Ministry of Higher Education and Scientific Research

Abdelhamid Ibn Badis University - Mostaganem

Institute of Physical Education and Sports

Division: Physical Education and Sports /Sports Training

Option: Competitive sports training.

In Partial Fulfilment of the Requirements for the Degree of Licenses in sports training

Title:

# Study of the Real-time effect of Special Judo Fitness Test Performance Before and After: Active, Passive & Judo Specific Recovery

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**University year:2022-2023**

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## List of summery

# Dedicate:

I dedicate this work to my parents, and my small family for love i get

and my sensei and my teacher the doctor Belkadi Adel.

for all the support and the helps that I received from him

# Acknowledgments

I thank, in the first place, God for giving me the protection and health

complete this mission.

I thank my parents, and my small family who they always beside me

I thank my sensei and my teacher the doctor belkadi Adel for all help and

support his orientation that I received from him

I thank all the athletes of the national judo team of algeria

I also thank the Sensei .belkadi adel and bendjeloul salah eddine., which had

stimulated

its athletes to participate in the study.

I thank to the members of the Judo Club Of Mostaganem

I thank my friends:…………………………………..

Finally, I thank my idol, ……………………………………………………………………………………………

Many thanks to all of you

## المُلخَّص باللغة العربية

**الهدف :** تهدف هذه الدراسة إلى التحقيق في تأثير طرق الاسترجاع المختلفة ، بما في ذلك ( AR ) الاسترجاع الايجابي ، السلبي ,( PR ) والاسترجاع الخاص بالجودو ( JSR ) على أداء ما قبل وبعد الاسترجاع لاختبار اللياقة البدنية الخاص بالجودو .( SJFT ) بالإضافة إلى ذلك ، تهدف الدراسة إلى مقارنة فعالية طرق الاسترجاع هذه من حيث طرد اللاكتيك من الدم. الأساليب: تم تجنيد ما مجموعه 12 مشاركًا من معسكر الجودو في عام 2022 ، واستوفوا معايير الدراسة. تم إجراء القياسات الأنثروبومترية واختبار عتبة اللاكتيك ( LT4 )في اليوم الأول ، تليها SJFT في الأيام الثاني والثالث والرابع. وعقب كل SJFTإحدى طرق الاسترجاع الثلاثة. تضمنت طرق الاسترجاع الاسترجاع السلبي ( الذي لا يزال ) ، والاسترجاع الايجابي ) يعمل بنسبة 80٪ من ( LT4 ، والاسترداد الخاص بالجودو uchi-komi ) بنسبة 80-100٪ من .( LT4

**النتائج:** أظهر أداء الاسترجاع قبل وبعد الاختبار انخفاضًا كبيرًا في الأداء مع الاسترجاع الإيجابي اما الاسترجاع السلبي فقد أدى إلى اختلاف كبير في الأداء, في حين أظهر الاسترجاع الخاص بالجودو اتجاهاً مختلفا اختلافا كبير. ولوحظت اختلافات كبيرة أيضا من حيث القضاء على حمض اللاكتيك في الدم بين الاسترجاع السلبي واسترجاع الجودو ، و الاسترجاع الإيجابي و استرجاع الجودو, مع كل من الاسترجاع السلبي والايجابي مما يؤدي إلى القضاء على حمض اللاكتيك في الدم افضل من الاسترجاع الخاص بالجودو.

**الخلاصة:** يمكن استخدام الدراسة لاختبار القدرات البدنية للمصارعين, حيث يمكن لجميع المدربين استخدام SJFT اليوم لأنه الاختبار الأساسي لتقييم الأداء الخاص بالجودو ، الموثوق به للغاية والسهل في التطبيق و الموفر من حيث التكلفة ويمكن مقارنته بالعديد من الاختبارات المعملية.

يجب أن يكون SJFT أحد الأدوات الرئيسية للمدربين لتقييم تطور فترة التدريب و مدى نجاعة البرامج التدريبية ، خاصة للجودو عالي الأداء.

