	2	2	2	2	2	2	2	14
8	2	2	2	2	2	2	2	14
9	2	2	2	2	3	2	2	15
10	2	2	2	1	2	2	2	13
11	2	2	2	2	3	2	2	15
12	3	2	2	2	2	2	2	15
13	2	3	2	2	2	2	3	16
14	2	2	2	2	2	2	2	14
15	2	2	2	2	2	2	2	14
Averages	2,13	2,2	2,13	2	2,47	2,27	2,27	**14,46**

A t-test for dependent group (tab. 4) was conducted to evaluate any significant differences between test and retest performed after four mounths of work on specific exercises (Screening by Cook).
The results show a significant difference between the data collected during the first period (test in august) and the data collocted during the second period (retest in december). Finally, the estimation of the training effect, due to the type of method used (screening by Cook), it gaves an improvement percentage increasement on experimental group, at the final of the four mounths of training, of about 30,7% (Fig. 1).

Table 4.

t-test group dependent (test-retest)		
t-test	1,32	(Significant)
Critical value =1,76		df= 15-1 = 14
Level significant α = 0,05 Average Test = 11,06 Average Retest= 14,46 Difference between Test and Retest = MD = 3,40 % increasement = MD/Average test = 3,40/11,06 = 0,307*100 = 30,7%		

Figure 1

Movement patterns can increase the risk of injury to athletes. A score of 14 or less on the FMS resulted in an approximate 4-fold increase (3.85-4.58) of the risk of lower limb injuries during a competitive season in soccer athletes. The FMS may be able to predict injury in soccer athletes without a history of serious skeletal muscle injury.

Discussion

The results of the present study reveal advantageous improvements, using the Functional Movement Screen (FMS) as a support tool in the prevention of sports injuries training. A practice distributed and extensive over time but constant involves undoubtedly significant advantages. The results obtained, using a sample of 15 adult of aged between 18 and 28 (males), allow some considerations. The four training mounths for 3 no consecutive days were sufficient to get improvements significant in prevention of injuries and of the balance neuromuscular. It can then be concluded that, to prevent injuries and avoid dysfunctional movements, the footballers need of preventives training and of rebalance of the muscular chains throught exercises personalized and using the method FSM.

Conclusions

Dysfunctional movements are risk factors for footballers injuries; in fact, players with dysfunctional movement patterns, as measured by the FMS, are more likely to suffer an injury than those who score higher on the FMS. Soccer is a very technical sport but also physical, where good control is required in the fundamentals and balance neuromuscular. To prevention and to improve the quality of the performance is the main purpose of any staff sportive-medical. The results of experimental group have showed a significant percentage increase of the 30,7% at the end of the four mounths of training. Finally, and in line with the data of the present study, the FMS method and a training personalized are resulted as a determining factors for the prevention of injuries and the stabilization of muscoular chains. Furthermore, coaches and anyone involved in training of footballers should account of these methodological indications as tool of prevention and of recovery for professional soccer players. This study sought to highlight whether “specific” movement patterns predispose athletes to injuries and whether an FMS functional movement screening tool can be used to predict injuries in this population during a competitive season. The collected data allow to confirm the effectiveness of the FMS method.

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Differences in physiological loads and energy consumption of handball referees between periods in handball match

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ABSTRACT
The aim of this study was to determine differences in physiological loads and energy consumption of handball referees between halves during handball match.
The sample consisted of all 16 referee pairs which counts 32 handball referees who are on list of Croatian Premier handball league (highest handball rank in Croatia). Before the start of testing each participant had signed a voluntary statement for testing and also provided confirmation from medical institution confirming proper state of health. Handball referees measurements were divided into two parts. First part was conducted as laboratory testing, while second part was field test on matches of Premier Croatian handball league. Laboratory measurements started with measuring kinanthropometric measures to identify morphological characteristics. On field tests referees were monitored for physiological loads during matches with a telemetry system for monitoring the heart rate frequency. The average age of referees was 34,29 ± 6,20 years with an average experience of 13 ± 4,99 years in handball refereeing in total (highest level refereeing experience 7,03 ± 4,00 years). Referees had average body height of 184,46 ± 5,78 centimeters and weight of 91,73 ± 10,57 kilograms.
Data processing was carried out by statistical package Statistica (version 8). Differences between the two periods of handball matches were tested by t-test for independent samples and the level of significance was set at $p < 0,05$. T-test for independent samples shows there are no statistically significant differences in maximal and average heart frequency of handball referees during first and second half of handball match as well as there are no statistically significant differences in energy consumption between halves also.
Based on the results obtained in this study it can be concluded that handball referees are exposed to high physical and physiological loads during the match with no difference on periods of the match. Due to high influence of referees on final outcome of matches and competitions they need to be at highest possible fitness and concentration level during whole match.

Key words: team handball, referees loads, pressure, heart frequency

Introduction
Handball is characterized by changeable high-intensity contacts that require a combination of aerobic and anaerobic endurance and well-coordinated field activities (Cazan et al., 2012). During the game, players averagely cross (depending on the positions of the game) between 4 kilometers and 510 meters and 5 kilometers and 130 meters. The biggest distance crossed by wings and line players, while backcourt players

are not much behind these values (Bon et al., 2002). Since the referees must follow the game by their movement, in the study of Estriga et al. (2013a) referees exceed distances covered by players during the game (6.2 ± 0.3 km).
Handball has evolved from the last few rule changes and game has greatly accelerated. Several factors have contributed to this direction, and one of the most important changes is the rules such as the quick restart of match after receiving a goal and changes regarding passive play (Sevig and Bilge, 2007; Kruger, 2013). After these changes in handball, time between the defense phase and attack phase was significantly reduced, so the game became more dynamic and demanding (Sporis et al., 2014; Povoas et al., 2014) for both players and referees. Interpreting the rules of passive play resulted in concentration of the best teams on the tactics of counter-attacks and the acceleration of the game during attack phase, and it is precisely the situation in the game that the referees must follow and always be right next to the place of the event in order to make the right decision. According to this rule, the quick restart of the match after receiving a goal has also contributed to the greater physical demands of the players (Kruger, 2013), as well as referees whose physiological loads during the game could be more than the physiological load of the players during the match (Matković and Nedić, 2012).
The success of refereeing in contact sports (handball, rugby, basketball, soccer etc.) is closely related to the ability to follow physical and physiological demands during the match (Castagna et al., 2004; Reilly and Gregson, 2006; Weston et al. et al., 2011; Valdevit et al., 2011). Handball referees are exposed during the season not only to physical loads (maintain fitness skills), but must also undergo psychological pressure (Mirjamali, 2012). Given the fact that there are more types of stress the work of sports referees at sport events is recognized as a very stressful activity. The more important the game is, the pressure is bigger because their decisions can affect the final result of matches and competitions (Unkelbach and Memmert, 2010; Chelly et al., 2011; Estriga, 2013a; Elsworthy, 2014; Caballero et al., 2015, Brightmore et al., 2016). Pressure can be from officials of clubs, fans, media and players (Titlebaum, 2009; Boyko, 2007).
Good positioning of referees is only possible if the referee is mobile and physically fit for the physical requirements of the sport, and referees must also be able to maintain mental concentration and make decisions on field situations in a fraction of a second (Reilly and Gregson, 2006). The time for making a decision is short, and decisions are made frequently. Attention and concentration of judges at the moment of decision-making must be at the highest level of effectiveness so this research will check if there is a statistically significant difference in physiological loads and energy consumption of referees between the two handball match halves which last 30 minutes of effective play. Halves last longer than 30 minutes because referees stop time during some events like team time-out, floor drying, injury, equipment problems, change of ball etc. Studies which main interest are referees in team sports are very rare and mostly research in team sports are related to participants themselves, competitors, but there is a tendency to study sports referees, although the research area has not been directly studied.

Methods

Subjects

The sample consisted of all 16 referee pairs, or 32 handball referees who are on the list of Premier Croatian handball league (highest league ranking in Croatia). The list of referees is suggested and confirmed every year by the professional committee of the Croatian Handball Referees Association. In sample there were 5 referees who are referees not only in Croatian leagues, but they are also on the lists of competitions under the jurisdiction of international handball federations (both European and International). The referees were of average age of 34.29 ± 6.20 years, height of 184.20 ± 5.87 centimeters and body mass of 91.25 ± 10.45 kilograms. Referees average experience in refereeing is 13.00 ± 4.99 years while they were in the highest rank of handball competition in Croatia for 7.03 ± 4.00 years.

Procedure

Each examinee signed a voluntary approval statement and provided a medical certificate confirming that there are no health-related contraindications to referee a handball match as well as to conduct the testing for this research. The measurements of handball referees were carried out in two parts: the first part of the measurements - anthropometric characteristics of the examinees was conducted at the Diagnostic Center of the Faculty of Kinesiology of the University of Zagreb. The body height was measured with a precision of 0.1 cm, while body weight was measured on the digital scale Tanita BC-418 MA as part of the anthropometric measures to identify the morphological characteristics of the referees.

The second part of the measurements was performed during the official matches of the Premier Croatian Handball League. The physiological loads during the match was measured trough heart rate measurement method. Referees were wearing the invisible telemetry system under official match shirts for referees to record heart rate frequency (Polar RS 400) during matches. Based on the data collected from referees and added to telemetry system and as well the ones recorded during the match, energy consumption values were obtained. After the match the results were transferred and processed in the Polar Pro Trainer software package.

Data Analysis

The statistical software Statistica (version 8) was used for the statistical analysis. Central and dispersion parameters, arithmetic mean (Mean) and standard deviation (Std.Dev.) were calculated for two halves of handball match. Normality of distribution was checked by the Kolmogorov-Smirnov test. Differences between the two periods of handball matches were tested by t-test for independent samples and the level of significance was set at $p < 0,05$.

Results

Table 1. shows descriptive statistical parameters and distribution parameters. For each variable, basic statistical parameters were calculated: arithmetic mean, minimum value, maximum value, standard deviation and skewness and kurtosis of distribution.

Table 1. Descriptive statistical and distribution parameters

N = 32	Mean	Minimum	Maximum	Std.Dev.	Skewness	Kurtosis
FSmax	185,17	140,00	203,00	12,05	-1,85	6,16
FSmin	70,31	50,00	97,00	11,80	0,63	0,15
SFL	5,97	4	8	1,21	0,46	-1,21
EnerM	1186,24	540,00	1779,00	281,92	0,03	-0,14
FSmin1p	109,38	75,00	139,00	15,49	0,07	-0,06
FSmax1p	166,17	117,00	193,00	18,31	-0,75	0,33
FSAv1p	144,28	97,00	167,00	17,36	-0,63	0,42
FSmin2p	104,72	78,00	148,00	15,43	0,42	0,81
FSmax2p	165,41	116,00	191,00	17,21	-0,90	1,04
FSAv2p	141,17	96,00	170,00	16,22	-0,54	0,71
FSAvM	141,52	97,00	164,00	15,50	-0,56	0,82

Ener1p	502,10	248,00	728,00	117,88	0,11	-0,43
Ener2p	511,48	262,00	788,00	111,47	0,41	0,41
REner1p	13,21	6,53	19,16	3,10	0,11	-0,43
REner2p	13,46	6,89	20,74	2,93	0,41	0,41

Legend: FSMAX – maximal heart frequency during laboratory testing, FSMING - minimal heart frequency during laboratory testing, SFL – subjective feeling of load, ENERM – energy consumption during match, FSMIN1P – minimum heart frequency during 1. period, FSMAX1P - maximal heart frequency during 1. period, FSAV1P - average heart frequency during 1. period, FSMIN2P – minimum heart frequency during 2. period, FSMAX2P - maximal heart frequency during 2. period, FSAV2P - average heart frequency during 2. period, FSAVM - average heart frequency during match, ENER1P - energy consumption during 1. period, ENER2P - energy consumption during 2. period, RENER1P – relative energy consumption during 1. period, RENER2P – relative energy consumption during 2. period

There are no statistically significant differences between variables maximum heart frequency during first and second half of handball match (Table 2.)

Table 2. T-test for independent samples for variables maximum heart frequency (FSmax) during 1. and 2. half of handball match

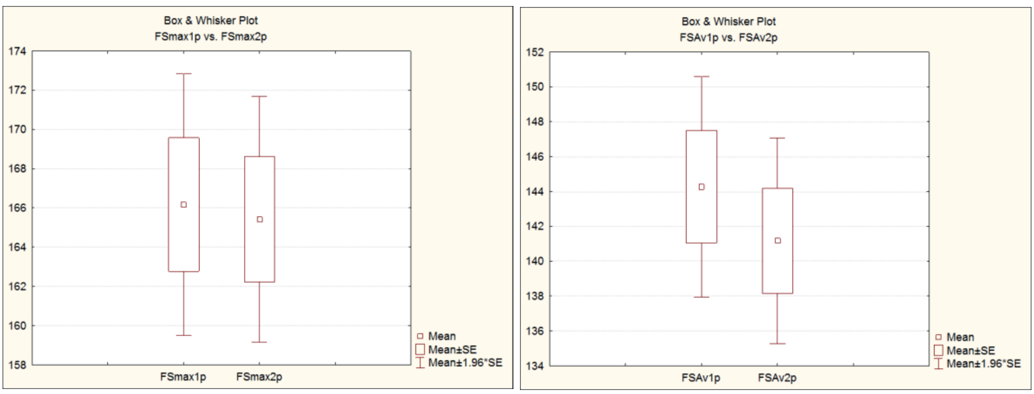
N = 32	Mean1	Mean2	t	df	p	St.Dev1	St.Dev2	F	p
FSmax 1P / 2P	166,17	165,41	0,16	56	0,87	18,31	17,21	1,13	0,75

No statistically significant differences were found between variables average heart frequency during first and second half of handball match (Table 3.)

Table 3. T-test for independent samples for variables average heart frequency (FSAv) during 1. and 2. half of handball match

N = 32	Mean1	Mean2	t	df	p	St.Dev1	St.Dev2	F	p
FSAv 1P / 2P	144,28	141,17	0,70	56	0,48	17,36	16,22	1,15	0,72

There are no statistically significant differences between variables energy consumption and relative energy consumption during first and second half of handball match (Table 4.)



Picture 1. and 2. – Dispersion of the results in the variable maximum heart rate (1.) and the average heart rate (2.) during the first and second half of the match

Table 4. T-test for independent samples for variables energy consumption and relative energy consumption (EnerM / RenerM) during 1. and 2. half of handball match

N = 32	Mean1	Mean2	t	df	p	St.Dev1	St.Dev2	F	p
EnerM P1 / P2	502,10	511,48	-0,31	56	0,76	117,88	111,47	1,12	0,77
RenerM P1 / P2	13,21	13,46	-0,31	56	0,76	3,10	2,93	1,12	0,77

Discussion

The aim of this research was to analyse differences in physiological loads of handball referees between halves of handball match. Results of study shows that handball referees are getting close or in some cases they are reaching their maximum heart rate from laboratory testing. Also, their minimum heart rate in match is way above their minimum frequency which was measured during testing. This data is confirming ascertainments from Titlebaum (2009) and Boyko (2007) and just shows referees are under big pressure during, before and after the match. Referees must be ready to endure psychic pressure (Mirjamali, 2012), especially in matches which are deciding outcome of knock out phase, competitions or similar important event.

On picture 1. and 2. there is a higher frequency of the heart, both the average maximum and the average heart rate during the game, between the two periods of the game. Higher frequency is visible in descriptive statistics also but performing t-test for independent samples (Table 2) shows there are no statistically significant differences in maximal heart frequency of handball referees during first and second half of handball match which is showing that referees are in same physiological load during both halves of match. Also, result of t-test for independent samples in variables for average heart frequency of referees during first and second half (Table 3.) show there are no statistically significant differences between halves. Referees are under same physical and psychological pressure during both halves of the match which means they need to be ready for both of those loads to prevent making mistakes in their decisions during high intensity in the match. This is particularly important because one bad decision can make a difference on outcome of the match. The more important the game is, the pressure is bigger and therefore the loads in the game are also bigger and the decisions of the referees can affect the final result of the matches and the competition (Unkelbach i Memmert, 2010; Chelly i sur., 2011; Estriga, 2011; Elsworthy, 2014; Caballero i sur., 2015; Brightmore i sur., 2016).

Estriga et al. (2013b) obtained an average of 900 to 1100 kilocalories during Portuguese Cup handball matches, which are similar values to this research (1186.24 ± 281.92 kilcalories). Reilly and Gregson (2006) measured 1337.53 kilocalories during football match. Rupčić (2010) measured consumption by basketball referees of 1271.19 ± 189.97 kilocalories. Given data in this research as well as in most other team sport researches energy consumption in a match of over 1,000 kilocalories can lead to conclusion that handball is a very intense activity for referees. Especially this can be concluded for handball referees where the total playing time of the match is much shorter than in football.

These data are interpreted for easier comparison of results with previous research but considering that not all respondents have the same body mass, it is considered that the relative value for energy consumption is better used. The relative value of energy consumption, namely consumption per kilogram of examinee during the matches of the Croatian Premier League in handball was 11.30 ± 2.60 kilocalories. The highest relative energy consumption during the game was 18.07 kilocalories per kilogram of examinee, while the lowest measured consumption was 5.07 kilocalories per kilogram

of examinee. Looking at results of t-test for independent samples in variables measuring energy consumption and relative energy consumption (Table 4.) there are no significant differences. Regarding physiological loads and results obtained in previous statistical analysis this result is in line with previous ascertainments in discussion.
Based on the results obtained in this study it can be concluded that handball referees are exposed to high physical and physiological loads during the match, which are not statistically significant looking at differences in halves in the match. The results of this study coincide with the results obtained in other studies on the physiological loads of referees during other team sports matches where no statistically significant differences were found between periods in the game (D'Ottavio and Castagna, 2001, Rupčić 2010)

Conclusion

Referees are a homogeneous group that have been selected by grades from supervisors for their referee performance, and elimination criteria on tests that must be met at official seminars in the early and mid-season to be competitive for referee a handball match. Taking this into consideration handball referees are physically prepared to follow the demands during games that are almost equal throughout the game and there is no significant difference between the halves of matches. Referees must be physically and mentally at the highest possible level throughout the match to make a perfectly time related and correct decision as close as possible to the event on the pitch which may change the outcome of the match or the course of the whole competition.

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Correlation between motor abilities of handball referees and quality of refereeing

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ABSTRACT
The aim of this study was to determine correlation of motor abilities and quality of refereeing in Croatian national and international handball referees.
Examinees were 32 handball referees from Premier Croatian Handball League. They are divided in pairs in which they are refereeing a match during their career. The list of Premier league handball referees is made every year according to previous performance by the professional committee of the Croatian Handball Referees Association.
Testing of handball referees was performed in two parts: the first part of the testing was performed at the Diagnostic Center of the Faculty of Kinesiology of the University of Zagreb. All examinees had protocol of warm up which lasted for 20 minutes and after warm up examinees conducted motor abilities testing in 5 different motor tests which measure agility, coordination and explosive sprint power. The second part of testing was performed on official Premier Croatian Handball League matches. With multiple regression test variables were tested to check if there is correlation of motor abilities (independent variables) and quality of refereeing (dependent variable) and the level of significance was set at $p < 0,05$.
In frontal agility test with 180 degrees turn a statistically significant negative correlation was obtained with quality of refereeing. Negative correlation explains that a lower result in the test (reverse scaled variable - lower value is a better result) means better quality of refereeing. In the motor test eights with bending, the results of multiple regression analysis show a statistically significant positive correlation with the quality of the refereeing
The scientific contribution of this research is reflected in the correlation of motor abilities and quality of refereeing, and in particular refers to frontal agility test with 180 degrees turn. Movement in the test also reflects the movements of referees during the handball match and it is recommendable that this test should be used in official handball referees tests during official seminars.

Key words: team handball, referees loads, motor abilities

Introduction

Handball is a sport dominated by speed, (specific) power, strength, change of course and direction, ability to repeat short maximum stimuli during the match and other high intensity actions (Marques, 2007, Chelly, 2011, Aguilar-Martínez 2012; Ghobadi, 2013; Corvino et al., 2014; Haugen et al., 2016) which enable advantage over opponent (Povoas, 2014). The ability to repeat these skills at the highest level during the match is very important for the quality of the game (Massuca, 2013) as well as for the final result, both for handball players and referees (Belcic, 2017).
To ensure that players will play swimmingly and will comply with pre-established rules of the international handball game, a game is managed, respectively refereed by two

equally important referees (International Handball Federation, 2016). They cooperate with time keeper and score keeper who are at official desk along with official supervisor of referees (delegate). Indirectly in the game management supervisor of referees participates also and at the end of the match evaluates and advises the referee pair. Jungebrand (2006) states that the most important predictive values for success in refereeing are psychological stability, fitness and condition-motor preparedness, ability to control the situation on the court, honesty and objectivity in decision-making, understanding of the game, nonverbal communication, ability to apply the acquired knowledge and ability to control stress.

Handball has evolved in recent decade significantly and time between the defense phase and attack phase is highly reduced, so the game is more dynamic and demands more (Sporis et al., 2014; Povoas et al., 2014) from players and referees. New trends in technical, tactical and physical development of handball game require new technical and motor skills and characteristics of referees. Modern handball requires from referees to be quicker, more dynamic, more agile in their movements, and to be as close as possible to the place of action, or to the place of situations which needs their action in type of decision making. Good positioning of handball referees is possible only if referee is mobile and physically fit for the physical requirements of game. Referees must maintain mental concentration and make decisions based on field situations in parts of a second (Reilly and Gregson, 2006).

Researches by multiple groups of authors (Harley et al., 1999; Castagna et al., 2007; Lategan, 2011; Mallo et al., 2012; Matković and Nedić, 2012; Luis 2015) have shown that the distance of referees from the rule violation is important for a proper decision. This decision is depending on the position on the court where the event occurred, time in the match when the decision was made and the physical preparation of the referees (Lategan, 2011; Birinci et al., 2014; Matković et al., 2014; Nazarudin et al., 2015; Pearce et al., 2015; Castillo et al., 2015; Mazaheri et al., 2016). On the other hand, large distance from the event that occurs in the part of handball match when physical ability (fatigue) is reduced increases the risk of wrong decision given that visibility is not clear enough (Rupčić, 2010, Mallo et al., 2012; Elsworthy, 2014). At the same time when referees adapt their selves to a good position on the court, it is very important to make the right decision (Mallo et al., 2012). Especially in these situations it is crucial that referees are motorically good prepared and that their motor skills are at a level that allows them to unquestionably meet all the demands of a modern handball game.

Motor skills determine the motor capacity of examinees / athletes (eg coordination, flexibility, explosive power, agility, etc.). Different modalities and training methods are used to develop motor skills and they are determined by motor skills tests (Jukić et al., 2008). The athlete's success is determined by a wide spectrum of motor skills, particularly in polystructural complex activity (sports) such as handball. Regarding these ascertainments, research will show if there is a correlation between the motor skills of handball referees with the quality of their refereeing.

Methods

Subjects

Examinees were 32 handball referees from Premier Croatian Handball League. They were divided in pairs in which they are refereeing a match during their career and like this they have attended testing for research purposes. The list of Premier league handball referees is made every year according to previous performance by the professional committee of the Croatian Handball Referees Association. Referees average age was 34.29 ± 6.20 years, height 184.20 ± 5.87 centimetres and body mass 91.25 ± 10.45 kilograms.

Procedure

Each subject provided a medical certificate confirming health-related readiness without any contraindications to referee a handball match and to conduct procedure of testing for this research. Testing of handball referees was performed in two parts: the first part of the testing was performed at the Diagnostic Center of the Faculty of Kinesiology of the University of Zagreb. All examinees had protocol of warm up which lasted for 20 minutes (dynamic stretching, basic running and running with change of speed, direction and intensity, static stretching). After warm up examinees conducted motor abilities testing in 5 different motor tests which measure agility, coordination and explosive sprint power. The second part of testing was performed on official Premier Croatian Handball League matches. Official delegate gave his evaluation of referees performance during match and this was considered as evaluation of referees quality.

Variables sample

In research there were 5 motor test which are best represents of the movements of handball referees. Lateral agility was tested with side step test. Agility and coordination was tested with frontal agility test with a turn (9-3-6-3-9 with 180-degree turn), eights with bending test and agility T-test. 20 meters sprint with split times on 5 meters and 10 meters was used to test of explosive power - sprint type. All tests are standard tests with valid metric characteristics of high reliability, validity, homogeneity and sensitivity used to assess the aforementioned motor space at the Diagnostic Center of the Faculty of Kinesiology at the University of Zagreb.

Table 1. List of variables with short name and measuring unit

Name of variable	Variable short name	Measuring unit
Side step	KUS	s
Frontal agility test with a 180º turn	93639OK	s
Eights with bending	OSS	s
Agility T-test	T-TEST	s
20m sprint with split time on 5m	5m SPRINT	s
20m sprint with split time on 10m	10m SPRINT	s
20m sprint	20m SPRINT	s

Criterion variable is evaluation (grade) of referees success during match. In remainder of this article variable will be called quality of refereeing. Quality of refereeing is average evaluation of all grades received by supervisors during season. This is ratio between sum of all grades during season with number of matches during a season.

$$\textbf{Quality of refereeing} = \frac{\text{Sum of all grades in season}}{\text{Number of matches in season}}$$

The “refereeing report” is the supervision conducted during the entire handball match by the official supervisor. In the report, match supervisor, who is an expert in refereeing due to long-term refereeing experience (must be former referee), and supervisory experience, records the overall situation on the handball court. There are 14 elements in the report which are evaluating referees performance during match: progressive punishment, penalty shot, offensive foul, play on goalkeeper line, rule enforcement, steps, passive play, improper goal, advantage, personality, game understanding and game management, signalization (body language), positioning and movement, as well as collaboration with the official desk. Supervisors give grades to referees according to number of mistakes. Grades can be --, -, 0, +, ++, +++ (2 minuses, 1 minus, zero, 1 plus, 2 pluses and 3 pluses), each of which has a separate meaning. At the end grades are summed up and the maximum number of points is 100.

Data Analysis

The statistical software Statistica (version 8) was used for the statistical analysis. Central and dispersion parameters, arithmetic mean (Mean) and standard deviation (SD) were calculated for five motor tests. Kolmogorov-Smirnov's test was performed to check normality of distribution and the maximum deviation of the empirical and theoretical relative cumulative frequency (Max D). Correlation of motor abilities (independent variables) and quality of refereeing (dependent variable) was tested with multiple regression analysis test and the level of significance was set at $p < 0,05$.

Results

The results obtained in the selected motor tests are reversed scaled, meaning that the lower value gives a better result. The arithmetic mean, the minimum and the maximum value are expressed in the standardized unit of time - seconds.

Table 2. Descriptive statistical parameters of motor abilities

N = 32	Mean	MIN	MAX	SD	SKEW	KURT	MAX D
KUS	8,78	7,53	11,14	0,74	1,04	2,31	0,10
93639OK	8,91	7,49	11,33	0,84	1,20	1,78	0,14
OSS	19,16	16,73	23,59	1,56	0,95	1,23	0,09
T-TEST	9,28	7,71	11,87	0,80	1,14	3,19	0,16
5m SPRINT	1,61	1,31	1,86	0,16	-0,21	-0,96	0,09
10m SPRINT	2,42	1,98	2,81	0,22	-0,15	-0,36	0,08
20m SPRINT	3,87	3,40	4,79	0,29	1,23	2,82	0,20

Legend: KUS – side steps; 93639OK – frontal agility test with a 180° turn; OSS – eights with bending; T-TEST – agility t-test; 5m SPRINT – sprint on 20m with split time on 5m; 10m SPRINT – sprint on 20m with split time on 10m; 20m SPRINT – sprint on 20m

The correlation of the selected motor abilities and criterion variable quality of refereeing was tested by multiple regression analysis. In the implemented regression model, the dependent variable is quality of refereeing and the independent variables are the variables which represent the selected motor abilities.

Table 3. Results of regression analysis - the influence of the motor skills on quality of refereeing

Overview of the regression analysis for the dependent variable quality of refereeing: $R = 0,81$ / $R^2 = 0,66$ / Adjusted $R^2 = 0,55$ / $F(7,21) = 5,93$ / $p < 0,001$ / Standard error = 2,60

N = 31	Beta	Std.Err. of B	B	Std.Err. of B	t (21)	p-level
Intercept			**60,84**	**7,47**	**8,14**	**0,0001***
KUS	-0,25	0,24	-1,31	1,25	-1,05	0,307
93639OK	**-0,57**	**0,19**	**-2,62**	**0,90**	**-2,92**	**0,008***
OSS	**0,79**	**0,22**	**1,97**	**0,54**	**3,64**	**0,002***
T-TEST	-0,41	0,32	-1,98	1,56	-1,27	0,218
5m SPRINT	-0,11	0,51	-2,62	12,42	-0,21	0,835
10m SPRINT	0,79	0,50	14,13	8,97	1,58	0,130
20m SPRINT	-0,16	0,15	-1,27	1,24	-1,02	0,320

Legend: KUS – side steps; 93639OK – frontal agility test with a 180° turn; OSS – eights with bending; T-TEST – agility t-test; 5m SPRINT – sprint on 20m with split time on 5m; 10m SPRINT – sprint on 20m with split time on 10m; 20m SPRINT – sprint on 20m; R – multiple correlation; R – multiple regression determination coefficient; F – value of testing variables significance; p – the level of significance of the coefficient of multiple correlation; Beta – standardized regression coefficient; Std.Err. of B – standard error of standardized regression coefficients; B – non-standardized regression coefficients; Std. Err. of B – standard error of non-standardized regression coefficients; t – the value of degrees of freedom when testing the significance of the regression coefficients; p – the level of significance

In Table 3. a multiple correlation coefficient of 0.81 was obtained, while the coefficient of determination of 0.66 and the adjusted coefficient of determination was 0.55 with the significance p less than 0.001. The standard error prognosis is 2.60.

Discussion

The aim of this study was to analyse correlation of motor abilities and quality of refereeing in Croatian national and international handball referees. In results of multiple regression analysis where the correlation between the better motor abilities and the better quality of refereeing was tested, the regression analysis is significant (R2 = 0.66 with the $p < 0.00$). A more detailed overview of the standardized regression coefficients shows that the differences are most influenced by test eights with bending and frontal agility test with 180 degrees turn, since both standardized regression coefficients are statistically significant. In frontal agility test with 180 degrees turn a statistically significant negative correlation was obtained with quality of refereeing. Negative correlation explains that a lower result in the test (reverse scaled variable - lower value is a better result) means better quality of refereeing. Regarding the movement of two equally important referees the confirmation of the statistically significant correlation of the frontal agility test with 180 degrees turn and quality of refereeing is logical. Movement in this test is extremely similar to the movements of referees in the field. At the start of the attack on one of the teams, one referee stands in front of the centre line of the court, about half the distance between the side boundary of the court and the imaginary line passing through the entire field right through the middle of the goal. Referee according to the instructions of the referee commissions and mentors, should never passive in one place of the field, but should move and seek the best angle for a better and clearer overview of the game. This is especially important considering that too big distance from the event that occurs in the part of handball match when physical ability (fatigue) is reduced increases the risk of wrong decision given that visibility is not clear enough (Rupčić, 2010; Mallo et al., 2012; Elsworthy, 2014;).

When referees adjust to a good position in the field, it is extremely important to make the right decision (Mallo et al., 2012), and the chances of good judgement of situation and good decision are much higher when the referee has a good overview of the game at any time of the match. Well-developed motor abilities will make it easier for the referee to position himself and raise the quality of the refereeing, knowing that a shorter distance from the action will result in a larger number of properly awarded decisions (Nazarudin, 2015). It is assumed that referees with poor fitness and motor abilities will have problems to come to high-quality positions during matches (Rupčić, 2010). Movement in frontal agility test with 180 degrees turn can be more closely visualized by movement of referees in two fast counterattacks. After a turnover in the attack of one of the teams, first referee who is standing behind goal line sprints to the opposite side of the court and tries to be in front of the player to have the best possible view of counterattack, knowing that the counterattack is the main determining factor for success in the same level handball teams (Gutierrez and Lopez, 2011) This is particularly important taking into consideration the fact that the position of shooting on goal in counterattack is the most efficient in handball with 88.23% success (Alexandru and Alexandru, 2009). When attacker misses a shot with off target shot or goalkeeper makes a save or some other scenario which leads to opposite counter attack, referee runs until the defending team moves into a new counterattack and makes completely identical stop and turn as in frontal agility test with 180 degrees turn and heads in another sprint to the opposite side of the court. Second referee stands behind the goal line at crossing of the 6 meters line and the goal line but stands opposite in the court in relation to his colleague. His movement is mostly left-to-right with effect of sunflower to the ball movement. Occasionally referee makes very short entry into the goalkeeper area to have a good view on the opposite side of goalkeeper area (most commonly in jump shots that are performed by wing players) when his view is blocked by a goalkeeper or a goal with a net. After the end of an attack the referee who was in the firstly explained position sprints (never turning his back to the players) to the opposite side of the playing court where he takes the same position as his colleague was on the opposite side of the court behind goalkeeper line. With this explanation, it is clear that referees move with similar movement structures as in the frontal agility test with 180 degrees turn.

In the motor test eights with bending, the results of multiple regression analysis show a statistically significant positive correlation with the quality of the refereeing. When looking at the results, this was not the expected correlation, but a negative correlation was expected, since the variable eights with bending was reversed scaled. The contradictory result is explained by the fact that referees who are the best in quality of refereeing are the the oldest and most experienced referees (statistically significant correlations in the assessment of quality of refereeing and refereeing experience (Belcic, 2017)). Older referees have reduced motor abilities as those abilities are decreasing with age and this has negative effect for success of this test. When the top three referees (according to quality of refereeing) are excluded from the results, this test is no longer statistically significant and this confirms explained thesis.

In motor test side steps and 20 meters sprint with split times on 5 meters and 10 meters there was no statistically significant correlation with the quality of refereeing. Agility T-test has also no statistically significant correlation with quality of refereeing, but it is worth to mention that correlation is high. The agility T-test is very similar to the way referees moves when they take position (not in the same speed as in test) during the attack phase of one of the teams and this hence results in high correlation, although not statistically significant.

Conclusion

Referees are selected by their grades (quality of refereeing) from supervisors for their performance during season and elimination criteria on tests which must be completed with success at official seminars in pre-season and mid-season to be competitive to referee a handball match in highest level of competition. Motor abilities have very important part in quality of refereeing. Especially this is reflected on good positioning during match which is allowing referees to be as close as possible to the action on the court which demands their decision. Correct decision is important and it is connected with distance to the event which has to be judged by referees and good motor abilities increase certainty of good decision. Regarding this, scientific contribution of research is reflected in the correlation of motor abilities and quality of refereeing, and in particular refers to frontal agility test with 180 degrees turn. Movement in the test also reflects the movements of referees during the handball match and it is recommendable that this test should be used in official handball referees tests during official seminars, along with other fitness tests because the test makes difference between examinees.

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Differences in time spent in the anaerobic zone between incremental treadmill test and incremental kettlebell swinging test

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ABSTRACT
Diagnostic procedures comprise numerous methods to evaluate aerobic and the anaerobic capacity. Many studies have been conducted with the aim of establishing an adequate protocol for evaluating functional capacities (Myers et al., 2000). Some studies show that kettlebell may have impact on cardiorespiratory system (Farrar et al., 2010, Fallatic et al. 2015). Stimulate the already mentioned and similar works Šentija et al. (2017) constructed new protocol for evaluating functional capacity. The main goal of this study was to determine does this newly designed protocol, incremental kettlebell swinging test – IKT, can use for determination of anaerobic capacity.
The study group consisted of 2 females and 8 male healthy subjects (age=24,27±2,17; height=181,32±9,29; weight=78,73±12,73). Measurements were carried out at the Faculty of Kinesiology, University of Zagreb. The duration of anaerobic zone was measured in Incremental treadmill test (tAn-ITT (s)) and incremental kettlebell swinging test (tAn-ITT (s)). For statistical analysis we used Correlation ($p<0,05$) in software package Statistica for Windows 12.0.
We found there are mild negative correlation between variables tAn-ITT and tAn-IKT ($r=-0,42$ $p>0,05$). Considering achieved values average spent time in anaerobic zone in ITT was 255,00±32,40 sec and in IKT was 129,00±54,86 sec.
This differences in time spent in the anaerobic zone between ITT and IKT protocol most likely emerged because in ITT protocol cardio-respiratory endurance play a dominant role while in IKT protocol power endurance comes to the fore. The male subject that have more muscle mass had better results in IKT, while females and male subject with less muscle mass had worse results. These results show us that power endurance has an impact on anaerobic capacity in activities that include external load. For more accurate conclusion it is necessary to do further research's with incremental kettlebell swinging test.

Key words: cardio-respiratory, endurance, power

Introduction

Proper diagnostic allows a coach to do a proper periodization of trainings. The basics of diagnostic is determination of functional capacity (aerobic and anaerobic). Diagnostic procedures comprise numerous methods to evaluate aerobic and the anaerobic capacity (Vučetić, 2009). Many studies have been conducted with the aim of establishing an adequate protocol for evaluating functional capacities (Myers et al., 2000). Many protocols such as incremental treadmill test aim to determine aerobic capacity of athlete. However, it is also important to determine anaerobic capacity, since in many sports, anaerobic capacity plays a major role in success. As the determination of anaerobic

capacity is still quite vague, further research is needed (Vandewalle et.al., 1987; Green and Dawson, 1993).
Some studies show that kettlebell may have impact on cardiorespiratory system (Farrar et al., 2010, Fallatic et al. 2015). Their researches indicate that training with kettlebell have an impact on VO_{2max}. Stimulate the already mentioned and similar works Šentija et al. (2017) constructed new protocol, incremental kettlebell swinging test (IKT), for evaluating functional capacity and compared it with standard incremental treadmill test. Results shows that IKT has benefits and practical application. Dajaković (2017) has further investigated the impact of IKT on functional capacity. The results also show that IKT can be a great test for evaluation of ventilation and metabolic parameters.
the main objective of this research, triggered by the above-mentioned researches, was to determine does this newly designed protocol, incremental kettlebell swinging test – IKT, can use for determination of anaerobic capacity.

Methods

Subjects
The study group consisted of 2 females and 8 male healthy subjects (age=24,27±2,17; height=181,32±9,29; weight=78,73±12,73). Measurements were carried out at the Faculty of Kinesiology, University of Zagreb. The duration of anaerobic zone was measured in Incremental treadmill test (tAn-ITT (s)) and incremental kettlebell swinging test (tAn-IKT (s)). All subjects were familiar with both tests.

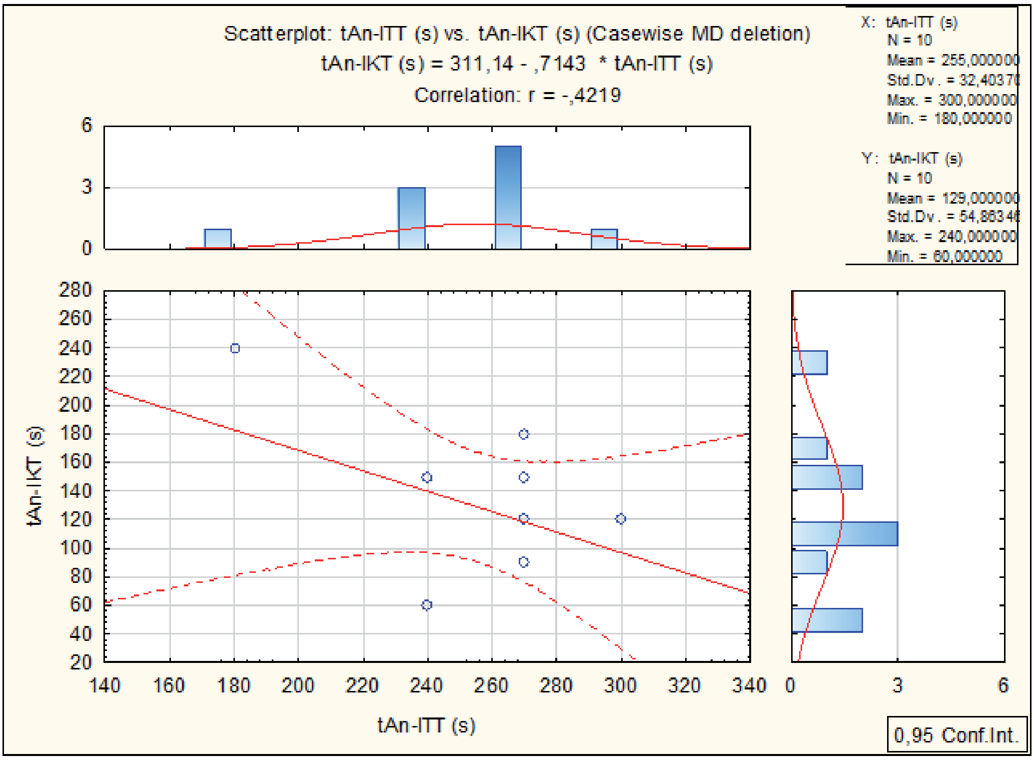
Testing procedure
The study was carried out within two weeks, with each subject completing both tests. The IKT protocol starts with one-minute resting followed by warm – up consisting of 30 imitations of swing. After 30 seconds begins the main part of the protocol testing. Each stage lasts for 30 seconds, without rest, with a starting load of 4 kg kettlebell and increasing the load (kettlebell weight) for 2 kg (4, 6, 8, 10, etc.) with each successive stage. The task was to swing at maximal speed, to do as many swings as possible in every stage. The test ended when the subject could not perform further swings for any reason. In the ITT test, a standard protocol for assessing aerobic and anaerobic fitness was carried out. A warm-up consisted of walking at a speed of 3 km/h at 1% incline for 2 minutes. After warm-up the subject accelerates every 30 seconds for 0.5 km/h continuously until exhaustion (Šentija et.al., 2017).