**الكلمات المفتاحية:**

اختبار اللياقة الخاص بالجودو ,الاسترجاع الإيجابي و السلبي و الخاص بالجودو

**Abstract:**

**Objective:** This study aimed to investigate the effect of different recovery methods, including active (AR), passive (PR), and judo-specific recovery (JSR) on pre- and post-recovery performance of the Special Judo Fitness Test (SJFT). Additionally, the study aimed to compare the efficacy of these recovery methods in terms of blood lactate elimination. Methods: A total of 12 participants were recruited from a judo camp in 2022, and met the study criteria. Anthropometric measurements and Lactate Threshold Test (LT4) were conducted on day one, followed by SJFT on days two, three, and four. Each SJFT was followed by one of the three recovery methods. The recovery methods included passive recovery (sitting still), active recovery (running at 80% of LT4), and judo-specific recovery (uchi-komi at 80-100% of LT4).

Results: Pre- and post-specific recovery performance showed a significant decrease in performance, with passive recovery resulting in a significant difference in performance, while active and judo-specific recovery showed a trend in significant difference. Significant differences were observed in blood lactate elimination between passive and judo-specific recovery, and active and judo-specific recovery, with both passive and active recovery resulting in more stable blood lactate elimination than judo-specific recovery.

Conclusion: the study can be used to test the physical abilities of practitioners, as the SJFT can be used by all coaches today as it is the primary test for examining performance related to judo, very reliable, easy to perform and very cost effective and can be compared to many laboratory tests. The SJFT should be one of the coaches' main instruments to evaluate the development of a training period, especially for high performing judo.

**Keywords**: Special Judo Fitness Test, Active, Passive , Judo Specific Recover

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# Study Introduction

## I. Introduction:

Judo is a martial art that requires a combination of physical abilities such as strength, power, speed, endurance, agility, and flexibility (Fukuda et al., 2018). Due to its high-intensity nature, Judo has been the subject of several scientific studies aimed at understanding the physiological and neuromuscular variables associated with performance during fights (Franchini et al., 2016; Szmuchrowski et al., 2013). It’s is a physically demanding sport that requires high levels of fitness and technical proficiency(Torres-Luque et al., 2016).

several studies found that Judo athletes have higher levels of aerobic and anaerobic fitness compared to non-athletes, with better oxygen uptake and utilization during exercise (Franchini et al., 2011; Wolska et al., 2022). Another study found that Judo athletes have greater isometric and dynamic strength, particularly in the lower limbs and core muscles (Belkadi et al., 2020; Mala, 2017).

Moreover, analyses of neuromuscular variables such as reaction time, muscle activation patterns, and force production have revealed that Judo athletes have faster reaction times and more coordinated muscle activation patterns during throws and other techniques (Kons, da Silva Athayde, et al., 2020; Kons, Orssatto, et al., 2020).

According to the International Judo Federation, the regulation time for men's matches is four minutes, while for women's matches, it is four minutes (Kons et al., 2022). In 2017, the International Judo Federation made changes to the scoring system, with only ippon and waza-ari scores given during a match (Kons et al., 2022).

During judo practice, Athletes work in high-intensity intervals lasting 20-30 seconds and low-intensity intervals lasting 5-10 seconds for recovery (Adel et al., 2019; Kons & Detanico, 2022). Recent studies suggest that the time in high-intensity intervals has increased slightly, while the time in low-intensity intervals has decreased slightly (Julio et al., 2018; Kons et al., 2018; Kons, Orssatto, et al., 2020). The time spent in standing fights has also increased compared to ground fights, possibly due to rule changes and changes in tactics during low-intensity intervals (Franchini et al., 2017)

Special Judo Fitness Test (SJFT) is a standardized physical fitness test designed to evaluate the fitness levels of judo athletes and control their training process (Belkadi et al., 2015; Benbernou et al., 2022; Szmuchrowski et al., 2013). The normative values of SJFT are used to assess the performance of judo athletes and develop age-specific norms. However, little is known about the real-time effects of SJFT performance and the recovery process after completing the test (Sterkowicz-Przybycień & Fukuda, 2014).