Variables
Two variables were used in this study, time spent in anaerobic zone in ITT (tAn-ITT (s)) and time spent in anaerobic zone in IKT (tAn-IKT (s)). The anaerobic zone was measured from heart rate deflection point to the end of the test.

Statistical analysis
Statistica for Windows 10.0 and Microsoft Office Excel 2016 were used for storage and statistical analysis of the results. Pearson's correlation coefficient was used to determine correlation between variables. The difference in statistical significance was set at $p < 0.05$.

Results

Results of descriptive parameters and correlation are shown in graph 1.



Graph 1. Descriptive statistic and correlation

Table 1. Results of the subject achieved in the tests IKT and ITT

Subjects	MASSant(kg)	MASSpeak (kg)	tAn-IKT (s)	Vant (km/h)	Vmax (km/h)	tAn-ITT (s)
1	18	20	60	12,5	16	240
2	24	28	90	15,5	19,5	270
3	18	24	120	12,5	16,5	270
4	24	32	150	12,5	16	240
5	16	30	240	13,5	16	180
6	26	32	120	13	17	270
7	12	18	120	10,5	15	300
8	16	26	180	13	17	270
9	12	20	150	11	15	270
10	20	22	60	12,5	16	240

MASSant (kg):kettlebell mass at anaerobic treshold (IKT);
MASSpeak(kg):maximal achived kettlebell mass (IKT);
Vant (km/h): speed at anaerobic treshold (ITT);
Vmax (km/h): maximal achived speed in ITT

Discussion

We found there are mild negative correlation between variables tAn-ITT and tAn-IKT ($r=-0,42$ $p>0,05$). Considering achieved values average spent time in anaerobic zone in ITT was 255,00±32,40 sec and in IKT was 129,00±54,86 sec. This differences in time spent in the anaerobic zone between ITT and IKT protocol most likely emerged because in ITT protocol cardio-respiratory endurance play a dominant role while in IKT protocol power endurance comes to the fore. The male subject that have more muscle mass had better results in IKT, while females and male subject with less muscle mass had worse results. In Table 1. we can see results that subjects achieved in IKT and ITT. We can see that subjects who cross anaerobic threshold at higher kettlebell weights have shorter duration in anaerobic zone. Due to the involvement of smaller motor units, local muscular fatigue is coming (Dajaković, 2017), which is perhaps the reason why the subjects who cross the anaerobic threshold at higher kettlebell weights have shorter duration in anaerobic zone. It is important to mention that all subjects end the test due to local muscle fatigue rather than cardio-respiratory fatigue (Dajaković, 2017). Therefore, it is to be assumed that subjects that cross anaerobic threshold at higher kettlebell weights cannot reach their maximum in the anaerobic zone and therefore the values in IKT are slightly lower than ITTs. These results show us that power endurance has an impact on anaerobic capacity in activities that include external load.

Conclusion

Applying the achievements of modern sports science and modern diagnostic procedures for athlete training analysis can provide us with accurate and reliable information on the current level of aerobic and anaerobic energy capacity of athletes. These findings, differences in time spent in the anaerobic zone between ITT and IKT protocol, can help to understand that different stimulus on human body have different outcomes. The external load that the respondents use in IKT, in addition to affecting the cardio-respiratory system, also has a major impact on muscle fatigue. If we compare ITT and IKT we can see that in ITT protocol cardio-respiratory endurance play a dominant role while in IKT protocol power endurance comes to the fore (Layec et.al. 2008). The male subject that have more muscle mass had better results in IKT, while females and male subject with less muscle mass had worse results (Hicks et.al. 2001). These results show us that power endurance has an impact on anaerobic capacity in activities that include external load.

Kettlebell is a very popular tool with great benefits for human body but to what exactly and how much it affects the human body is still insufficiently explored. Studies like this can help coaches, scientists and athletes to better understand how kettlebell impact on human body. For more accurate conclusion it is necessary to do further researches with incremental kettlebell swinging test.

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Ambidexterity of discrete motor skill through bilateral learning process

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ABSTRACT
The goal of the study was to analyze one discrete motor skill learning processes. In accordance with the goal, N=36 male students underwent controlled cartwheel learning process and were measured through initial, transitive, final and retention measurement point. By using 4×2 ANOVA, differences in the learning dynamics of skills through the learning processes were identified. The coefficient of asymmetry revealed equality in skills levels in the initial and in the retention point of measurement, confirming the existence of bilateral transfer within those skills. The obtained results confirm positive effects of the appliance of the bilateral learning process and authors suggest its appliance with the aim of overcoming different restricting factors during the learning/ training process (when improve skills performance, apply conditional training, overcome "plateau" phases, maintain functions of an injured limb, provide morphologically symmetrical growth of athletes ect).

Key words: cartwheel, dominant and non-dominant side of the performance, coefficient of asymmetry

Introduction
Every human movement is the result of a neuromuscular integrated brain and body controlled process (Voight, Hoogenboom, & Preventice, 2007). This process is termed motor learning process and refer to the relatively permanent gains in motor skill capability associated with practice or experience (Schimidt & Lee, 2011). Because motor learning process can not be seen directly, it is evaluated on the basis of motor performance - an end result or outcome of executing a motor skill that can be observed from an external perspective. Methods used to evaluate learning process are *acquisition* (refers to a direct measurement and recording of observed performances during a certain period, usually in certain points during the process of learning), *retention test* (refers to performance measurements conducted after a certain period in which there was no performance of an acquired skill) and *transfer test* (refers on influence of learning one skill on the performance of another skill; Schmidt & Lee, 2011).
Transfer of learning is one of the most frequently applied principles in education and rehabilitation, used to teach a highly adaptive motor skill, especially referring to bilateral transfer of learning or training. Bilateral transfer can be explained as a phenomenon of practicing a new task with one limb which then typically facilitates subsequent learning and performance of the same task with the opposite, untrained limb (Land et al., 2016). Bilateral transfer may result in saving of practice time, better understanding of the skill learned, shed light on whether and/or how transfer occurs in learning the complex movements that characterize most sports skills, and whether and/or how transfer can be enhanced by practicing and training (Ziheng & Faro, 2004). The same authors state that understanding of bilateral transfer within the learning process of motor skills would enhance the teaching effectiveness of sport-specific skills.

Artistic gymnastics skills, according to how well the beginning and end of the skill is defined belong to a group of discrete skills (skills of brief duration, with a clear, definite and identifiable beginning and end; Schmidt & Lee, 2011). Some of those skills can be/are performed with rotation around the longitudinal axis of the body. Such skills, realistically, is possible to learn and perform with rotation around the right and left side of the body, that is bilaterally. However, generally, there are several reasons why bilateral performance of gymnastic skills is not usually practiced at all: lack of time, "loss of perception" that gymnasts undergo when learning longitudinal rotations around both sides of the body (Arkaiev & Suchilin, 2004), (non)ability of a coach to assist gymnasts while performing the same skill with the non-dominant hand (Lenoir, Van Overschelde, De Rycke, & Musch, 2006). In accordance with the above-mentioned facts, it is considered that the unilaterality (functional ability to dominate with one part of the body against the other in performance of a particular motor skill) prevails in learning processes, and thus in performance of gymnastic motor skills.

Ability to equally well use the left and the right side of the body in motor performance is termed ambidexterity (Oxford dictionary). It does not specify whether the left and the right hand are equally adept at performing all tasks or are they interchangeable, ambidexterity just presents equality of bilateral skill performance. Corballis (2009) estimated that only 1% of the world population is innately ambidextrous, meaning their brain hemispheres are lateralized — symmetrical. Everyone else who is not strictly right-handed is cross-hand dominant or even mixed-handed to some degree (Price, 2009). Ninety percent of people are right-handed, 80% right-foot, 70% right-eyed, about 60% are right-eared (Saudino & Mc Manus,1998), about 35% of right-handers and 57% of left-handers are left-eye dominant (McManus, Porac, Bryden, & Boucher, 1999).

Among humans, particularly in sports, there is a tendency among athletes to preferentially use one side of the the body to perform a motor action. This tendency characterizes the lateral preference which appears to influence subsequent performance asymmetries (McCartney & Hepper, 1999). Carpes, Mota and Faria (2010) cite different studies that used different procedures to quantify asymmetrie (measurement of asymmetry indexes, left to right ratios or statistical procedures).

Based on previous facts the aims of the study have been set: 1) to determine the dynamics and quality of the bilateral learning process; 2) to identify dynamics of the coefficient of asymmetry under the influence of an eight-week learning process.

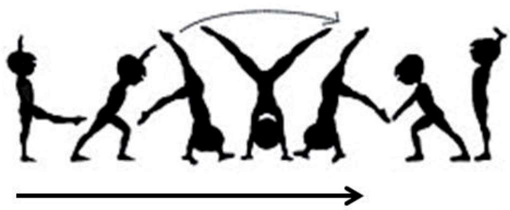
Methods

Subjects

The sample included 36 second-year-pre-graduate male students (19.65±1.49 years) who had no previous experience in artistic gymnastics. Three students were eliminated from the learning process due to health issues or similar causes. A total of 33 students executed all exercises. All participants volunteered to this research and were completely informed on the goal of the study. The research was entirely done in accordance with the declaration of Helsinki and was approved by the institutional ethics committee.

Variables

For the needs of this study, level of a *cartwheel* from a front position has been analyzed. Its performance starts with a lunge, so the leading leg (the stronger leg) is in a front position and the weaker leg in the back position. During the lunge, a gymnast holds the arms high and straight in the air, holding the hips tight, facing forward. The gymnast then pushes off with the front leg and brings the hands side by side on the ground, in front of the body. While performing the movement, the gymnast swings the legs up and over the torso and head as the body becomes inverted. During the rotation, straight legs with pointed toes and feet stay apart in a large, wide straddle. After passing through the straddle handstand the gymnast sets the first foot on the ground, followed by the second foot, followed by pushing with hands from the floor and then landing in a lunge with the weaker leg in front and the leading leg in back. The gymnast lands facing the opposite direction from the one they started from, holding hands and arms straight and high.



Picture 1. Cartwheel

Because this is a skill during which performance it is possible to rotate around the longitudinal axis of the body, to the left and to the right side of the body, at this point, it is important to emphasize how in this study the *cartwheel left* (CL) has implied the performance of *cartwheel* with the left leg as the leading leg while *cartwheel right* (CR) implied the performance of *cartwheel* with right leg as lead leg. All performances of CL and CR were recorded with a digital video camera (Canon, XA30, 20×Optical Zoom), and were judged by 6 experienced gymnastics judges. Criteria for judging were done according to Women Artistic Gymnastics Code of Points Table of General Faults and Penalties (WAG CoP, 2016) prescribed by International Gymnastics Federation (FIG). Accordingly, performance without any technical and/or aesthetical flaws was for grade 5, performance with some small technical and/or aesthetical flaws was for grade 4, performance with some middle technical and/or aesthetical flaws was for grade 3, performance with big technical and/or aesthetical flaws was for grade 2 while inability to perform skill was for grade 1. About defined rating criteria judges were taught in previously organized court training.

Experimental procedure

Participants underwent experiment for 8 weeks (2 times 90 minutes per week) under the supervision of the same experienced teacher. Each class of experimental treatment was conducted in the same gym, on the temperature of 21-23°C, in morning hours. Each class was starting with 30 minutes of warm-up: 10 minutes of running with different tasks and 20 minutes of the performance of stability skills that mostly included stretching. Warm up was followed by 20 performances of CL and with 20 performances of CR. Before the performance, students were verbally encouraged by a teacher to perform. After performing *cartwheel* particular students obtain feedback, while general descriptive and prescriptive feedback was given after all participants did the task. Recording of the levels of both skills (CL and CR) was conducted at four time points: 1) first recording (initial point – I) was taken in the first week of the learning process; 2) second recording (transitive point – T) was taken in the fourth week of the learning process (eight training lesson of those skills); 3) third recording (final point – F) was taken in the eighth week of the learning process (during the last lesson of the training); 4) fourth recording (retention point – R) was taken twenty days after the third recording. While recording, each student performed each skill only once. No feedback was provided during recording. Evaluation of the recorded performances was done at the end of the experimental procedure.

Statistical Analysis

All data has been reported as Mean±standard deviation (SD). Kolmogorov Smirnov test was applied for examination of variable's deviation from a normal distribution. For this research, the relationship between performance of the cartwheel in the right and in left side of the body is defined by an equation for coefficient of asymmetry (AS)

$$AS = \frac{D - ND}{D} \cdot 100$$

where D presents the score achieved by the dominant side of the body, ND refers to the score achieved by the non - dominant side of the body (Božanić & Miletić, 2011).

The dominant side of the body was determined based on the student's scores gained at every measurement point and coefficient of asymmetry was calculated (Božanić & Miletić, 2011). Reliability was assessed through both inter-item correlation (IIR) and Cronbach Alpha coefficient (Cα). Additionally, due to the fact that each subject was measured by each of six raters, all of them taken from a wider population of raters, while the final score was the average score of raters, the coefficient of Intra Class Correlation (ICC(2,6)) was calculated. Construct validity of measurements was examined by using factor analysis, through the percentage of total variance accounted by the (single) extracted factor (ExplVar) in each evaluation point for both sides of the body.

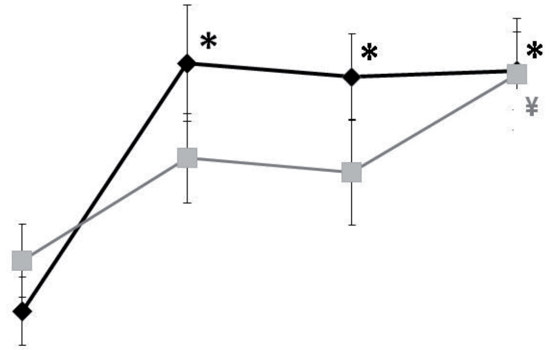
All data have been checked for univariate outliers. Due to significance identification of within-subjects factor *Treatment* (initial measurement point (I), transitive measurement point (T), final measurement point (F) and retention point (R)) and within subjects factor *Side* (Left and Right) on all observed variables segmental and in total 2-way 4×2 ANOVA with repeated measurements on both factors was applied. Within-subjects one way ANOVA was applied for identification of significance of mean differences in coefficient of asymmetry between measurement points. Degrees of freedom were Greenhouse-Geisser corrected and correction parameter (ε) was presented if the assumption of sphericity of within-subjects factor was violated. Bonferroni correction was used to identify particular significant differences. Partial eta squared (partial η^2) was used for effect size assessment. The effect size of 0.1 or less has been interpreted as trivial, between 0.1 and 0.5 as moderate and greater than 0.5 as large.

Type one error was set at α=5%. For statistical analysis and graphical presentations of the obtained data, we used software systems Statistica for Windows (version 13.2., Dell Inc., Tulsa, OK, USA) and Microsoft Excel (versions of Microsoft Corporation, Redmond, WA, USA), respectively.

Results

Reliability was found to be satisfactory for both skills. Regarding CL, IIR ranged from 0.79 to 0.88, Cα ranged from 0.90 to 0.95 through four measurement points. Similarly, regarding CR, IIR ranged from 0.72 to 0.86, Cα ranged from 0.88 to 0.95. Similarly, ICC(2,6) ranged from 0.77 to 0.90 and from 0.82 to 0.91 for left and right side respectively. Construct validity of 6 judges appeared to be appropriate with ExplVar in single-factor structure ranged from 73% to 89% and from 72% to 82% for CL and CR, respectively.

Dynamics of improvement of the left and right sided performance analysed through scores achieved in initial, transitive, final and retention measuring point for CR and CL is shown in Figure 1.

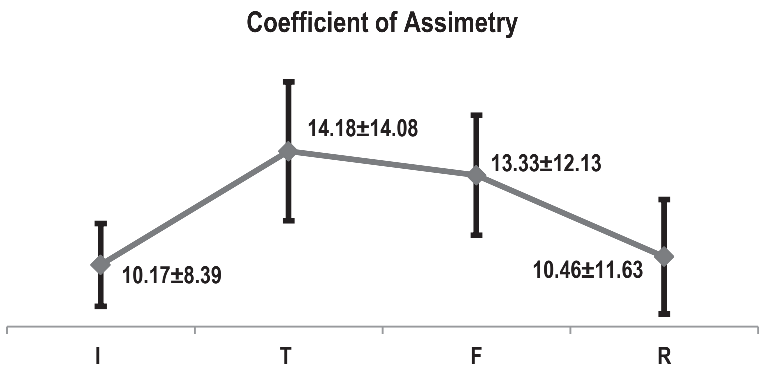


	I	T	F	R
RIGHT	2.89±0.49	3.52±0.84	3.48±0.61	3.50±0.57
LEFT	3.01±0.53	3.28±0.65	3.24±0.77	3.49±0.81

Legend: I – initial measurement, T – transitive measurement, F – final measurement, R – retention measurement, * - significantly different from the initial point of measurement of CR, ¥ - significantly different from the initial point of measurement of CL

Figure 1. Dynamics of the bilateral learning process of cartwheel

Regarding overall results which relate on the side performance improvement, the main effect of factor *Treatment* appeared to be significant ($F_{3,96}$=17.019; p<0.001; η^2=0.347), while the main effect of factor *Side* was found not to be significant ($F_{3,96}$=2.174; p=0.150; η^2=0.064). Interaction effect *Treatment×Side* appeared to be significant ($F_{1.961,62.737}$=4.155; p=0.021; η^2=0.115; ε=0.654). Bonferroni correction revealed no significant differences between CR and CL in all measurement points. Regarding CR, significant differences were identified when the initial measurement was compared to all others (I-T, I-F, I-R). Regarding CL, significant differences were identified only when the initial measurement was compared to the retention one (I-R).
Dynamics of changes of the coefficient of asymmetry, through the learning process and retention phase, is shown in Figure 2.



Legend: I – initial measurement, T – transitive measurement, F – final measurement, R – retention measurement

Figure 2. Dynamics of the coefficient of asymmetry during the learning process

One way-within subjects ANOVA revealed that main effect of treatment had no significant effect ($F_{3,96}$=1.338; p=0.267; η^2=0.040) on the coefficient of asymmetry. Furthermore, Bonferroni correction did not identify any particular difference as significant.

Discussion

Despite different dynamics of bilateral learning processes of CL and CR, their final adoption level in the analysed period has reached the same numerical level, and, it is assumed, the same motor level of adoption.

The results for CL in the initial point indicate that at this point the CL was dominant if compared with CR. Since the subjects were students without any previous experience in the performance of this skill, what also confirms the results obtained by Živčić Marković, Sporiš and Čavar (2011) on student's unfamiliarity with cartwheel during primary and secondary education, the reason for this kind of results can probably be found in student's intuition that a new skill (*cartwheel*) will be performed better on a side of their lateral preference, that is on the side which they consider to be their lateral preference (Serrien, Ivry, & Swinnen, 2006).

Since we did not ask students about their hand and foot preference, in clarifying the obtained results we rely on the to the results of previous research according to which the population is predominantly right-handed (about 90% of the human population uses the right hand for most skill activities; Scharoun & Bryden, 2014) and 80% right-footed (Saudino & Mc Manus, 1998). Relying on these results, it is likely that these respondents considered how swinging with the dominant leg (right leg) and pushing from the floor (after the passage through the straddle handstand, which represents the key point of performance and greatly influences the overall rate) firstly with the dominant arm (right arm) will make the performance of the new skill easier. The same probably caused a lower level of fear, and ultimately produced a somewhat higher average rate for CL compared to CR in the initial point. However, generally, during the performance of the cartwheel from the front position, stronger leg should be front leg and pushing from the floor should be with both arms together. Therefore, right leg (if it is dominant/stronger one) should be front leg and right arm (which is probably dominant/stronger) needs to be placed first on the floor and push a bit stronger that the arm which is placed second on the floor. This fact, that is that a performance of CR is actually a dominant performance, students probably (unconsciously) became aware already in the second point since CR and CL average values changed the domination position (CR values were higher than CL values).