During high-intensity, short-duration performance, the immediate energy system, also known as the anaerobic lactic energy process, is responsible for providing energy without the use of oxygen or lactate formation (Wolska et al., 2022). This system primarily relies on the release of adenosine triphosphate (ATP) and creatine phosphate (PCr) from muscle fibre depots, which are sufficient to support maximum intensity work for up to 10 seconds, or even up to 15 seconds in highly trained individuals (Franchini et al., 2016).

The PCr process is the fastest way to rebuild ATP, allowing athletes to perform intense work in a short period of time (Benhammou et al., 2022; Nasikhah et al., 2021; Youcef et al., 2022). Many sports, such as wrestling, weightlifting, gymnastics, athletics, baseball, and volleyball, rely heavily on the PCr system to generate energy for short maximal efforts (Forbes et al., 2008).

While high-energy phosphates are crucial for movement, stored carbohydrates, fats, and proteins are also necessary to replenish high-energy phosphate stores and provide the energy needed for recovery (Nasikhah et al., 2021). Understanding the contribution of the immediate energy system and the role of different energy sources in short-duration, high-intensity exercise is essential for developing effective training and recovery strategies for athletes (Belkadi et al., 2019; Scott, 2011).

physiological recovery is crucial for athletes as it involves restoring the body's various systems to their pre-exercise state. This includes the musculoskeletal, nervous, immune, and metabolic systems, which can all be affected by the stress of exercise (POWERS & JACKSON, 2008). Recovery strategies post-exercise, such as rest and relaxation (passive), light exercise (active), and nutrition, hydration, and sleep (proactive), are essential in allowing the body to regenerate tissues, replenish energy stores, and recover from the stress of exercise (Cullen et al., 2021). It's important to note that recovery after exercise is not just limited to muscle tissue, as aspects of elevated metabolism also need to recover following high-intensity exercise. By implementing effective recovery strategies, athletes and coaches can optimize performance, prevent injury, and maintain overall health and well-being (Beboucha et al., 2021; Berria et al., 2018; Simjanovic et al., 2009; Yacine et al., 2020).

Recovery after exercise is crucial to optimize performance and prevent injuries. Different recovery methods, including active, passive, and sport-specific recovery, have been used to enhance recovery after exercise (Cullen et al., 2021). Active recovery involves low-intensity exercise, while passive recovery involves rest without any physical activity. Sport-specific recovery involves performing exercises that mimic the movements used in the sport (Perrier-Melo et al., 2021). Optimizing recovery strategies for judo athletes is essential to achieving peak performance in competition (Perrier-Melo et al., 2021).Therefore, understanding the immediate effects of SJFT performance and the recovery process is crucial.

Passive recovery (PR) refers to a state of complete inactivity or the use of external methods such as massage, cold water baths, sleeping, resting on the couch, or bonding with others (Wijianto & Agustianti, 2022). Active recovery (AR) involves any physical activity aimed at recovering from the direct metabolic stress of physical fatigue, such as running, walking, or cycling (Brown et al., 2022).  Perrier (2021) further divides active recovery into general (non-specific) or sport-related (specific), which focuses on the type and magnitude of the need for recovery.By understanding the different forms of recovery and implementing effective strategies, athletes and coaches can optimize performance, prevent injury, and maintain overall wellness.

## II. The study problems:

1. Which recovery method results in a similar performance before and after recovery at the Special Judo Fitness Test?
2. Are there differences between the different recovery methods in terms of pre- and post-recovery performance?
3. Which recovery method results in the fastest blood lactate elimination?

## III. Purpose:

This study aims to investigate the real-time effects of SJFT performance before and after active, passive, and judo-specific recovery, providing insights into the recovery process of judo athletes and their performance optimization strategies. By understanding the real-time effects of SJFT performance and the recovery process, judo athletes and coaches can develop effective training and recovery strategies to enhance their performance and achieve their goals.

## IV. Hypothesis

1. Since all energy systems are involved in different amounts during SJFT performance, the performance in this study should not be equal between the two different SJFT performances such as before and after recovery, despite the recovery time being 15 minutes.

2. As no previous differences between the different recovery methods (PR and AR) in performance at SJFT, as well as trends in difference between PR and JSR at other test were observed. No significant differences will be seen between recovery methods and performance before and after recovery is seen in this study.

3. AR and JSR together will result in the fastest blood lactate elimination, as blood circulation will be higher and blood lactate will be transported faster to other tissues, therefore becoming important.

## V. Study highlight

The aim of this study was to investigate pre- and post-recovery performance in the Special Judo Fitness Test, using different types of recovery methods such as active, passive and judo- specific recovery.

## VI. Key words

Special Judo Fitness Test: The Special Judo Fitness Test (SJFT) was developed by Sterkowicz (1995) and described by Franchini et al. Since then, it has been used in different investigations on judo. The SJFT consists of a test in which the judoka must project (throw) his opponents as fast as possible and is divided into three periods: 15, 30 and 30 s, with 10-s intervals among them. During each period, the executor throws two partners (6 meters apart from one another) as many times as possible, using the ippon-seoi- nage technique. The athlete's heart rate (HR) is recorded immediately after the test and 1 min later.

- Performance : Performance is a concept that refers to the relationship between the means used to achieve something and the result finally obtained.
- Active Recovery
- Passive Recovery
- Judo Specific Recovery

## VII. Similar studies

**1. Title: Developmental associations with muscle morphology, physical performance, and asymmetry in youth judo athletes.**

**Autor: Fukuda, D. H., Beyer, K. S., Boone, C. H., Wang, R., La Monica, M. B., Wells, A. J., … Stout, J. R. (2018).**

**Purpose**: This study evaluated the contributions of somatic maturity (years from estimated peak height velocity) and training experience as developmental indicators of muscle morphology, biomechanical parameters, and bilateral asymmetries in youth judo athletes. Methods Twenty-six judo athletes aged 8–18 years (mean ± SD; age = 12.9 ± 2.6 years, maturity offset = − 0.6 ± 2.2 years, training experience = 6.1 ± 2.9 years) completed anthropometric measurements, performance testing, and ultrasound evaluation of the vastus lateralis.

**Results:** Somatic maturity had the greatest relationship with handgrip performance ($r^2 = 0.76–0.80$; $p < 0.01$) and lower-body plyometric ability ($r^2 = 0.23–0.72$; $p < 0.05$). Somatic maturity and training experience accounted for 72% of the variance in hopping power. Bilateral asymmetries in average/peak force and 1-/2-s force–time integration during isometric handgrip increased with training experience ($r^2 = 0.17–0.46$ $p < 0.05$). Muscle morphology ($r^2 = 0.29–0.75$; $p < 0.01$) was best related to somatic maturity. Significant differences were found between child and adolescent judo athletes in force–time curve parameters, muscle morphology, and plyometric ability.

**Conclusions:** These results indicate that somatic maturity and training experience exert unique influences on muscle morphology, biomechanical parameters, and bilateral asymmetries in youth judo athletes.

**2. Title: High-Intensity Intermittent Training Positively Affects Aerobic and Anaerobic Performance in Judo Athletes Independently of Exercise Mode**

**Franchini, E., Julio, U. F., Panissa, V. L. G., Lira, F. S., Gerosa-Neto, J., & Branco, B. H. M. (2016). High-Intensity Intermittent Training Positively Affects Aerobic and Anaerobic Performance in Judo Athletes Independently of Exercise Mode. Frontiers in Physiology, 7, 268. https://doi.org/10.3389/fphys.2016.00268**

**Purpose:** The present study investigated the effects of high-intensity intermittent training (HIIT) on lower- and upper-body graded exercise and high-intensity intermittent exercise (HIIE, four Wingate bouts) performance, and on physiological and muscle damage markers responses in judo athletes.