From the transitional to the final point, although there was a supervised and directed process of adoption and improvement of CR and CL, numerical increase in average values was not recorded; on the contrary, a certain decrease in average values of both cartwheels was determined. While the obtained results can be relatively disappointing for those who teach, it confirms the certain legitimacy of the process of learning discrete motor skills (group including artistic gymnastics skills; Delaš Kalinski, Jelaska, & Knežević, 2017). Independently from the complexity of such skills, the process of learning such skills is long-lasting (Erceg, Delaš Kalinski, & Milić, 2014), and during which shorter and/or longer time lags (so-called "plateau") occur, characterized by invisible advances in the performance of a skill that is being taught (Schmidt & Lee, 2011). Accordingly, increasing the level of some motor skills in the learning process is not continuous (Schmidt & Wrisberg, 2008; Magill, 2011).

If the experimental process was completed in the final point of the experimental procedure the general conclusion would be that students adopted CR somewhat better than the CL. However, by analysing the level of CR and CL in the retention point, somewhat different conclusions are underlined. Namely, the obtained results show that in the time period from the final to the retention point, the CR level has not been changed, while the CL has experienced a numerical increase (equalization with the level of CR). For CR can be concluded that in the analysed period remained in "plateau" phase, likely due to certain cognitive and motor restraining factors that probably could not be overcome in the period of three weeks of practicing. Assimilation of the levels of non-dominant and dominant performance confirm statements of Ziheng and Faro (2004) according to who during the learning process, bilateral transfer of performance errors occurs in both directions, from the preferred to the non-preferred limb and vice versa. Accordingly, it can be assumed how there was a transfer of performance errors from CL (non-dominant performance) to CR (dominant performance), while transfer of motor components of performance (velocity and acceleration) appeared from CR to CL; all in accordance with the results of previous research (Teixeira, 2000; Baliarsing, Doi, & Hattori, 2002; Kumar & Mandal, 2005; Noguchi, Demura, Nagasawa, & Uchiyama, 2009; Pan & Van Gemmert, 2013). However, further research is needed to confirm this assumption.

Equivalent levels of non-dominant and dominant performance determined only in the retention point (3 weeks after the end of the learning process) suggest that the bilateral transfer appears despite skills being in “plateau” phase. Also, that bilateral transfer occurs apart from time training (Dawson, Frazer, & Pearce, 2017), although the time of maximal bilateral transfer can be correlated with the complexity of the studied skill. Difficult skills need more time for learning, retention, and transfer because it imposes an additional cognitive load on the data processing system (Zolfaghari, Zareian, & Salman, 2014). Nearly identical values of CR and CL in retention point confirm the high degree of bilateral transfer between these two skills.

If other theoretical settings are considered (which cite how the skills that stay at the same and/or similar level, to the one that they had after an intensive period of learning, are considered to be better learned from those skills whose “retention” level is changed compared to the level of that skill determined at the end of intensive learning process; Schmidt & Lee, 2011), than it is questionable to bring conclusion about equality in levels CL and CR learned in this bilateral learning process. However, with the results obtained for the coefficient of asymmetry, the previously stated can be confirmed: CR and CL have been learned at the same motor level at the end of the experimental procedure. This conclusion can be reached when comparing the results of the initial point (in which the respondents had identical values of this coefficient and did not have almost any pre-knowledge about CR and CL) with the results at the final point (when the values of coefficient of asymmetry were again almost identical, and CL and CR performances were almost equal). However, the answer to the question: “Which measure (comparison of final and retention checkpoint or the value of coefficient asymmetry) indicates more precisely the equivalence of the adoption of bilateral skills?”, should be given in future research.

For the results it is important to note that they have been obtained through and after the bilateral learning process that started at the very beginning of the experimental process, since the author did not find scientific confirmation about optimal time at which bilateral learning should start and about optimal bilateral practice order. Various researchers have come up with different conclusions on optimal time for bilateral learning. Mauer (2005) determined how early beginning of bilateral practice seems to be beneficial compared to a delayed start of bilateral practice while Stöckel, Weigelt and Krug (2011) determined how subjects who had started learning a new task with the non-dominant side before changing to the dominant side, compared to subjects who had the opposite learning schedule, had a larger learning gain.

Despite unique information obtained through this research, it is important to emphasize that this research has its disadvantage in the size of the sample. By expanding this study to a wider age group, the findings can be translated towards especially, as mentioned previously, in rehabilitation. Additional studies should also investigate if the effects of bilateral transfer are equally strong in older and/or in younger population compared to the age group used in this study.

Conclusion

As indicated by the obtained results, when bilateral practice appears from the beginning of the learning process, despite the different dynamics of the learning processes of bilateral skills performed with whole body, skills reach levels which are not significantly different at the end of the learning process. On the contrary, their final adoption levels can be equal.

In conformity with this study design, no assumptions can be made regarding the optimal time at which a bilateral practice should be started.

The importance of learning bilateral skills in mostly symmetrical/unilateral sports arises from many different reasons. Except for improving performances of non-dominant limb/part of a body, diagnosing relation between left and right side of limb/body can be significant information for: planning and programming in "plateau" phases (when the practice with the non-dominant limb may help in overcoming restraining factors of dominant limb and in overcoming "plateau"), for conditional training, for sporting techniques for every athlete and for enabling and maintaining functions of an injured limb by focusing on the non-injured limb. If asymmetry refers to the morphological asymmetry of the body, performances with non-dominant limb/part of the body is needed to compensate such deficiency (as early as possible and as much as possible) in order to provide morphologically symmetrical growth of athletes.

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Monitoring speed tarining load during running using 3D wearable sensing devics

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ABSTRACT
Performance analysis tools can provide data that coaches can use to ensure accurate feedback for their participants and make informed decisions, where they use the analysis results to identify the strengths and weaknesses point to build their training programs. With the technological revolution in which we live, numerous new interactive sensing devices have been developed for coaches to use with their athletes. In this paper researchers are trying to provide a model to analyze and monitoring running performance using G-Link® -LXRS® Wireless accelerometer to record data at 1024 Hz with duration 15.039 Seconds. The data is stored locally on the device and downloaded by USB cable to a computer after each trial. The sample consisted of six athletes between 20 - 35 years of age. Each player runs 15 meters twice, once maximum intensity and the second moderate intensity. The results show the difference between each trial and the G-Link® -LXRS® Wireless 3D Accelerometer can provide coaches and researchers reliable running information such as velocity, stride number, stride time, stride frequency and peaks in three axes. Discussion will center on the value of this tool for testing and training of athletes; the cost implications and the impact on coach. Authors recommend using sensing devices especially it's a small device and Coaches can monitor the athlete's performance in the natural training environment and practice.

Key words: wearable technology, 3D accelerometer, performance analysis

Introduction
The major objectives of coaching are to help athletic performance learn, develop and improve their skills. (Carling, Le Gall, & Dupont, 2012), and to ensure athletes are in peak condition to perform successfully during competition and monitor how athletes are coping with training (Joyce & Lewindon, 2014). In order to ensure training quality by controlling the training intensity appropriate to the players' potential to avoid over training. Trainers can control the intensity by controlling resistance levels, speed, distance and performance. In weight training programs trainers use one repetition maximum (1RM) as an indicator of training intensity, while in cardio exercises, the Heart Rate (HR) is the main indicator and trainers often use the Karvonen Formula, in speed training, time is the most reliable and accurate indicator of training intensity by recognizing the maximum speed a player can achieve. (Chandler & Lee E. Browm, 2008)
Speed is an important element of fitness in most sports and can be defined as performing a motor task over time. In scientific terms, speed equals change in distance divided by change in time. For many sports, acceleration is the most important component of speed development. Acceleration is the rate of change of velocity, or how quickly an athlete can increase the velocity of the motion over time. All athletes accelerate by increasing

stride time, length and stride frequency. The highest rates of acceleration are achieved in the first 8 to 10 strides taken by athletes (Brown & Ferrigno, 2005; Gambetta, 2007; Jeffreys, 2013; National Strength and Conditioning Association, 2008). Speed can be improved by applying principles of training.

Stride frequency refers to the number of strides taken per second, and stride time refers to the time the time taken by each stride. The discussion of stride length and stride cadence requires an analysis of the phases of a running stride. Each running stride can be divided into two components: a stance phase and a flight phase. The stance phase can be further divided into an early-stance, mid-stance and a late-stance. The flight phase is the period between toe-off and the next foot contact and can be further divided also into an early-flight, mid-flight and a late-flight. (Owen Anderson, 2013; Hughes & Franks, 2008)

Use of wearable sensors has increased due to ease of use, lower cost, and advancements of personal computing devices such as tablets and smart phones. The wearable devices are used extensively in healthcare, Infotainment, pharmaceuticals, sports, nutrition, fashion and the military. Wearable technology provides coaches with reliable and accurate real time physiological and biomechanical data, which helps them to design effective training programs and consider potential causes of injury (Abdelrasoul, Mahmoud, Stergiou, & Katz, 2015; Mahmoud, Othman, Abdelrasoul, Stergiou, & Katz, 2015). There are two types of wearable devices that differ according to the function: movement wearable devices such as pedometers, accelerometers, gyroscopes, and global positioning satellite (GPS) devices; and physiological wearable devices such as heart rate monitors, sleep monitors and temperature sensors.

Sensor technology and performance analysis has become a widespread and useful tool for both clinical use and biomechanical research. Using small, low-power, and low cost wearable sensors, running analysis has been used in sports, rehabilitation, and clinical diagnostics (Tao, Liu, Zheng, & Feng, 2012). The primary purpose of the current paper is to use a 3-D acelerometer and evaluate the relationship of acceleration to intensity.

Methods

Participants

Six recreational male volunteer runners age range from 33 to 36 years participated in this study. These participants were healthy and free of any lower body injuries at the time of the study. The experiments were approved by the local ethics committee, and all participants provided written informed consent.

Wearable Device

The researchers collected data using G-Link® -LXRS® Wireless accelerometer to record data at 1024 Hz with duration 15.039 seconds. The data was stored locally on the device and downloaded to a computer after each trial via a wireless protocol (Figure 1). The device was attached to the participants using an attachment on the back (Figure 2a). Data was captured along three axes as shown in Figure 2b.

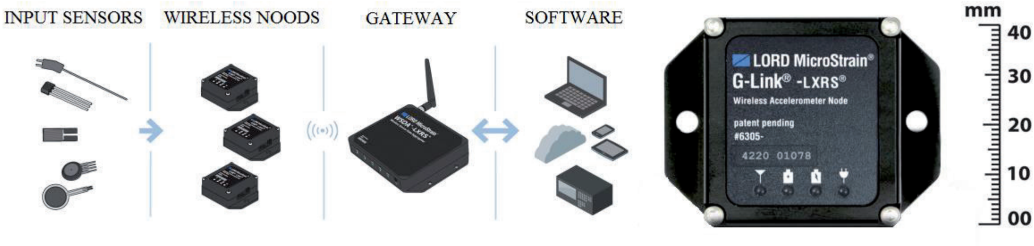

Figure 1 G-Link® -LXRS® low-cost integrated accelerometer node

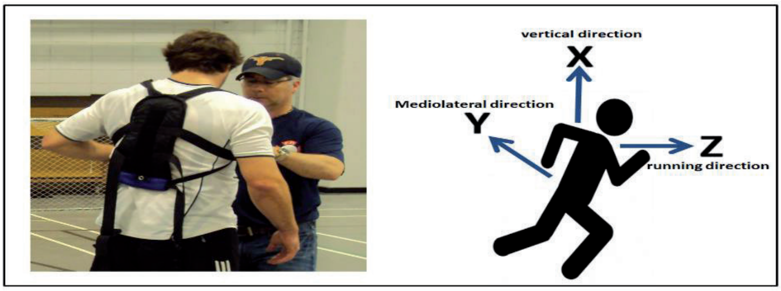

Figure 2. The Position and coordinate system of the three axes

Procedure

Pre-study familiarization with the device allowed participants to be habituated with the requirements of the study and testing procedures. Each subject was allowed a 5-minute warm-up period which they became accommodated to the backpack and testing procedures. Each participant ran 15 meters twice, once maximum intensity and the second moderate intensity on two separate trials. Data were collected using the accelerometer and video was recorded using high speed camera.

Data analysis

The raw acceleration data was imported into Microsoft Excel for analysis. The acceleration data was processed to get an indication of intensity using the following equation: Intensity =SQRT ((A2*A2) + (B2*B2) + (C2*C2)). After acceleration data was calculated, MATLAB (ver. R2015SP1, Nantick, USA) was used to create the graphs depicting the individual data for 3 axes of acceleration and resultant acceleration. Peaks for resultant acceleration and 3D acceleration were measured during a 15-m running for each participant. An example of 3D acceleration signals in three directions and the resultant acceleration for moderate and maximum intensity are shown in Figures (3) (4).

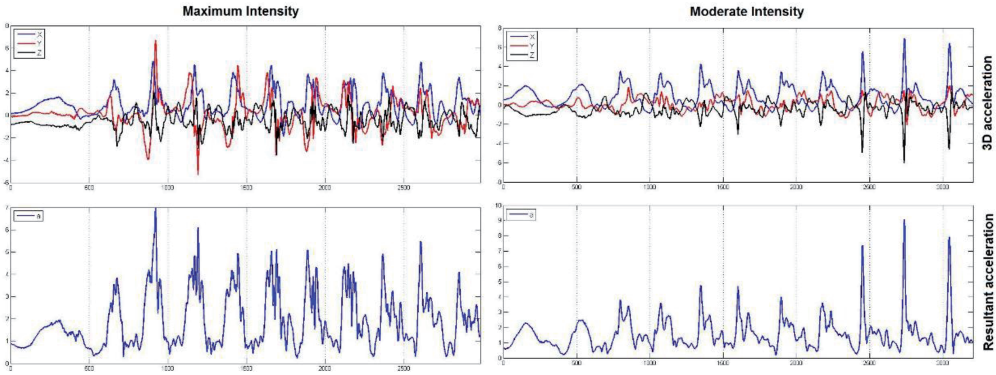

Figure 3. Three directions and resultant acceleration for moderate and maximum intensity

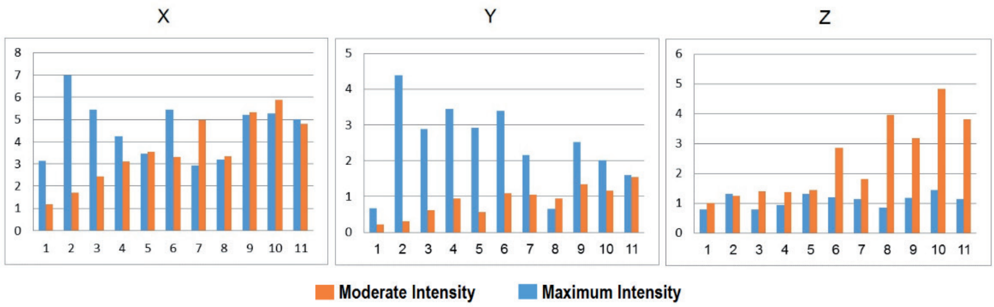

Figure 4. Moderate and maximum intensity peaks for resultant and 3D acceleration

Results

Table 1 and Figure 5 show the differences of peak values for Intensity between the maximum and moderate running the difference is evident in the (X) and (Y) axes, while the difference is not as pronounced in the (Z) axes. Calculating the number of samples between each peak we can identify the stride rate and stride time of each step (Figure 6).

Table 1: Average peaks value in three axes

Steps	(X) Peaks		(Y) Peaks		(Z) Peaks	
	Maximum	Moderate	Maximum	Moderate	Maximum	Moderate
1	2.223	1.927	0.892	0.425	0.527	1.045
2	3.701	2.457	2.781	0.737	1.091	1.332
3	4.367	2.834	4.865	0.936	2.279	1.338
4	3.963	2.859	3.566	1.08	1.764	1.518
5	4.109	2.996	4.448	0.984	2.151	1.635
6	4.132	3.303	4.199	1.221	2.353	2.863
7	3.678	3.132	4.032	1.205	2.379	2.266
8	3.57	3.634	3.107	1.204	2.289	3.069
9	4.246	4.057	3.649	1.189	2.574	3.422
10	4.211	5.514	3.557	1.4	2.025	4.778
11	4.901	4.707	3.043	1.715	2.135	3.721
Average	3.918273	3.401818	3.467182	1.099636	1.960636	2.453364

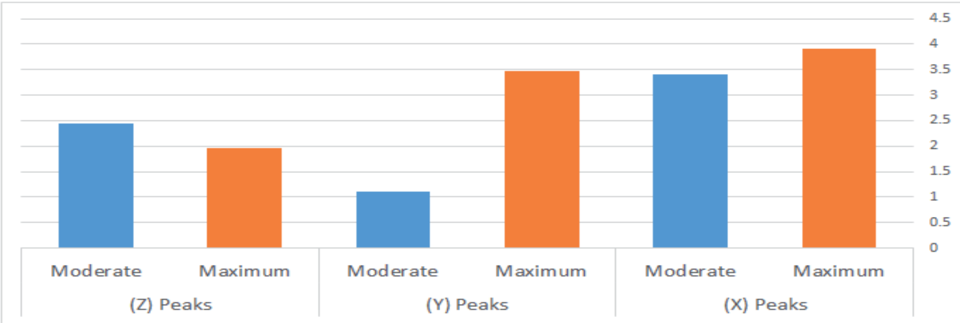

Figure 5. Average peaks values in three axes

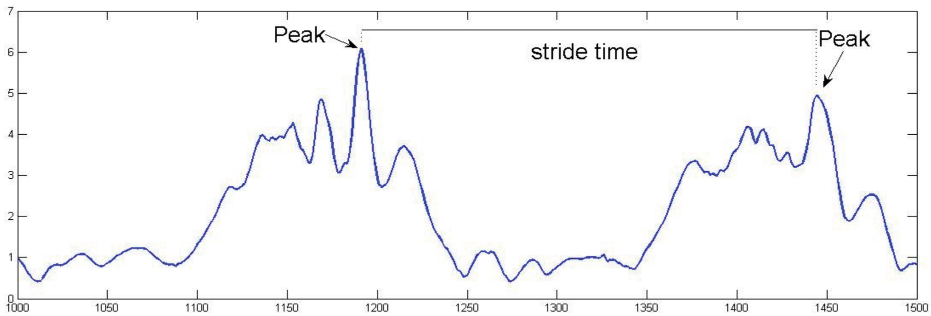

Figure 6. Stride time

Table (2) shows the difference between the maximum and moderate running in velocity, stride number, stride time and stride frequency.

Table 3: comparison between maximum and moderate running

Variables	Maximum Running	Moderate Running
Average velocity	5.22 m/s	4.13 m/s
Total Stride	11	11
Stride Time average	254.5 Hz (0.24 Seconds)	310.1 Hz (0.30 Seconds)
Stride Frequency average	3.83 stride/seconds	3.03 stride/seconds

Discussion

Many recent studies have used wearable technologies and have shown that accurate information can be collected and used related to a player's performance (Carling, Le Gall, & Dupont, 2012; Coutts & Duffield, 2010; Fortune, Lugade, Morrow, & Kaufman, 2014; Gastin, McLean, Spittle, & Breed, 2013; Gurchiek, McGinnis, Needle, McBride, & van Werkhoven, 2017; Kobsar, Osis, Hettinga, & Ferber, 2014; Raper et al., 2018). The aim of the current study was to use 3D acceleromtery to see how processing of the signals into an Intensity value was related to changes in actual speed of motion. Additionally, variables such as stride time and stride frequency were extracted from the data.

It was shown that the acceleration (peaks) in the medial-lateral (y) and vertical (x) directions were good indicators of running speed. The peak accelerations in the anterior-posterior (z) direction was not a good indicator of running speed. Also, analysis of the time between peaks can be used as an indicator of average running speed. Other information that can be extracted from the acceleration data include the total number of strides achieved, by simply counting the number of peaks.