**Methods:** Thirty-five subjects were randomly allocated to a control group (n = 8) or to one of the following HIIT groups (n = 9 for each) and tested pre- and post-four weeks (2 training d·wk−1): (1) lower-body cycle-ergometer; (2) upper-body cycle-ergometer; (3) uchi-komi (judo technique entrance). All HIIT were constituted by two blocks of 10 sets of 20 s of all out effort interspersed by 10 s set intervals and 5-min between blocks.

**Results:** For the upper-body group there was an increase in maximal aerobic power in graded upper-body exercise test (12.3%). The lower-body group increased power at onset blood lactate in graded upper-body exercise test (22.1%). The uchi-komi group increased peak power in upper- (16.7%) and lower-body (8.5%), while the lower-body group increased lower-body mean power (14.2%) during the HIIE. There was a decrease in the delta blood lactate for the uchi-komi training group and in the third and fourth bouts for the upper-body training group. Training induced testosterone-cortisol ratio increased in the lower-body HIIE for the lower-body (14.9%) and uchi-komi (61.4%) training groups.

**Conclusion:** Thus, short-duration low-volume HIIT added to regular judo training was able to increase upper-body aerobic power, lower- and upper-body HIIE performance.

3. **Title : The Effect of High-Intensity Exercise on Changes of Blood Concentration Components in Algerian National Judo Athletes.**
   **Adel, B., Abdelkader, B., Alia, C., Othman, B., Mohamed, S., & Houcin, A. (2019). Acta Facultatis Educationis Physicae Universitatis Comenianae, 59(2).**

**Purpose:** The aim of the present study to verify the impact of judo competition on changes in the blood count of judo athletes during an official competition. Also to compare these results with the different weight category.

**Methods:** fifteen youth trained athletes were included in the study were divided into three groups according to weight category (light, medial, and heavy) weight. All subjects performed a 5x4mn round of competition with 15mn of rest between rounds and Complete Blood Count (CBC) were collected before, immediately after the competition, Data are reported as mean and standard deviation. The Shapiro-Wilk test was performed to verify the normality of the data, and the significance level was set at $P < 0.05$. Blood sample count was tested by a paired Student's t-test to compare the pre-test and post-test for the three groups.

**Results :** showed that blood cell count was significantly decreased immediately after judo competition ($p < 0.05$). However, red blood cell, White blood cell Blood platelets, Mean Cell Volume were significantly increased after the performance ($p < 0.05$). The current study showed that the judo competition (Rondori) effectively enhance some blood cell count; these changes are transient and probably due to the adaptation to efforts related to judo competition in highly-trained athletes.

**Title: Short-term low-volume high-intensity intermittent training improves judo-specific performance. Journal of Science and Medicine in Sport, 20, e116.**

**Franchini, E., Julio, U., Panissa, V., Lira, F., Agostinho, M., & Branco, B. (2017).**

**Purpose:** An important aspect concerning the specificity principle is related to the time structure of the sport. The aim of our study was the effects of short-term low-volume high-intensity intermittent training (HIIT) added to traditional judo training on physiological and performance responses to judo-specific tasks.

**Material and Methods:** Thirty-five judo athletes were randomly allocated to a control group (n=8) and 3 HIIT groups: lower-body cycle-ergometer (n=9); upper-body cycle-ergometer (n=9); uchi-komi (technique entrance) (n=9). All protocols were constituted by 2 blocks of 10 sets of 20 s of all-out e□ort, with 10 s interval between sets and 5 min between blocks, executed twice per week for 4 weeks. Pre and post-training the athletes performed the Special Judo Fitness Test (SJFT) and a match simulation, with blood lactate, hormones (cortisol, C, and testosterone, T) and muscle damage marker (creatine kinase, CK, lactate dehydrogenase, LDH, aspartate aminotransferase, AST and alanine aminotransferase, ALT) measurements.