Conclusion

In particular, the G-Link® -LXRS® Wireless 3D Accelerometer can be used to identify differences in accelerometer data between high and moderate intensity in velocity, stride time, stride frequency and peak impact acceleration in all three planes. The results from this study have provided a methodology for analyzing the stride frequency in constant speed running data and have shown that there is a relationship between stride frequency and velocity. Based on this simple analysis of data, an accelerometer can provide a coach with valuable information for understanding and improving athlete performance.

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Differences in motivation and dropout among athletes from different individual and team sports

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ABSTRACT
Objectives: The purpose of this study was to evaluate the psychometric properties of scores derived from the PMQ and the drop-out scale. This study compared athletes' motivational characteristics in individual and team sports. It explored significant individual, social and environmental factors and how they interact to influence participation in sport for adolescent. In total, 203 athletes completed PMQ and Dropout scale, 114 from individual and 89 from team sport (3 individual and 3 team sports).

Methods: 203 participants, competitive athletes, aged 14-19, were invited to participate in this study. There were 131 males and 72 female athletes from 6 different sports: 56.2% were from individual sports (swimming, athletics, tennis) and 43.8% athletes came from team sports (volleyball, basketball, water polo).
The questionnaire used in this investigation to assess participants' motivation was Participation Motivation Questionnaire, designed by Gill, Gross & Huddleston, 1983. It assesses 30 questions focusing on skill/competence, status/acknowledgment, energy release, team atmosphere and affiliations. The follow –up questionnaire was Dropout questionnaire designed for the purposes of this research with aim to get more information on the different reasons for leaving sport.

Results: The results show that there are significant differences in motivation participation depending on the sport. There are differences between swimming and - basketball, water polo and athletic. Basketball players are attained the most, while the results show that least motivated athletes are swimmers.
The result revealed that type of school (elementary school or high school) doesn't make a difference in motivation or in withdrawal aspects. According to the reasons named in dropout questionnaire there are no differences between individuals who are engaged in different sports.
There are differences in dropout questionnaire where sources within the individual are gender-dependent. Girls have more prominent reasons to leave the sport than boys do. There is no school influence ie. athletes do not differ depending on whether they attend elementary or high school. Based on number of sessions per week, analysis showed that group 1 (more than 8 sessions per week) is most persistent in training and shows less dropout, compared to groups which have less sessions per week.

Conclusions: The results of this study support the importance of negative factors related to the aspects of the athletic environment that lead to discontinuing in competitive sport. Our investigation confirms that research in sport withdrawal (dropout factors) must

neglect type of the sport (individual or team sport) because there were no significant results found on this topic.

Key words: team sport athletes, individual sport athletes, dropout, adolescent, reasons, sport motivation

Introduction

The importance of doing youth-sport and its benefits to a variety of important physical, psychological and social aspects of life have been well documented in an extensive line of research.

The period of adolescence is considered to be essential for human development and behavior as patterns of behaviour followed during this stage are often repeated in adulthood. It is therefore a vital period for developing adaptive types of motivation towards physical activity (Wang, Chow and Amemya, 2017).

Organized sport has an important role in children and adolescent development (Fraser-Thomas, Côte and Deakin, 2008.). Over the years, the development of performance in elite youth sport has required increasingly more strenuous workouts, early specialization, careful planning, and the ability to handle tough competitions (Gambetta, 1989.; American Academy, 2000.; Wiersma, 2000.; Baker, 2003.)**.** Combined with handling the necessities of education, work, and other interests, this demanding situation applies more pressure on the young athlete - physical, psychological and social (Augustini and Trabal, 1995.; Mchale et al.,2005.; Cervello et al.,2007.). In many sports those requirements have led to the early dropout of many young talented boys and girls (Petlichkoff, 1992.; Sarrazin et al., 2002; Molinero et. al., 2006) and motivation plays crucial importance as a predictive variable in sports dropout (Weiss and Amorose, 2008).

To evaluate why some young athletes are more motivated while others are not, we examined difference between some individual and team sport.

Motivation can be defined as the force that energizes and directs behaviour (Roberts and Treasure, 2001). Motivation appears to be responsible to explain initiation, direction, intensity and persistancy of behaviour (Deci and Ryan, 1985). Nevertheless, little is known about dropout's motivational determinants, making it essential to recognize the reasons for dropping out, specifically to each sport, and understanding how to help athletes to persist in sports over time (Cervelló, Eseartí and Guzman, 2007).

Since athletes' athletic and competitive demands are becoming bigger and bigger, early secession in sports and a high resignation in sports make it characteristic for a sensible age.

According to Barić (2001.), motivation factors in sport play a very important and often crucial role. To reduce the growing trend of children quitting from sports activities by entering the puberty age, and often earlier, it is necessary to gain insight into their motivational structure, to find out which exercise programs attract children, why they invest and why they stop investing in sport. Intrinsic motivation has been recognized in numerous researches as one of the crucial factors for both sport success and persistence in sports. The underlying problem of this work is based on the assumption that different sports due to the diversity of characteristics (the way of organizing the movement, the stability of the environment during the task performance, the prevalence of the feedback type, and the emotional load during the activities) contribute differently to satisfying the motives of achievement and to increasing, or maintaining intrinsic motivation.

The main *goal* of this work is to check the differences in motivation between athletes participating in some individual and team sports. By using result of the motivational questionnaire/dropout questionnaire we expect that given results will help us to understand different reasons of dropout ("personal" and „other" reasons). New insights could be of great importance in answering the problems associated with adolescent athletes' situations leading to exit the sport. By using these two questionnaires, we wanted to examine what launches them in their daily sport life and what stops them in their sport routine. It is expected that it will be possible to talk about different factors defining the reasons for potentially dropping out of sports Also, by using these questionnaires we will try to compare results using characteristics of individual/team sport and check the significant differences in motivation. It is expected that there will be differences considering the type of sport, age, gender and school that individuals are attending.

Methods

Participants

203 participants, from Zadar and other cities (swimmers were from other cities except Zadar), aged 14-19, were invited to participate in this study. There were 131 male and 72 female athletes from six different sports: swimming (33.5%), athletics (14.3%), tennis (8.4%), volleyball (20.7%), water polo (11.3%) and basketball (11.8%).
Among participants, 56.2% were from individual sport and 43.8% from team sport. Most athletes were in high school (62.5%) while the others (37.4%) were in elementary school. The participants were defined as competitive athletes, competing in national and higher level.

Instruments

In the study two instruments has been used.
PMQ questionnaire (designed by Gill, Gross & Huddleston, 1983; Senjanin, 2002.) comprises of 30 questions focusing on skill/competence, status/acknowledgment, energy release, team atmosphere and affiliations. The PMQ is a useful psychometric instrument to measure individual's reasons or motivations for participating in physical activity. The ratings were made on a five-point Likert type scale ranging from very little (minimal or no influence) to very much (extremely important influence). Reliability of this questionnaire was more than satisfying and Cronbach alpha was 0.934.
Dropout questionnaire was designed for this research to get more information on different internal and external reasons for leaving sport. Questionnaire had 24 questions and the ratings were also made on a five-point Likert type scale ranging from 1 (strongly agree) to 5 (strongly disagree). Participants were asked to think of the situation when they felt it was very difficult to be in competitive sport, and to indicate how strongly they agreed with the motives expressed in each item. Dropout questionnaire was constructed with the idea of its usage in further exploring of sport withdrawal. Since there wasn't suitable dropout questionnaire, it was made for the purposes of this and future researches and it was made based on literature regarding dropout research. Cronbach alpha of the questionnaire (0,87) shows great reliability in both dropout factors, so this instrument is valid for research. Details of the analyses will be more pointed out in the result section.

Procedure

Participants were selected from Zadar sport clubs, except swimming (swimming gathered clubs from Zadar, Šibenik, Sisak, Zagreb, Rijeka and Dubrovnik) in April and May 2018. The study was conducted by the code of ethic for research with children (Ajduković and Kolesarić, 2003). We obtained permission for clubs and coaches who were introduced with study, and we collected data from athletes who were 14 to 19 years old. Standard consent procedure was as follows: prior or after sessions, the researcher explained to athletes both types of questionnaires. It was emphasized that it was on a voluntary basis and anonymous. Athletes completed the questionnaires within 10-15 minutes.

The statistical analysis of the data were carried out using the TIBCO Statistica package, version 13.3.

Results

Descriptive statistics pointed out that the mean of the age was 15,49 years old. Mean of the number of sessions per week was 5,8 and mean of the duration in participating sport was 6,6 years.

The results indicate that there are significant differences in motivation influence depending on the sport ($F=3,32$, $df=5/192$, $p<0,01$). There are differences between swimming and: basketball, water polo and athletics. According to results, basketball players have the highest motivation, while the lowest one is measured with the swimmers (see Table I).

Table I: Post-hoc comparison of Motivation scores for different individual / team sports (LSD Test)

Sport	Marked differences are significant at p < ,05000					
	1 M=3,8358	2 M=4,2750	3 M=4,2290	4 M=4,0508	5 M=4,1149	6 M=3,9750
1 (swimming)		**0,001103**	**0,003928**	0,051203	**0,025316**	0,426863
2 (basketball)			0,777932	0,118252	0,300228	0,130253
3 (water polo)				0,220115	0,465383	0,203034
4 (volleyball)					0,634737	0,678835
5 (athleticks)						0,466185
6 (tennis)						

The factor structure of the motivation questionnaire indicates that motivation is a unique factor - therefore it will be further analyzed as such. It explains 32,58% of variance.

The factor structure of the Dropoutd questionnaire indicates that there are two factors. The first factor will be referred to as „personal reasons" while other factors will be referred to as „other reasons" due to impacts outside the individual (some club influences, injuries, love life, etc.).

Table II: The factor structure of Dropout questionnaire
Sometimes I feel I want to give up active training because:

	F1	F2
1. ...I had other things to do	0,579	
2. ...I wanted to play another sport	0,393	
3. ...I wasn't as good in training as wanted to be	0,550	
4. ...I didn't have enough fun	0,645	0,364
5. ...I didn't like the pressure	0,606	
6. ...my parents expected too much from me	0,356	0,480
7. ...I disagree with my coach	0,380	0,424
8. ...I disagree with my teammates		0,604
9. ...sport is no longer important to me as it used to be	0,648	0,368
10. ...of injury I have	0,248	0,557
11. ...coach doesn't give me enough attention	0,421	0,470
12. ...I miss peers in my sports environment	0,475	0,452
13. ... I feel great rivalry with my brother / sister who are in the same sport	0,032	0,653
14. ...of lower socioeconomic status (inability to purchase equipment, going to competitions ..)	0,150	0,686

15. ... my peers are more dominant than me.	0,310	0,539
16. ...jump to new age category is giving me too much pressure	0,391	0,486
17. ... I can't find a motive for daily sacrifices	0,636	0,292
18. ...lack of publicity	0,448	0,238
19. ...no future potential career opportunities	0,722	0,119
20. ... it's not always interesting to fight with the same opponents.	0,520	0,310
21. ...of risk of getting hurt	0,286	0,444
22. ... team spirit isn't good	0,296	0,661
23. ...no role models in my environment	0,486	0,194
24. ...of love relationship	0,199	0,315
	4,915	4,397
	0,205	0,183
Cronbach alpha	,872	,877

Due to the reasons listed in dropout questionnaire there are no differences between individuals who are engaged in different sports (Personal reasons – F=1,40, df=5/196, p>0,05; Other reasons – F= 1,63, df=5/194, p>0,05).

Table III: Results of gender differences in different aspects of motivation and dropout

	Mean Boys	Mean Girls	Std.Dev. 1	Std.Dev. 2	t-test	df	p	Valid N 1	Valid N 2
Motivation	4,069767	3,954589	0,600802	0,517977	1,34673	196	0,179622	129	69
personal reasons	3,178348	3,476312	0,662059	0,667241	-3,04555	200	0,002635	131	71
other reasons	1,511032	1,684724	0,651069	0,569165	-1,88565	198	0,060806	129	71

Depending on the gender, there are differences within dropout motivations. Girls have more prominent personal reasons to leave the sport than boys.

Table IV: Results of differences in different aspects of motivation and dropout regarding the school

	Mean 2	Mean 1	Std.Dev. 2	Std.Dev. 1	t-test	df	p	Valid N 2	Valid N 1
Motivation	4,001913	4,074123	0,589677	0,550464	-0,85940	196	0,391171	122	76
personal reasons	3,284993	3,279904	0,677023	0,682527	0,05159	200	0,958906	126	76
other reasons	1,530397	1,641700	0,526291	0,763006	-1,21939	198	0,224146	124	76

Depending on the attendance of school (elementary or high school), there are no differences either in motivation or in withdrawal factors. There is no school influence ie. athletes do not differ depending on whether they attend elementary or high school.

Table V: Analysis of Variance based on number of sessions per week

	Df	*F*	*p(F)*
Motivation	*2/195*	0,014177	0,985924
personal reasons	*2/199*	4,753118	0,009628
other reasons	2/197	2,219504	0,111373

Based on number of sessions per week, we divided athletes into 3 groups: *group 1* - less than 5 sessions per week; *group 2* - 5-7 sessions per week and *group 3* - more than 8 sessions per week. The analysis indicated that group 1 is the most persistent in training and shows less dropout, compared to groups which have fewer sessions per week.

Table VI: Post-hoc analyses based on number of sessions per week

	1 M=3,4279	2 M=3,3196	3 M=2,9818
1 - less than 5 sessions per week		0,366159	0,003969
2 - 5-7 sessions per week			0,008495
3 - more than 8 sessions per week			

Discussion and Conclusion

The purpose of this study was to examine the differences in motivation between some individual and team sport. Also, to examine the structure and psychometric properties of Dropout questionnaire, new measurement used in this research with aim of its usage in further exploring of sport withdrawal. Findings supported the validity of the instrument in establishing the dropout climate perceived by adolescent athletes in the context of competitive sport. Cronbach's alpha was satisfactory.

Result of our study indicates that the most motivated athletes are basketball players and the least motivated athletes are swimmers. Authors believe that the reason for that is in fact that basketball is the most popular sport in the native city of tested athletes. The great tradition and history of this sport in athletes' hometown contributes to the popularity of this sport and them, as athletes.

Our investigation confirms that research in sport withdrawal (dropout factors) must neglect type of the sport (individual or team sport) because there were no significant differences found on this topic. According to the reasons named in dropout questionnaire there are no differences between individuals who are engaged in different sports. Based on differences between individual and team sport, the authors of this paper expected to find more motivated athletes in team sport but motivation questionnaire showed no differences, only dropout questionnaire did. Since swimming and athletics are cycling sports, authors believed to find less motivated athletes in these two particular sports.

Based on the literature review we expected that different dropout reasons could be obtained. Results of the analyses have showed that two factors could be explained related to dropout reasons – personal factors and other factors. Differences were found depending on gender: girls showed stronger motives in withdrawal topic. Many sports notice a significant dropout from their sport among female participants in their teenage years. This can be partly explained by the important life transitions that occur for young women from the ages 12 to 15 and 16 to 19. Humbert et al. (2008) suggested that moving from primary to secondary school might be a key transition that influences participation in physical activity.

There were no differences considering the school as well. Athletes showed no differences either in motivation or in withdrawal factors depending on their school: elementary or high school. Authors find this topic very interesting because of athletes who dropout from sport during elementary school. It is undeniable that education program in elementary school is much less demanding than the one in high school, but still, there is withdrawal in this age, too. Researches in sport motivation believe that individuals' motivation in sport may not always be related to or explained by a desire to demonstrate or develop physical ability. Rather, social concerns such as developing and demonstrating social connections may also be important to understanding young athlete's motivation.

However, there were differences in dropout based on numbers of sessions: athletes who train at least 8 times per week are more resistant to dropout.
We find this topic very interesting, too, because of continuity of training. Since this principle is one of the most important principle of sport training and competitive sport.
In this study, we conducted investigation of the participation motivation and dropout questionnaire - a new survey which we developed for measuring the motives for sport dropout.
The close correlation between 24-item dropout factors and the 30 - item PMQ factors lends support to the status of the factors, given that the origins of the two questionnaires and their specific items are quite distinct. The future research should include a wider group of athletes - both age and other features, to better understand the findings of this research. Also, this study underlines the need to check the metric features of the used instruments on wider population of athletes and also to develop better pedagogical interventions at critical periods.

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The importance of head control and its relevance in sports performance

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ABSTRACT
In the early motor development of a child, head control is a crucial component for achieving normal neuromotor control of movement. Achieving head control is necessary for accomplishing further motor activities. In most children, the development runs smoothly without any difficulties. Therefore, we are often unaware of the importance of the aspect of head control for further functioning.
In children whose motor development is delayed or disrupted, head control is not established (on time). Getting the control of head movement is a very complex task, and if it is lacking - a physiotherapeutic guidance is of crucial importance.
The aim of this paper is to stress the importance of establishing head contol in children. Head control is the crucial aspect of development, especially for children with motor disabilities but also for top athletes, with the aim of pointing out how important physiotherapeutic work is for achieving better quality control. Our contribution with this paper is to point out a functional approach to the motor development of a child and its connection with top athletes.
Methods for establishing head control are just an initial point of achieving control of normal movement. Bobath neurodevelopmental treatment for children is used for facilitation of motor development. This aproach includes a lot of activities in different body positions.
An educated and experienced neurophysiotherapist will assess a child´s initial status. Then the therapist chooses special techniques and undertakes specific procedures in order to encourage the child to achieve developmental progress. The important role of neurophysiotherapist is to facilitate early neuromotor development of the child, with the aim of achieving neuromotor control.
A child who is not controlling the head, cannot achieve motor development nor can it walk independently. Athletes who have not mastered head control of the sport they are a part of, up to the mastery, cannot achieve significant sports results.
In terms of motor control, we can compare head control of a child with head control of top athletes. Every athlete has to go through normal motor development in order to improve their skills to the top results. We must not forget the fact how important head control is, in achieving better sports results.

Key words: head control, neuromotor control, normal development, neurodevelopmental treatment, sports success.

Introduction
If one thinks that time needed to develop into a top athlete is just a few years of intense training, one is wrong. To achieve the basics of normal motor development, a child needs at least 12 to 18 months of «work» in the first months of life. „A development of a healthy baby in its totality, i.e. physical, mental, emotional and social aspect depends on his ability to move.“ (Bobath, 1980, p. 88). If everything is fine, a physiotherapist can just

stimulate a child to promote its development.and. inhance development of head control (Lee, Galloway, 2012). „Head stabilization during posturokinetic activities, particularly locomotion, constitutes a complex motor skill requiring a long time to develop during childhood." (Assaiante, 2005, p. 109).
But if the development is delayed or disturbed, a physiotherapist has the main role in stimulating and facilitating the child´s developmental improvement.
Early neurodevelopmental treatment in children with brain damage is important and well known. Why is an early neurodevelopmental treatment important for a child? To achieve a normal motor skills repertoire (Assaiante, 2005).
What is the link between early motor development, especially head control and its connection to sports achievements?

Picture 1. Stimulation of an early head control of a 6 months old child in a side lying position.

Picture 2. Control of movement in lateral position in martial art.

In literature we can find that head control is a crucial aspect of development, especially for children with motor disabilities. Original work of Karel Bobath highlights the advantages of very early treatment of infants before the disordered postures and movements are established (Bobath,1980; Richards, 2013). „Early treatment is considered to be if it starts at the age of two to three months corrected age, that is before antigravity voluntary movements emerge and before abnormal movement patterns begin to be predominant." (Dolenc Veličkovič, Veličkovič Perat, 2005, p. 112). „Neurodevelopmental treatment is a holistic approach dealing with the quality of patterns of coordination and not only with the problems of individual muscle function." (Dolenc Veličkovič, Veličkovič Perat, 2005, p. 113).
There are no studies which would draw the line between head control in a developing child with head control in top athletes.

Hypothesis

When considering early child development, a child who cannot control its head, cannot achieve functional movement nor can he walk independently**.**

The role of sports physiotherapist

The role of the physiotherapist in top sports today is not only to prevent injuries or just to relieve the muscle pain. A sports physiotherapist, as a part of the team, is involved at all levels of training of any player to provide better performance by achieving better quality control and consequently better result.(Kerkar,2017).
Sports physiotherapists suggest and demonstrate how to normalize muscle tone during training. They demonstrate exercises for increased range of motion, for increased strength, for preventing and reducing pain and swelling. If damage has occurred they undertake procedures to speed healing as well as demonstrate a range of exercises to

improve breathing, which increases endurance. All of that helps athletes to carry out daily activities and sports competitions better. That way sports physiotherapy greatly improves athletes quality of life.

Methods

After setting up the diagnosis, children were given the Bobath neurodevelopmental treatment. One of the most important aims of Bobath therapy is to increase and improve motor skills repertoire and to improve and maintain their functional level.
In the period from 1997 to 2016, a research study was conducted within the framework of the Ustanova za zdravstvenu njegu u kući, Zagreb. Twenty children were involved, divided into two groups. In the first group there were 11 healthy children and children with neurological risk. In the second group, there were 9 children with the central nervous system (CNS) damage. Children were treated based on the Bobath concept. The aim was to stimulate the motor development of children and to stress the importance of encouraging early motor development.

Group I

There were 11 children in the first group (Table 1): 7 girls and 4 boys born between 1999 and 2014. Five of them were born prematurely (in the 33rd gestational week 1 child, in 36/3, in 37/1). Six children were born around the term: in 38th gestational week 2 children, in 40/3 and in 41/1.They started with exercises between the 1st and 6th month, by a frequency of one, two or three times a week. There were different initial diagnosis: healthy children whose development was delayed (4), a mother with *diabetes mellitus type I* (2), a mother with *sclerosis multiplex* (1), hypoxia II stage (1), hemorrhage II stage (2) and lateral ventricles expansion (1).

Table 1: Healthy children and children with neurological risk (NR)

	Patient, sex	Year of birth	Gest. week	Medical condition	Exercise started/ frequency	Head control	Walked At
1	J.G. - m	2008	38+5	healthy	6 m / 10 x	✓	14 m
2	L.P. - m	2009	41+6	healthy	6 m / 10 x	✓	12 m
3	L.H. - f	2007	40	in vitro, delay	3 m / 1x w	✓	17.5 m
4	A.O. - f	1999	40+2	NR - m DM 1	1 m / 3x w	✓	12 m
5	L.O. - f	2002	38+3	NR - m DM 1	1 m / 3x w	✓	11.5 m
6	N.B. - m	2009	36+1	NR – m MS	2 m / 3x w	✓	10.5 m
7	I.R. - f	2013	36+1	in vitro, tween	14 m/1x w	✓	12 m
8	N.R. - f	2013	36+1	in vitro,delay	14 m/2x w	✓	18 m
9	S.K. - f	2011	33+4	hemorrhage II	1 m / 3x w	✓	12 m
10	L.C. - f	2008	40	HY II, HE II	3 m / 3x w	✓	12 m
11	B.J. - m	2014	37+2	ventricles expansion	3 m / 3x w	✓	11 m

Table 1 index:

m = male
f = female

developmental delay
NR = neurorisk
m DM I = mother - diabetes mellitus typ I
m MS = mother multiple sclerosis
HE II = hemorrhage II stage
HY = hypoxia II stage

m = months
10 x = 10 times
3x w = three times per week

Group II
There were 9 children in the second group (Table II): 1 girl and 8 boys born between 1992 and 2007. Seven of them were born prematurely (in the 29th gestational week 2 children, in 33/2, in 34/1 and in 38/2). Four out of nine children started an early Bobath treatment in first three months corrected age (2 months old 1 child, 3 months/3, 5 months/2, 6 months/1, 10 months/1 and 12 months/1). Frequency was three to five times a week. Initial diagnosis was brain damage, later cerebral palsy.

Table 2: Children with cerebral palsy (CP)

	Patient, sex	**Year of birth**	**Gest. week**	**Diagnosis**	**Exercise started/ corr. age**	**Head control**	**Walking**
1	I.B. - m	1992	38	CP quadri	12 m	partially	**wW**
2	M.K.- m	1993	29	CP hemi	7 m	**good**	**walks**
3	M.R. - f	1995	33	CP quadri	1 m	partially	**wW**
4	J.J. - m	2002	32	CP quadri	1 m	partially	**wW**
5	M.K - m	2003	29	CP quadri	2 m	partially	**wW**
6	S.S. - m	2004	33	CP quadri	on term	partially	**wW**
7	I.V. - m	2002	32	CP quadri	4 m	**no**	**no**
8	M.M - m	1999	34	CP quadri	1 m	partially	**wW**
9	L.V. - m	2007	38	CP hemi	5 m	**good**	**walks**

Table 2 index:
m = male
f = female
CP = cerebral palsy
quadri = quadriparesis
hemi = hemiparesis
corr. age = corrected age
wW = with walker

Methods of treatment
„The most important function of posture is to ensure the maintenance of equilibrium during the initiation and continuation of movement.“ (Assaiante, 2005, p. 109).
In Bobath treatment the therapist encourages the principles of child development through different positioning. Three months old baby should be able to keep its head in midline position in supine. After that it is time for a child to train head control in prone, side lying and pulled to sit.
When this is accomplished it is time to upgrade this achievement with better antigravity movements (Tecklin, 2008). Better head control is required for better trunk stability and the latter for better postural stability (Scharli, 2013). Goals of development are to achieve, maintain and control muscles needed for antigravity movement, to mantain body center within the base of support and to secure isolated movement of the body parts while the body is in a stable position. The control of posture develops normally in craniocaudal direction.

Head control and righting reactions
Head control, as a part of the normal postural reflex mechanism (NPRM) is one of the most important factors for achieving neuromotor control. Righting reactions are automatic responses which maintain normal position and normal alignment of the head, neck, trunk and limbs in the space and one with another (Figures 3, 4, 5).

Head lifting from supine

Figure 3: Facilitation of lifting the head.

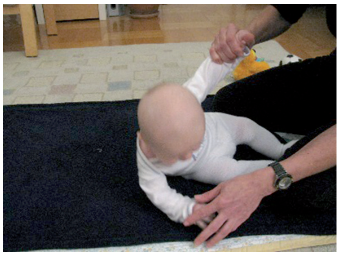

Figure 4: Head control in rightt side lying.

Figure 5: Head control in facilitated sitting.

Head lifting and head control in prone (Figures 6, 7, 8).

Figure 6: Head down in prone.

Figure 7: Weight shift in prone. Key point of control: right arm.

Figure 8: Arm supported back externsion. Head is well controled.

Head control in left side rolling to the prone position (Figures 9, 10, 11).

Figure 9. Control of the head and body in left side lying position.

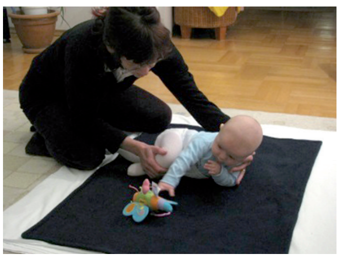

Figure 10. Riching up for a toy. Weight on the left side.

Figure 11. In prone, weight shifted more on the left side.

This functional approach involves a gradual mastering of coordination, anticipation and adaptation in postural controll (Assaiante, 2006, p. 109).

Interaction and coordination (Massion, 1992) **of movement, posture and equilibrium** (Figures 12, 13, 14, 15).


Figure 12. Antigravity head control.


Figure 13. Weight shift.


Figure 14. Coordination of movement.


Figure 15. Posture in equilibrium.

Results

Children who were treated by neurodevelopmental treatment achieved the following accomplishments:

Group I

All of the children with neurological risk (11) have achieved head control and all of them can walk independently (Table 1).

Group II

Two out of nine children with CNS damage have achieved head control and they can walk independently. Both of them have been diagnised with hemiparesis and their gait is asymmetric because of weight bearing asymmetry (Szopa, 2017). Six out of nine children have achieved partial head control. Their walk is unstable and they need assistance of a walker and another person. One child has not achieved head control. He cannot sit independently nor walk (Table 2).

Discussion

Neurophysiotherapy is without any doubts very useful. The results though depend on the initial damage and how early the treatment begins. It also depends on the frequency and quality of the treatment and how often have the parents proceeded recommended handling. Child´s motor development also depends on the way the child reacts to the therapy. If a child is haelthy, a physiotherapist can just stimulate the child to promote its development. But if development is delayed or disturbed, a physiotherapist has the main role in stimulating and facilitating the child´s developmental improvement. „Neurodevelopmental treatment (NDT) is in practice a successful approach but we should not think that we can cure a brain lesion or cerebral palsy. We can only help the child to organize his potential abilities." (Dolenc Veličkovič, Veličkovič Perat, 2005, p. 118).

Conclusion

We have confirmed the hypothesis.

A child who cannot control its head, cannot achieve functional movement nor can he walk independently. Athletes who have not mastered head control of the sport they are a part of, up to the mastery, cannot achieve significant sports results.

Normal motor development is required to control posture and movement. It is not necessary to emphasize that achieving neuromotor development in athletes childhood is inevitable for being in a top of the range athlete. Afterwards it is necessary to master special skills as an upgrade to normal motor development.

Further researches are needed to find out in which circumstances athletes achieve better sports results. The study would need to compare sports achievements of healthy children who have achieved neuromotor development independently by themselves, without any additional stimulation of parents or environment and healthy children who have received early neurodevelopmental treatment.

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Parameters of physical performance and physical effort required in the different playing positions in the soccer

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Purpose: The purpose of this study is to examine, with respect to their playing position, the effort physical required at footballers during the match, the relationship between the metabolic power and the resistance capacity (total distance covered).

Methods: The study method is experimental with the division of the sample in 3 groups of 10 players, divided by role (Attackers n = 10, Midfielders n = 10 and Defenders n = 10). The physical effort required, metabolic activity profiles and endurance capacity were collected on **(30)** elite senior male Italian football players using global positioning system. Data were collected during **(20)** friendly matches. Analysis of statistical data has been conducted with Anova to check the differences between the three groups of footballers; while has been used Person's correlation to compare the metabolic power with resistance capacity (total distance covered). The significant differences has been fixed in $p<0.05$.

Results: For all match-related parameters, physical performance was higher for defenders and midfielders compared to attackers. Correlations were observed between metabolic power and total covered distance in the different roles of play.

Conclusions: The physical effort demands during a football game differ by game position as well as the correlation between the metabolic potency and the distance covered in the different play positions has been confirmed.

Key words: global positioning systems, total distance covered, metabolic power, performance

Upper body resistance exercise reduces time to recover following a high-volume bench press protocol in resistance trained men

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Purpose: The aim of this study was to investigate the effects of different recovery strategies on the recovery response following a high-volume bench press protocol.

Methods: Twenty-five resistance trained men (Mean ± SD: age = 25.8 ± 3.6 y; body mass = 87.1 ± 12.1 kg; height = 177.4 ± 4.9 cm) performed a high-volume bench press session (8 sets of 10 reps at 70% of 1RM). Subsequently, they were randomly assigned to an active recovery (AR) group (n = 11) or to a passive recovery (PR) group (n = 14). AR consisted of light bench press sessions performed 6 hr and 30 hr after the high-volume exercise protocol. Muscle performance [bench throw power (BTP) and isometric bench press (IBP)] and morphology [muscle thickness of pectoralis major (PECMT) and of triceps brachii (TRMT)] were measured prior to exercise (BL), and at 15-min (15P), 24-hr (24P) and 48-hr (48P) post-exercise.

Results: Post-exercise recovery of both maximal strength and power were accelerated in AR compared to PR. Both BTP and IBP were significantly ($p<0.001$) reduced at 15P and 24P in PR while changes were significant ($p<0.001$) at 15P only in AR. PECMT was still significantly ($p=0.015$) altered from BL at 48P in PR while changes were significant ($p<0.001$) at 15P only in AR (see Figure 1). No significant interactions ($p>0.05$) between PR and AR were detected for TRMT and muscle soreness.

Conclusion: The present results indicate that AR enhances the recovery rate of both performance and muscle morphology following a high-volume exercise session for upper body.

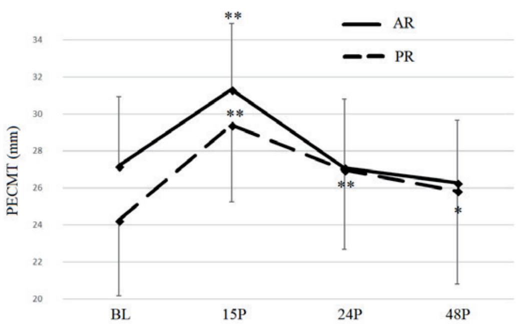

Figure 1. Changes in PECMT occurred 15-min (15P), 24-hour (24P) and 48-hour (48P) post the training session. *indicates a significant ($p\leq0.05$) difference from BL.**indicates a significant ($p<0.01$) difference from BL. AR = active recovery. PR = passive recovery.

Interrelationships between sympathetic nervous system-related heart rate variability parameters of badminton players when correcting for subjective indicators of recovery status

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Purpose: The purpose of this study was to determine the interrelationships between sympathetic nervous system (SNS)-related HRV parameters measured over different periods of matches in male, African, singles badminton players while also correcting for subjective indicators of recovery status.

Methods: Twenty-two male, African, singles badminton players (age: 23.3 ± 3.9 years) participated in the study. Fix Polar HR Transmitter Belts were used to record variations in beat to beat (R-R) intervals before (pre-match), during (in-match) and after (post-match) 46 matches. Only the following SNS-related HRV parameters were used for further analyses: The very low band peak frequencies in hertz (Peak VLF Hz), the low band peak frequencies in hertz (Peak LF Hz), the natural logarithmic transformation of LF relative power expressed as normalised units (Ln-LFnu), VLF relative power expressed as percentage (VLF %), LF relative power expressed as percentage (LF %), the ratio between Ln-LFnu and Ln-HFnu components (Ln-LFnu:Ln-HFnu) and the natural logarithmic transformation of standard descriptor 2 (Ln-SD2). Interrelationships between cluster analyses reduced SNS-related HRV parameters were determined by making use of partial correlation analyses and by controlling for subjective indicators of recovery status. The level of significance was set at $p \leq 0.05$.

Results: Last-mentioned analyses showed that eight significant correlations were identified between pre-match HRV variables (range: r = -0.58 to 0.94), and nine between the in- (range: r = -0.56 to -0.94) and post-match period (range: r = -0.57 to -0.86), respectively. Therefore, results suggest that the interrelationship between SNS-related HRV parameters differ according to the match period during which parameters are measured. The number and strength of interrelationships were higher for the pre- and in-match than the post-match period. Further analyses (normal Pearson correlation analyses), also showed that correlation values increase when researchers do not control for subjective indicators of recovery status.

Conclusion: Consequently, the assumption that specific HRV-related parameters always reflect activity of certain branches of the autonomic nervous system may be inaccurate when different match periods are analysed. Values of last-mentioned variables may also be influenced by subjective indicators of recovery status.

Key words: autonomic nervous system, sympathetic nervous system, indicators of recovery status, heart rate variability

Validity and reliability of the track160® system for measuring movement demands of outdoor sports: a pilot study and preliminary results

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Purpose: In team sports, tracking technologies are widely utilized to collect the positional features of the athletes thus quantifying physical load demands and the tactical behavior characteristics of interest. Tracking procedures are mostly based on global positioning systems (GPS), multiple camera setups and radio-frequency based systems (Coutts et al., 2010; Di Salvo et al., 2006; Frencken et al., 2010). In the last years, the employment of computer artificial intelligence, relying on deep learning algorithmic procedures has opened up new possible solution for sport movement tracking. In this context, very recently a new fully automatic tracking system (Track160®) combining computer-vision-based and iso-inertial measurement units inputs has been developed for collecting and providing accurate positional information. In view of the evident interest about accurate tracking solutions (Memmert et al., 2016), an important first step is to investigate and establish the reliability and validity of the developed system. Therefore, the main purpose of this study was to investigate the reliability and validity of the Track160® system.

Methods: A repeated measures design was used for investigating the reliability of the Track160® system outcomes and the agreement with those of a ground truth reference. Four football players performed a variety of locomotor activities like walking, jogging, fast running, sprinting along linear and multidirectional paths both as individuals and as couples with the between-subject distance kept known and constant. Moreover, the same trials and conditions where performed within a real game scenario of 5 vs 5 small sided games. The collected variables were: individual distances covered during different activities and through different paths, and between-subject positional relationships both in free view and occluded conditions.

Results: Intra-subject, inter-subject and test-retest reliability of the distance measures were very high as shown with intra-class correlations (ICC) scores ranging between 0.97 and 0.99. The percentage difference between the ground truth reference and the outcomes of the tracking system was 1.2±0.35% and 1.4±0.42% for the free view and occluded conditions, respectively. The percentage difference between the known between-subject distance reference and the tracking system outcomes was 1.3±1.4% and 1.5±1.8% for the free view and occluded conditions, respectively.

Conclusion: In light of these results, the Track160® system could be considered acceptable for capturing players' displacements in outdoor team sports such as football. The system showed high reliability and agreement scores when compared to ground

truth references. Furthermore, the mean absolute error did not change with increasing movement speeds and occluded view conditions. The Track160® system provides accurate and reliable positional details and offer likely opportunities to develop new performance indicators from an individual and collective basis.

Effects of two post-activation potentiation warm-ups on the energy cost and biomechanics of running

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Purpose: Post-activation potentiation (PAP), an acute phenomenon by which muscle performance is enhanced due to a previous activation, can play a key role in endurance sports (Boullosa et al., 2018). This study aimed to assess the effect of two different PAP warm-ups on the energy cost and a selection of biomechanical indices during sub-maximal running.

Methods: Eight high-level middle-distance runners (25.0 ± 4.2 years), completed on a track two 2000-m runs at 85% of the individual maximal aerobic speed, respectively before and after warm-up including 3 sets of 10 s of repeated jumps. In a subsequent session, the athletes performed the same running protocol with a warm-up including 3 sets of 3 back squats at 80% of 1RM. During all 2000-m runs, the energy cost (EC) and kinematic descriptors of running were measured.

Results: EC was almost unchanged after the jumping-based warm-up (p=0.86), whereas it decreased of about 6% after the back squats warm-up (p<0.05). Conversely, the jumping warm-up involved significant changes of angular kinematics, where kinematics was unaffected by the back squats warm-up.

Conclusion: The present findings indicate that the back-squat warm-up overall involves higher PAP compared to the jumping-based warm-up with possibly positive effects on the energy cost of running. Nevertheless, middle-distance runners may show individual PAP responses, suggesting that ad-hoc PAP warm-ups are to be recommended.

References

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An investigation into the effect of knee braces on the lower limb kinematics of badminton players

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Badminton players are prevalent to experiencing lower limb injures with 16.7% occurring in the knee (Fahlström *et al.,* 1997), the knee joint provides stability when performing technical movements such as a lunge by maintaining stability during frontal and transverse plane movements and decreases the risk of injury to surrounding joints (Thijs *et al.,* 2007). With 97% of orthopaedic surgeons prescribing braces to their patients (Rishiraj *et al.,* 2009), there is limited research in terms of the impact of knee braces used in the non-injured population due to concerns of decreased or impaired performance.

Purpose: The purpose of this study was to investigate the lower limb kinematics of Badminton players in both a braced condition and a non-braced condition during a lunge.

Methods: 8 male Badminton players were recruited to take part in the study (Age: 21.5 ± 0.76 years; Mass: 72.5 ± 6.36 kg; Stature: 178.4 ± 4.44 cm). 3D motion analysis capture was used to analyse the angle of the hip, knee and ankle joint with a primary focus on the knee. Surface electromyography was used to measure muscle activation of the bicep femoris, rectus femoris, medial gastrocnemius and tibialis anterior. The angle measurements and muscle activation levels were collected at the point of initial contact, maximum flexion and the recovery phase. Angular velocity of the hip, knee and ankle were also analysed in two specific time points; initial contact to maximum flexion and maximum flexion into the recovery phase.

Results: Significant difference was identified at the hip ($130.6^{o} \pm 9.3^{o}$ (NB), $127.4^{o} \pm 9.9^{o}$ (B), *P=0.010*) and knee ($170.2^{o} \pm 5.4^{o}$ (NB), $164.8^{o} \pm 3.1^{o}$ (B), *P=0.001*) at the contact phase and knee ($172.0^{o} \pm 10.5^{o}$ (NB), $170.2^{o} \pm 3.9^{o}$ (B), *P=0.004*) in the recovery phase. There was no significance identified in the hip, knee or ankle at the point of maximum flexion (*P>.05*), also no statistical difference was identified in the angular velocities of the hip, knee or ankle joints throughout the lunge (*P>.05*). There was no significant difference identified in the muscle activations of the rectus femoris, bicep femoris, medial gastrocnemius and tibialis anterior throughout the lunge (*P>.05*).

Conclusion: This study provided evidence that knee bracing had affected the hip and knee joints in the contact phase of the lunge and also the knee joint in the recovery phase. This differs to the findings of Singer & Lamontage (2007) as their results suggest that the brace has no significant effect on the knee at the point of initial contact (*P>.05*). Huang *et al.* (2013) identified that the knee joint having a greater range of motion increases the reach range of the player and therefore improving the possibility of making the shot. Hence it can be stated that the brace restriction observed in the contact and recovery phases at the hip and knee joint can negatively impact performance. However, the brace did not have an effect on any of the joints analysed in the stage of maximum flexion. It was also found that the brace did not impact the muscle activation across the muscle analysed or the angular velocity of the joints analysed. Where the brace did not have an effect, the null hypothesis was accepted. This study can now be added to the body of literature that surrounds knee braces in sport, however more studies are required in several different sports to analyse the validity of the brace.

(**KEY**: NB = Non-Braced, B = Braced)

Towards an adaptive lactate threshold estimation methodology: a personalized modelling approach

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Purpose: Lactate threshold is defined as the exercise intensity at which the concentration of blood lactate begins to significantly increase compared to the values at resting. It is considered an essential physiological variable for performance analysis in endurance sports. Moreover, its assessment without specialized equipment nor turning to specialized centres is of great interest for athletes and coaches. In previous works (Etxegarai et al. 2018), we proposed a static model to estimate the lactate threshold of recreational runners. Since any static model can have, by concept, difficulties dealing with unseen data which falls outside its boundaries, the objective of this work is to propose a methodology able to adapt to new data by filtering and integrating it in the modelling process. Thus, in this work, a personalized modelling strategy is proposed as adaptive solution.

Methods: The rationale behind personalized modelling is to find the correct subspace (most similar athletes) for a single point space (new athlete) and create a personalized model from it. This concept is naturally related to instance-based algorithms which, re-computing the subspace using the available data at the time, can adapt its model to previously unseen data. Thus, finding the correct subspace is key for the success of the personalized modelling approach. In this work, a combination of feature engineering and Nearest Neighbours clustering is proposed. The feature engineering step aims to find the features relevant for the outcome of interest (lactate threshold) and combine them in a way that the subspace is meaningful for the entire target population. Then, the nearest neighbours of the new athlete are selected according to these subspaces and used to create personalized models. This process is repeated using different feature subspaces so that several personalized models are created from a diverse set of perspectives. Finally, these models are ensembled to create a single personalized model more robust in the lactate threshold estimation.

Results: The results show that this methodology is as powerful as the static model previously presented (CV success rate: 92% vs 90%) and that, when feed with completely new data, is capable to adapt and integrate it into the modelling process, even slightly improving its performance (CV success rate: 93%).

Conclusion: This work proposes a first adaptive methodology as a step towards a fully adaptive strategy and in the way of continuing to close the gap between an accessible and the invasive gold standard lactate threshold measurement technique.

The influence of short term proprioception training onto stability of classical dancers

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Purpose: The classical ballet dancers has a great sense of balance and high level of postural control (Vuillerme et al., 2001). The aim of the study was to check does the additional proprioceptive training improve the postural stability of well-trained dancers.

Methods: The 13 students of the National Ballet School in Bytom (Poland) participated in the study. Professional training in this kind of school is intensive, around 21 hours per week. At the time of examination, they had already undertaken approximately 3000 hours of dance training. Mean age, body mass and body height were respectively: 15.1±0.95 years, 50.1±5.42 kg and 163, 5±4,1 cm, and all participants were right footed. To test the posture stability the subjects performed one leg standing with Passé position. The measurement protocol consisted of eight 30s trials (open and close eyes, right and left support foot, each condition twice (Slomka et al., 2012)). To avoid fatigue or boredom, there was a 30 s rest between trials (Da Silva et al., 2013). To measure the COP (center of pressure) characteristic we have used a force platform (AMTI, Accugait) with 100 Hz sampling frequency. The COP range, mean COP velocity and body sway (std COP) were analyzed to evaluate participants stability. The proprioception training was based on performing chosen dance figures with eyes closed (approx. 4h/week). The same measurements were repeated after 6 weeks.

Results: The postural stability didn't change when evaluated with eyes open condition. The tests with eyes closed showed the significant decrease of mean COP velocity for anterio-posterior plane and total mean COP velocity as well as lower body sway for AP plane. The values of all parameters were higher for eyes closed condition.

Conclusion: The short period of proprioception training can change (improve) stability characteristic even when applied to specific subjects with a high level of postural control. The next questions evaluated in the future research are how long this changes will be visible and can it transfer also to eyes open condition.

Evaluating personal well-being through heart rate variability with omegawave © – a single case study

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Purpose: Professional sports require a well-planned timing of training and recovering. Determining regeneration imply the knowledge of the recovery state of the athlete. Measurement of the heart rate variability (HRV) is one possibility to evaluate that state. The HRV describes the beat-to-beat variation of RR-intervals in the ECG. It is an indicator for the cardiovascular health of patients because decreased HRV is associated with increased mortality (Kleiger et al., 1987). It is also used as a predictor for the state of overtraining (Makivić et al., 2013). A declining HRV is a sign for an overtrained state and precedes a declining performance. The company *Omegawave* utilises this knowledge by evaluating the "Readiness" of an athlete for upcoming loads. Therefore, the resting HRV is measured for a few minutes. The aim of this study was to investigate the relationship between the resting HRV and the personal well-being of one beach volleyball player. A positive correlation was assumed.

Methods: A male beach volleyball player (26 years old) conducted 27 assessments with *Omegawave* within six training weeks. The assessments were carried out by himself in the morning before the breakfast. This procedure guaranteed standardized measurements under the same condition every day. The following HRV-parameters were used: SDNN (standard deviation normal to normal; in ms), RMSSD (root of the mean square of the differences of successive intervals; in ms), HF (power in high frequency; in ms^2) and LF (power in high frequency; in ms^2). After this assessment, he filled in a questionnaire containing five questions. He had to rate his state of muscle soreness, stress, mood, fatigue and his sleep quality last night from 1 (bad) to 5 (very good). Half points were allowed. The HRV-parameters were correlated using a Pearson correlation with the results of the questionnaire.

Results: RMSSD correlates significantly with sleep ($p = .012$; $r = .478$), stress ($p = .003$; $r = .543$), mood ($p = .006$; $r = .511$) and the overall well-being ($p = .003$; $r = .555$) as the sum of all five qualities. There are also correlations between HF and stress ($p = .019$; $r = .449$), mood ($p = .012$; $r = .477$) and the overall well-being ($p = .005$; $r = .005$; $r = .522$). No correlations are detected between SDNN, LF and the well-being.

Conclusion: HRV is used in clinical settings as an indicator for the cardiac health (McCraty & Shaffer, 2015). It is also used to guide endurance training and prevent overtraining as it reflects the cardiac autonomic state (Stanley et al., 2014). The results of this single-case study show that a higher HRV reflects a better personal well-being. This applies for the parameters RMSSD and HF, which are related to the parasympathetic activity (Thayer & Lane, 2009). SDNN and LF do not correlate with the well-being as they may reflect more factors not only related to the mental state. The lacking correlation with the muscle soreness could be explained by the lacking relationship between the state of the muscles and the cardiac state. This study shows that resting HRV is a valid tool to assess the personal well-being of athletes and to help to guide their training.

Can anaerobic energetic capacity be estimated from a primarily aerobic energetic capacity test protocol?

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Purpose: Soccer today emphasizes players fitness abilities more than it has in past. Players ability to perform well throughout all 90 minutes is a must (Stølen, Chamari, Castagna, & Wisløff, 2005)children and adults with different levels of expertise. Soccer performance depends upon a myriad of factors such as technical/biomechanical, tactical, mental and physiological areas. One of the reasons that soccer is so popular worldwide is that players may not need to have an extraordinary capacity within any of these performance areas, but possess a reasonable level within all areas. However, there are trends towards more systematic training and selection influencing the anthropometric profiles of players who compete at the highest level. As with other activities, soccer is not a science, but science may help improve performance. Efforts to improve soccer performance often focus on technique and tactics at the expense of physical fitness. During a 90-minute game, elite-level players run about 10 km at an average intensity close to the anaerobic threshold (80-90% of maximal heart rate. As well as aerobic energetic capacity, anaerobic energetic capacity is well measurable and sports scientists can have a good insight into the level of fitness for each player in the team. One of the aims of soccer is to postpone the effects of fatigue (Mohr, Krustrup, & Bangsbo, 2005). The goal of this study is to determine if there is any correlation between the distance run above the anaerobic threshold (VT2) in an incremental test to volitional exhaustion, and anaerobic energetic capacity estimated from a single ramp test protocol.

Methods: In Sports diagnostic center at Faculty of Kinesiology University of Zagreb 132 senior soccer players (20,9±3,5 yrs, 171,4±6,2 cm, 76,4±7,6 kg) of national and international level were tested on an incremental all-out test (every 30'' increment of 0,5 km/h, with constant inclination of 1%) for determining VO_{2max} and 300m ramp test (15x20m continuous dash) for estimation of their anaerobic capacity. Pearson's correlation coefficient was calculated for the relationship between distance run above the speed that corresponds to the AnT (VT2) up to vmax, and the speed in the 300 meters sprint test.

Results: The maximal speed achieved at 18,0±1,4 km/h, VO_{2max} was 60,0±4,9 ml/kg while the values at the VT2 were, the speed at 13,6±1,1 km/h, and VO_2 was 50,6±4,2 ml/kg (84,5±3,5 %VO_{2max}). The distance run above the VT2 until exhaustion was 1180,6±266,6 m. Average speed at 300m sprint test was 16,1±0,6 km/h. The correlation was found between the distance run above the VT2 until exhaustion and average speed in 300m ($r=0,5$ $p<0,5$).

Conclusion: While the found correlation is not great, it is still considerable and indicates that the distance that is run above the VT2 in a protocol designed for determination of aerobic energetic capacity is related to performance in a typical anaerobic energetic capacity test. Therefore, it is possible to gain insight into the anaerobic fitness of soccer players even if we only perform an aerobic fitness test.

Changes of the anaerobic threshold and VO2max at the various sports level canoists in the training macrocycle

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Purpose: The aim of the study was to assess the level and dynamics of changes in the anaerobic threshold and VO2max of junior and senior canoeists in a training macrocycle.

Methods: In examinations 13 canoeists participated in the age of 14-27 years representing the diversified sports level (junior man = 6 and senior man = 7). Examinations were being carried out three times in the training macrocycle: at the beginning of the preparatory period, at his ending and in the competition period.
All athletes underwent a graded exercise test (GXT) on a Dansprint PRO Canoe Ergometer. GXT began at workload of 0,3 W/kg. The work rate was incremented by 0,3 W/kg every 3 min until the subject could no longer maintain the workload. Each test lasted 12-18 min depending on age and aerobic fitness status. Physiological measurements: expired gases, minute ventilations (Ve) and heart rate (HR) during GXT were monitored continuously with an automated system (Oxycon Mobile). Oxygen intake (VO2) and carbon dioxide output (VCO2) were measured breath-by-breath, and were averaged at 15-s time periods. Peak VO2 was defined as the highest 15-s averaged VO2 obtained during the last exercise load on the test. HRmax (bpm) was measured as the highest 15 second average value in the test. To determine anaerobic threshold (AT) the OBLA method was administered. Lactate level was determine (Blood gas analyzer ABL90 FLEX) in capillary blood samples taken before GXT and after each workload.

Results: The threshold values of juniors changed in the macrocycle from the value of 51.07 (W) at the beginning of the preparatory period to 67.3 (W) at its end and to 68.35 (W) in the competition period. Relative power varied accordingly: from 0.75 (W / kg), through 098 (W / kg) to 0.99 (W/kg) and VO2max from 46.6 (ml/kg/min) in the first term, 47, 77 (ml/kg/min) in the second term and 49.22 (ml/kg/min) in the third term.
The threshold values of seniors changed accordingly: from 79.9 (W), 94.09 (W) to 97.23 (W), relative power per kg from 0.97 (W/kg), 1.12 (W/kg) to 1.17 (W/kg) and VO2max from 50.16 (ml/kg/min), 50.79 (ml/kg/min) to 51.90 (ml/kg/min).

Conclusion: There were found dynamic changes in performance indicators during the preparatory period and only slight increases in the competition period. The competitors of both groups slightly differed in the level of Vo2max, while significant differences were observed in the values of threshold power and relative threshold power (better indicators of performance).

The issue of time rule violations in tennis and the impact of a shot clock

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Purpose: The 2018 US Open will be the first Grand Slam tournament using an on-court shot clock, which was already intended for the 2018 Australian Open. The goal of this introduction is to ensure that players obey the 25-seconds-rule between serves, hereinafter referred to as time rule (formerly 20 seconds at ITF tournaments). Based on an investigation of the 2016 Australian Open this study discusses the need for this intervention and patterns of rule violations (Kolbinger, Großmann and Lames, 2018). The study will be replicated for the 2018 US Open to evaluate the success of the intervention.

Methods: The duration of 3475 inter-point breaks, which were subject to the 25-seconds-rule, was collected together with several context variables that were used to create a total of 29 predictors (designations of the variables *in italic*): Length of the previous rally (*PrevRL*), service *game*, *set*, current scoring *streak* and whether the serve was taken in a *tiebreak* or labeled as an *important point*. The serving players (n=24) were transformed into 23 dummy variables, equaling one if the respective player took that serve and zero if not. All those variables were then included in a regression model to screen their influence on the inter-point time.

Results: The time rule was violated for 58.5% of the investigated serves, with not even 0.1% of those violations being penalized by the umpires. The chosen model including all predictors was able to explain 60% of the variance in inter-point time, with the variables *PrevRL*, *game*, *tiebreak*, *important point* and *streak* showing an autonomous influence. Excluding the player dummies led to a significant drop of the adjusted R^2 to 0.35.

Conclusion: The study of the 2016 Australian Open pointed out important issues that should be considered during the introduction process of the shot clock at the 2018 US Open. First, the time rule is violated a lot and those violations only penalized occasionally. Second, the results for i.a. *streak* indicate that players extend the inter-point time for tactical reasons, in this case to interrupt the rhythm of the opponent. And finally, especially the longer breaks after extensive rallies show that there might be a need for longer recovery intervals after such points. Thus, it could be argued that the time rule should be applied using a dynamic time limit. The replication study of the 2018 US Open, therefore, will not just replicate the investigation but focus on the umpire's and player's behavior after long rallies.

The effectiveness of proprioceptive and cognitive training for improving motor and cognitive functions in nursing home residents

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Purpose: The primary aim of the present study was to test to what extent physical (proprioceptive training) as well as non-physical (cognitive training) intervention programs influence motor and cognitive abilities of older individuals who live in nursing homes. The secondary aim was to evaluate the effectiveness of two intervention programs in subgroups of healthy older adults, older adults with mild cognitive impairment and diagnosed with dementia.

Methods: Sixty-six older adults (83±7 years) with no cognitive deficit (MoCA ≥ 26), mild cognitive impairment (18 < MoCA ≤ 25), and dementia (MoCA < 17), were included in the randomized controlled trial. Physical and non-physical training were administrated for 8 weeks (2 times per week; altogether 16 sessions). In each session of physical training, participants had approximately 30 min of individualized proprioceptive neuromuscular facilitation techniques and approximately same amount of proprioceptive training, which included exercises for strengthening proprio and graviception, balance, coordination and strength. Moreover, participants randomized in cognitive training group performed approximately 60 min of computerized spatial navigation training. Participants were measured pre- and post-2-month intervention on a battery of physical performance tests as well as on neuropsychological assessment battery. Control group received no specific treatment and performed pre- and post-measurements only. Statistical evaluation was performed with RM ANOVA where statistical significance was set at the level of $p < 0.05$.

Results: No significant differences between three groups were obtained at baseline assessment on all functional and cognitive tests ($p>0.05$). Also, no significant improvements were not obtained in any of functional parameters (gait speed, semi-tandem stance, tandem stance, grip strength; all $p>0.05$). To the opposite, both training intervention triggered significant improvements on 1st and 2nd condition (of a total of 5) of Trail Making Test ($p<0.05$). Only cognitive training group improved significantly on the Rey Auditory Verbal Learning Test ($p<0.05$). Finally, when participants were split into three groups according to their cognitive status, larger improvements were seen

in healthy older adults and older adults with mild cognitive impairment, as compared to those diagnosed with dementia.

Conclusion: Our pilot study results showed that both, physical and non-physical trainings improved attentional abilities, while only cognitive training improved memory performance in normal nursing home residents as well as those with mild cognitive impairment. The absence of improvements on functional tests could be attributed to insufficient training dosage or low sensitivity of selected tests. Overall, our pilot study provide empirical evidence that physical and cognitive trainings are acceptable by nursing home residents, and most importantly, physical and cognitive training improve attentional and mnemonic cognitive abilities. Future studies could apply this knowledge for the purposes of cognitive-motor rehabilitation.

The effects of physical activity on depressive symptoms among elderly people: a systematic review

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Purpose: The purpose of this study was to investigate the potential effects of physical activity on depression or depressive symptoms among elderly people.

Methods: The most visible electronic databases: Web of Science, SCOPUS, MEDLINE and Google Scholar were searched for original research articles available until May 2018. Then, research findings were summarized in order to identify randomized controlled trials (RCT's) about the effects of physical activity treatments on depression or depressive symptoms among the elderly people. The studies were classified according to the baseline depression status of participants and assessed in relation to allocation concealment, blinding at outcome assessment, follow-up and whether intention to treat analysis was used. Studies meeting the inclusion criteria were accepted.

Results: Physical activity was effective in treating depression among those suffering from minor or major depression and in reducing depressive symptoms among those with a high amount of depressive symptoms at baseline. However, both the allocation concealment and the blinding method were adequately described in only four studies. Furthermore, intention-to-treat analysis was conducted in half of the studies and some follow-up information after the intervention has been published for five studies.

Conclusion: Physical activity may be efficient in reducing clinical depression and depressive symptoms in the short term among the elderly people suffering from depression or a high amount of depressive symptoms. In order to get more useful information, more well-controlled studies are to be done.

Key words: physical activity, depression, elderly people, systematic review

Motor imagery intervention improves functional performance following total knee replacement

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Purpose: Current study investigated the added value of motor imagery (MI) to common physical therapy in reducing the deterioration of quadriceps muscle voluntary activation (VA) and other variables related to functional performance in patients after total knee replacement (TKR) surgery.

Methods: Twenty-six patients (14 males and 12 females) were randomly assigned to MI practice combined with common physical therapy group (MIp) ($n = 13$; mean age: 61.7 y) or to a control group receiving physical therapy alone (CON) ($n = 13$; mean age: 58.9 y). MViC and VA of quadriceps muscle, pain level, along with timed up to go (TUG) were evaluated before (PRE) and one month after surgery (POST).

Results: Significant interaction indicated better rehabilitation outcomes on the operated leg for the MIp group compared to CON: at POST, the MIp showed lower strength decrease ($p = 0.012$) and unaltered VA, significantly greater then CON ($p = 0.014$). Additionally, MIp performed better in TUG ($p < 0.001$) then CON. The non-operated leg showed no significant differences in any outcome measures at POST (all $p > 0.05$). Furthermore, multiple linear regression analysis showed that failure of VA explained nearly half of the quadriceps muscle strength loss, with no significant difference in perceived level of pain.

Conclusion: MI practice, when added to physical therapy, improves objective measures of patients' physical function after TKR. Moreover, there was positive transfer of MI strength task on functional mobility battery tests.

A model for safe and effective return to sports after injuries

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Purpose: Not only the results of athletes and their teams are connected to sport injuries (SI), but also their long-term health, quality of life, socio-economic status and consequently, the general financial burden on the society. SI are often strongly connected with previous injuries and often repeat because of several simultaneous injuries (de Visser et al., 2012) or due to maximum burden after a previous injury (Creighton et al., 2012). The absence of pain and/or structural healing may in no case be the only factors on deciding on the return of an athlete to training or competition, which is often the reality. Therefore, the decisions about the right moment and method of return to sport are very important, but the information on this are difficult to obtain with currently available methods. Ideally, it is necessary to search for and eliminate the factors for the injury, which is often excessive burden, muscle fatigue, muscular imbalance, insufficient force, weakened part of the body due to previous injuries etc.

Methods: Methodology of ongoing research project aiming to monitor epidemiology of SI in Slovenian premium clubs in soccer, basketball and gymnastics will be presented. Furthermore, we will focus on thigh injuries to develop o model of safe return after SI as well as to design a prediction model. For the first time we will introduce the Tensiomyography (TMG), a non-invasive and selective tool for muscle screening, in a field of SI. As a recommendation from former experiences, a FC Barcelona documented a Muscle Injuries Clinical Guide 3.0 that explicitly emphasizes the use of TMG for the follow-up of functional recovery of muscle and to help decide the return to play. We will also monitor the possible relationship of re-perfectionism and life time events of athletes with prevalence of SI. So far, we collected data on 240 athlete's readiness and the incidences of SI of the 10 clubs of the first Slovenian soccer league.

Results: Background of the model for safe and effective return to sport after SI with some preliminary data will be presented. We will show that prediction model based solely on TMG data has a potential to predict thigh injuries with high objectivity and middle-to-high specificity. We believe there is a potential for high impact of experimental data in high-level athletes in the field of prevention and treatment of SI.

Conclusion: Basic outcome of the proposed project i.e., information system, will be available to scientists and expert from different fields for safe and ethically acceptable access to data with the goals to discovering new knowledge, risk factors, international comparability and transfer of best practices.

Does perfectionism in sports leads to “injury prone athlete” - the validation of “SPORT – MPS-2” questionarie

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Purpose: As perfectionism is broadly defined as a combination of excessively high personal standards and overly critical self-evaluation (Frost, Marten, Lahart, & Rosenblate, 1990), it is common among athletes to identify themselves as perfectionists. A wide range of different qualitative research (e.g., Gotwals & Spencer-Cavaliere, 2014; Hill, Witcher, Gotwals, & Leyland, 2015; Sellars, Evans, & Thomas, 2016) provided evidence that influence of perfectionism is exceedingly complex and affects athletes’ personal lives. Latest researches founded perfectionism at international level athletes as a major source of their motivation and professional success (Hill et al., 2015). However, at the same time also as a significant source of personal and interpersonal difficulties: negative mental (e.g., worry), emotional (e.g., anxiety), and physical experiences (e.g., sleepless nights), as well as poorer relationships with others such as family and friends. Whether perfectionism is something to be encouraged or to be avoided because of possible incidence of injury at athletes, was empirical question of our research.

Methods: The research is conducted in the frame of national applied project “The Development of sport injury model for effective prevention, diagnostic, and rehabilitation” led by Institute for kinesiology research, Science and research centre, Koper, Slovenia. To measure perfectionism, we used Competitive Orientations Scale (Sport-MPS-2) (Gotwals et al., 2012) with 42 questions and 6 subscales as a combination of the Sport Multidimensional Perfectionism Scale (SMPS; Dunn et al., 2006) and the Multidimensional Inventory of Perfectionism in Sport (MIPS; Stoeber, Otto, Pescheck, Becker, & Stoll, 2007). Because we used this questionnaire for the first time, we aimed to provide to Slovenian speaking community a valid and reliable version of Sport-MPS-2 questionnaire. To investigate both absolute and relative test-retest repeatability, the questionnaire was sent by mail to athletes 7-10 days after the first assessment.

Preliminary results: According to ongoing project, we have obtained 260 questionnaires from 10 clubs from the Slovenian first football league and there will be presented at the conference. Measurement of perfectionism (Sport-MPS-2) and other tests of proposed sport injury model will be repeated after one year to follow the possible incidence of injury with level of perfectionism of athletes participated in the project.

Conclusion: Our research findings will be available to the scientists and experts to avoid possible incidence of injury also from the point of negative impact of perfectionism.

Possibilities of using hyperoxia in floorball

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Purpose: The aim of this study is to propose the possible use of hyperoxia for increasing performance and accelerating recovery in female floorball players.

Methods: The information about the effect of hyperoxia on performance and recovery was assembled based on expert studies available from the primary databases Web of Science and Scopus. Articles were expanded using a reference pick ("snowball" method) of other works written by the same authors and works of cited authors in these articles.

Results: Haseler, Hogan & Richardson (1999) and Nummela, Hamalainen & Rusko (2002) claim that an increase of performance with the inhalation of hyperoxic oxygen was observed mainly in activities that last 2–3 minutes and also in ice hockey players (Suchý, Pupiš & Novotný, 2012). The results of many studies confirmed that the inhalation of concentrated oxygen is possible to accelerate recovery between short-term training loads by increasing the saturation of blood and tissues with oxygen (Suchý, 2012; Pupiš, Babaríková, Brunerová, & Suchý, 2011). Hyperoxia improves performance during both maximal and submaximal loads under cycloergometer training load (Grataloup et al., 2005; Linnossier et al., 2000; Lovering et al., 2008; Peltonen, Tikkanen & Rusko, 2001; Prieur et. al., 2002; Tucker et al., 2007). Since in the game of floorball there is an intermittent load of submaximal intensity, it seems appropriate to use hyperoxia to increase performance. The effect of hyperoxia on performance in team sports is still an unexplored area. It would be appropriate to find out the effect of hyperoxia on performance in floorball matches, but this can be affected by many surrounding factors. We will focus on performance by recurrent short-term anaerobic load in the laboratory and a sport-specific test. We will use a laboratory and sport-specific test – the Wingate test (Bar-Or, 1987) and the modified Illinois agility test (Cureton, 1951). In both tests two measurements will be done – with a hyperoxic mixture and with a placebo. We will use a crossover double-blind design. The testing battery of laboratory measurement and sport-specific test includes two tests; between them there will be a 2-minute pause with breathing of a hyperoxic mixture/placebo. Oxygen inhalation is not on the World Anti-Doping Agency banned list.

Conclusion: According to the theory research, we presume that floorball players could improve their performance after inhalation of the hyperoxic mixture, which can be verified by the proposed tests or by the pilot in a match.

Influence of the new regulated device (OMEGA OSB12) on the kinematic variables of the competitive backstroke start

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Introduction: The latest version start device (OMEGA OSB12) was allowed to use in swimming races in order to avoid swimmers' feet slipping and to add tactile feedback during the backstroke start. However, the impact of such device on biomechanical variables or start performance are unknown. Therefore, the aim of this study was to analyse the influence of the new device on kinematic variables of the backstroke start.

Methods: Ten national and international competitive level swimmers (16.0 ± 1.29 years, 56.4 ± 6.88kg, 1.67 ± 0.05m) completed three sprints of 25m at the maximum speed possible, using in each of them (in a random order) a start without start device, with start device in position -4 and 0. The aerial and subaquatic phases of the starts were recorded with the technique DLT-2D to acquire the real coordinates. The swimmer's twenty-one body landmarks were manually digitized into key events of the start. Variables of temporal, spatial, velocity, angular, kinematic and the parameters of swim stage were calculated. The comparisons were undertaken among three start positions via the non-clinical magnitude-based inference.

Results: The new device decreased the time in 5m (ES: 0.05 and 0.21) and increased the velocity in 10 and 15m (ES: -0.05 to -0.23). The time of hand release, take-off and entry, the initial height, release height, release distance, take-off height, entry height, entry distance, height of maximum depth and distance of maximum depth of swimmers using the device were increased (ES: -0.16 to -1.85). There were increases in velocity of release at *Y axis* and entry at *X axis* (ES: -0.23 to -1.01); and decreases in take-off at *X axis*, entry at *Y axis*, complete immersion at *X axis* and maximum depth at *X axis* when using the device (ES: 0.38 to 0.55). The angle of release, entry and complete immersion increased (ES: -0.27 to -0.98) while the angle of take-off decreased (ES: 0.43 and 0.44) using the device.

Discussion: The study showed that the following start-related variables: time of hand release to 5m, take-off and entry distances reached by center of mass (CM), velocities of CM in key positions, angles of hand release, entry, immersion and velocities in 5,10 and 15m, were improved after using new regulated device. The previous studies found that these variables are related to the performance of backstroke start. Thus, the new device helps to improve the performance of swimmers in backstroke start.

The relationships between blood lactate elimination and production rate with cyclists' aerobic and anaerobic performance during laboratory testing

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Purpose: The aim of this study was to examine the relationships between blood lactate elimination (BLA_{elim}) and production (VLa_{max}) rate with cyclists' aerobic and anaerobic performance parameters during laboratory testing.

Methods: During the preparation period (in January), 12 competitive U23 road cyclists (20.2±1.5 yrs., 183.6±7.5 cm, 77.2±7.7 kg, Vo_{2max} 70.5±4.6 ml/min/kg) performed cycling incremental test (step 3 min, increment 30 W) using cyclists' personal racing bikes mounted on the cycling ergometer Cyclus 2, until exhaustion. Blood lactate (BLA) levels were measured 60 seconds after the incremental test ended and in the end of every 5-minute period during a 20-minute active recovery which was performed at 100 W load. BLA_{elim} rate was calculated as a slope of linear fit of the measured samples during recovery period. The power (P [W/kg]) and oxygen uptake (VO_{2max} [ml/min/kg]) levels at maximal (VO_2-P; VO_{2max}), the first (AeL-P; AeL-VO_2) and second (AnL-P; AnL-VO_2) ventilatory threshold levels were assessed using Cosmed PFT Ergo. All parameters were normalized with body mass. After 20-minute active recovery cyclists performed 30-second maximal sprint test at fixed cadence of 110 rpm, to determine anaerobic power and capacity. VLa_{max} rate was calculated as $VLa_{max} = (La_{maxPost} - La_{Pre}) / (t_{test} - t_{alac})$ Abbr. are as follows: $La_{maxPost}$ = maximal post exercise BLA (max. value measured every minute until the first drop of the BLA), La_{Pre} = BLA before test (last sample from the 20-minute recovery period), t_{test} = test duration (29 s), t_{alac} = alactic time (5.5 s). BLA_{elim} and VLa_{max} ratio was calculated (EP_{ratio}). Descriptive statistics were computed for all variables expressed as a mean±SD. Pearson correlation was used to examine the relationships between BLA_{elim} and VLa_{max} with aerobic and anaerobic performance parameters. Significance level was set at $p<0.05$.

Results: Descriptive statistics: AnL-P – 4.4±0.3 W/kg; AnL-VO_2 – 63.2±3.8 ml/min/kg; VO_2-P – 5.1±0.3 W/kg; VO_{2max} – 70.5±4.6 ml/min/kg. EP_{ratio} correlated with AnL-P (r = 0.64); AnL-VO_2 (r = 0.63) and VO_2-P (r = 0.79); VO_{2max} (r = 0.68). As $EP_{ratio,}$ BLA_{elim} had similar but weaker relationships (r = 0.49; 0.57; 0.74; 0.64, respectively) with aerobic parameters. VLa_{max} did not correlate with any aerobic nor anaerobic performance parameters.

Conclusions: Lactate elimination rate and the ratio of lactate elimination and production are good indicators for predicting cyclists' aerobic performance in preparation period, before the racing season starts. Anaerobic power and capacity were not correlated with lactate production rate.

The application of notational analysis in futsal biomechanics research

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Purpose: In 1998, the British Olympics Association (BOA) initiate its Performance Analysis Steering Groups where effort was made to bring together application of biomechanical and notational analysis to help improve the athletes' performance by understanding more about human movement relation to sports performance (Bartlett, 2001). Since then, it can be argued that the lack of co-utilization between both types of analysis in team sports performance has been acknowledged for quite some time now. On a different note, biomechanical analysis on performance and footwear has received critique for not systematically reported the rationale of the analysed movement task in their research (Emery et al., 2016). Thus, the aim of this study was to use notational analysis to clarify the importance of selected futsal movements to be further analysed in footwear-related biomechanics research.

Methods: A total of eight futsal matches from the 2014 ASEAN Futsal Championship (AFF Futsal Championship) were recorded and observed. The matches consist of four group stages, two semi-finals, a third-place play-off and the final. These selections were made in order to obtain data from matches between the best performing teams and the team that finished last during group stages (n=4), and to compare them with matches among the best performing teams in the competition (semi-finals onwards, n=4). Based on the observation, eight movement indicators (*forward translation, backward translation, side translation and slow rotation;* defined as the low shoe-playing surface traction demand movement, and *side step, crossover cut, fast rotation and sudden stop;* defined as the high shoe-playing surface traction demand movement) were established. An independent sample t-test ($p<0.05$) was used to identify differences on the rate of occurrence of these movements in matches from different stages during the tournament.

Results: Based on the independent sample t-test results, it was found that there were significant differences in occurrence of the two of the high-traction demand movements (*crossover cut and fast rotation*). No significant differences were found for all low-traction demand movements when compared between the group stage matches and matches from semi-finals onwards.

Conclusion: The rate of occurrence of high-traction demand movements tend to be higher in futsal matches among the best performing teams. Based on the study results, these movements were selected to be further analysed in biomechanical analysis on performance and footwear.

Age-related slowing of tensiomyographic contraction time in non-athletes, power and endurance master athletes

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Purpose: In nonathletes muscle mass shows a progressive decline of as much as 1% to 1.5% per year after about the age of 50 (1). The age-related loss of muscle mass is a consequence of loss and atrophy of muscle fibers. Since many of the age-related changes in skeletal muscle are similar to those induced by disuse it is likely that the decrease in physical activity in old age is a major contributor to the muscle wasting during aging. Master athletes, however, maintain high levels of physical activity and suffer from fewer morbidities (2), thereby providing a unique human research model to disentangle the effects of disuse and comorbidities from aging per se. There are indications of disproportional age- and physical inactivity-induced muscle wasting between muscles. Therefore, the aim of this study was to assess age-related changes in the Tensiomyographic contraction time (3; Tc) of the vastus lateralis (VL), gastrocnemius medialis (GM), and biceps femoris (BF) muscles in older nonathletes and master athletes.

Methods: Tc was assessed in VL, GM and BF muscles in in older nonathletes (age=62.1±12.7 years; N_{MALES}=133; $N_{FEMALES}$=246), power (age=56.9±13.5 years; N_{MALES}=100; $N_{FEMALES}$=78) and endurance master athletes (age=56.5±14.5 years; N_{MALES}=76; $N_{FEMALES}$=73). Furthermore, in a subsample of 17 master athletes we obtained VL biopsies for myosin heavy chain (MHC) determination.

Results: We found an age-related slowing in all muscles, irrespective of discipline, where endurance master athletes had the longest and power master athletes had the shortest Tc. Our findings were confirmed also by MHC estimation, where power athletes had lower amount of MHC type 1 than endurance athletes.

Conclusion: TMG revealed that the age-related slowing of muscle contractile properties occurs particularly in endurance athletes. Here we suggest that this may be related to their high proportion of type I and IIa fibers that have been reported to exhibit an age-related slowing independent of shifts in myosin heavy and light chain composition.

Historical aspects of performance analysis in sport

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Purpose: Performance analysis in sport has the aim to advance the understanding of game behaviour based on the notation of some specific actions at the sports field with the ultimate aim to better understand different aspects of sports performance (tactical, technical, biomechanical, physiological etc.), and to predict the upcoming behaviour and actions of the opponent. The aim of this paper was to present the historical aspects of the performance analysis in sport, to find the roots of this very specific field of sports science and to identify the milestones in the development of performance analysis in sport.

Methods: This research is conducted as literature review. Articles were identified through multiple formal search methods including hand searching of key journals and textbooks relevant to performance analysis in sport, electronic searching of main databases and searching the references within relevant articles. Electronic searches of the following databases were conducted: Web of Knowledge, Web of Science, SPORTDiscus, Google Scholar, PubMed.

Results: The roots of performance analysis date back to the last decades of the 19th century and the newspaper reports about the sports statistics of game events. The first performance analyst were the journalist who reported from the sports fields about frequency of some actions in tennis, fencing, football and other, in this time popular sports. They have used hand notation, pen and paper method and the system of specific symbols to note the movement patterns, strategy and tactics. Development of IT brought performance analysis to the level of using specialized softwares which highly advanced the process of analysis. Computerised notation and coding system, using of digital video and automized data capture made performance analysis much easier and provided the opportunity of obtaining more data to analyse.

Conclusion: Until now performance analysis in sports evolved to the level of establishing study programs and even independent departments devoted to the performance analysis, and the influence in sport keeped this original informative level of reporting from sports events, and above all reached great influence on sports rules and introduction of the Hawk-Eye challenge system in tennis or Video assistant referee in football. Nowadays performance analysis is indespensable part of sports competition and training supported by the newest technical and technological devices.

Key words: sports analytics, history, time-motion analysis, notational analysis

Sanctions for (alleged) doping violations and the motivation of athletes

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Purpose: The banning of Russian athletes from participating in the Rio de Janeiro OG (2016) has unfortunately led to a growing influence of politics in sport again. The declaration of the fight for "clean sport" (against doping) is partially reminiscent of the situation with the Olympic boycotts in the 1980s, when the inability to attend the Olympics damaged the sporting careers of many athletes and thus had a fundamental influence on their motivation to compete.

Objectives, methods: A reflection on the current unsustainable system of sanctions for (both unproven and positive) doping findings and the related demotivation of athletes. The following was used in producing the text: search of the literature and output from discussions with coaches and experts. The author has no conflict of interest (including the fact that he was never a coach or member of a team whose athletes violated the anti-doping rules).

Results: Currently athletes are being disqualified from participating in many top competitions SOLELY on the basis of belonging to a certain nationality, not on the basis of (positive) results of doping tests. An example is the decision by IAAF for the "temporary" suspension of the Russian Athletics Federation's membership of 13 December 2015. In my opinion this decision is a continuation of the economic and political sanctions for the occupation of Crimea. The anti-doping rules are initiated by a narrow circle of persons from around WADA, the leadership of which is comprised of unelected representatives of the Olympic movement and "public authorities". This group of persons has issued (inter alia) a rule on disqualification up to several years back on the basis of (even alleged) retroactive doping finds. I consider this rule to be demotivating for athletes and devastating for the established system of competitions, and thus at fundamental odds with the principles of athletic competition. One cannot retroactively change the order of results unless there are negative samples available for all athletes who are placed higher in the overall order. The system of sanctions has a negative impact (inter alia) on the motivation of young athletes, because they do not know whether their victorious idol might end up being erased from the sporting world. What motivation do Russian youth coaches use now? If you win, you will not have the right to attend international competitions under your national flag and listen to your national anthem?

Conclusions: I am not defending athletes who knowingly violate any rules (including doping ones), I am just presenting for discussion the question of whether all athletes have the same conditions? Are the rules for starting at competitions the same for everyone? Can athletes attend competitions regardless of what specific federation, branch of sport or country they belong to? Recommendations for the order on many results sheets are initiated by a narrow circle, who unfortunately do not think through the consequences of

their decisions for the motivation of athletes and the popularity of sport. It is not possible to allow doping, but it is essential to initiate a discussion about the following key topics:

1. eliminate disqualification from competitions solely on the basis of nationality
2. cease disqualification and associated changes to results many years back
3. declare the official results for example one or two days after the competition with a statement that all participants have (current) negative doping tests
4. fundamentally elaborate on the methodology of “biological passports”
5. try to limit the influence of politics on the sporting environment, athletes and coaches
6. reorganise the actions, procedures and financing of WADA

Coach, an individual between the real condition and theoretical expectations

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Introduction: According to today's view, the work of a coach cannot be limited to the fact that the athlete, as an individual or a team, achieves a certain physical condition, or that the athlete is lead through technical and tactical challenges, but the work of a coach should also be the factor that analyses and synthesizes the facts about the condition of the athlete and the environment in which the athlete works. Thus, a picture is being created of a coach as a highly educated individual who stands at the forefront of a team of professionals of different profiles, a person who possesses professional, methodological and pedagogical knowledge. Since in practice there is a mismatch between expectations and the actual situation, coaches, who traditionally regard only technical and tactical skills as their domain, are under great pressure.

Methods: For this article we searched the "Hrčak" article database. We have reviewed and analyzed sixteen articles about trainers in all aspects.

Results: Sport results as the supreme benchmark for a trainer's success, psychologization and feminization of social norms and goals slowly take hold of debates about concealed authoritarianism, negative outcomes, subordinated personalities or anger, neglecting of social conventions, and unsportsmanlike conduct that would have all of its source in a trainer's ego, the lack of their social sensitivity and the tendency towards punishment. The same professional literature that has become aware of these behaviour patters strives to promote a democratic coach and a motivated athlete (i.e. the stereotype of the educational system), it is concerned with the questioning of the quality of the relationship between the coach and the athlete, it has also been trying to include the interpersonal aspects of coach behaviour into the existing questionnaires about the management in the sport, it also discusses the preoccupations of the old and young coaches, it establishes the limits and sets norms for the differences between coaching and abuse, and similar things.

Conclusion: We need to see what will bring a trend that in the first row pushes only the feelings of parents, athletes and trainers. Or, do you need the discipline and hard work to get the top result?

Key words: coach, quality of sport, psychologization

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