**Results:** There was an increase (p=0.031) in the number of throws in the SJFT for the upper-body group, while decreasing the HR immediately after the SJFT and the number of sequences in standing position for the lower body group ($p < 0.001$ and p=0.034, respectively), the index in the SJFT for the uchi-komi group (p=0.015) and the CK concentration (p=□0.014) in the match simulation for the upper-body group. T/C ratio increased (p=0.028) after the match simulation in the post-training.

# First party:

# Theoretical study of research

# Chapter I: Special Judo Fitness Test

# 1. Background: judo

In this study, the starting point will be Olympic judo. In judo, the athlete attempts to throw his opponent on his back or control the opponent through ground fighting (Kano 1932; Franchini et al. 2005a). Based on this, judo can be described as a weighted martial art (Franchini et al. 2011b), which is dynamic, high-intensity and intermittent in its form (Degoutte et al. 2003; Franchini et al. 2007; Franchini et al. 2009; Franchini et al. 2019; Crnogorack 2011). This thus requires complex skills and tactical competence in concert with good physical attributes for the athlete to succeed (Degoutte et al. 2003; Franchini et al. 2005a).

## 1.1. The nature of the judo match

The match time in judo is currently 4 minutes for both women and men (IJF 2020). However, the match time can vary anywhere from a few seconds to continue more than 10 minute, this entirely depending on what the practitioners do during the match and entirely depending on the rules of the sport (Onda 1994; Castarlenas & Planas 1997, Azevedo et al. 2007). To place in the top five at a competition, judo practitioners need to complete 5-7 matches (Franchini et al. 2003) sometimes up to 9 matches (Castarlenas & Solé 1997) in a competition day.

A normal judo match at the elite level lasts about 3 minutes (Onda 1994; Castarlenas & Planas 1997, Miarka et al. 2012). In a study by Monteiro et al. (2019), they show that the total match time for judo increased by 3.6% in the periods 2013-2017. Despite the fact that the match time was reduced from 5 to 4 minutes for men in 2017. This is a direct result of the rule changes and led to more time of the match being spent in the Golden Score (Monteiro et al., 2019).
Golden score is when the regular match time of 4 minutes has ended without any of the practitioners in the match having scored, this moment continues until one of the participants scores either by throwing in standing or controlling the

opponent in ground fighting, or winning on the opponent being disqualified due to direct fouls or too many (3st) warnings (IJF, 2020).

During judo practice, practitioners work in high-intensity intervals lasting 20-30 seconds, as well as 5-10 seconds in low-intensity intervals to recover between each high-intensity interval (Castarlenas & Planas 1997; Franchini et al. 2005b; Marcon et al. 2010 and Miarka et al. 2011, Miarka et al. 2012). However, recent studies such as Miarka et al. (2012) and Monteiro et al. (2019) can show that the time in the high-intensity intervals increased slightly while the time in the low-intensity intervals decreased slightly. At the same time, the time in the standing fight increased in relation to the time in the ground fight (Miarka et al. 2012; Monteiro et al. 2019). This may be a consequence of rule changes that seek a more dynamic and active judo and may have led to changes in tactics during the low-intensity intervals (Monteiro et al. 2019).

This in turn means that practitioners need to be able to perform a high number of intervals during each match. According to Monteiro et al. (2019), judo practitioners perform an average of 32 intervals per match with 25 intervals being high intensity and 8 intervals being low intensity. Other studies show 7-14 intervals in standing and 3-9 intervals in ground fighting. However, the number of intervals per match depends on the match time and the rules of the sport (Castarlenas & Planas 1997; Franchini et al. 2005b). During a competition day, the recovery time between two matches is at least 10 minutes at elite level, however, the usual recovery time between matches is around 15 minutes (Franchini et al. 2003).

The physical demand for a single judo match is therefore high (Franchini et al. 2011b), especially on the upper body (Franchini et al. 2007) as most of the match time (51 ± 11%) in the high intensity periods is spent establishing a grip (Marcon et al. 2010) similar results are also presented by Miarka et al. (2012) at 58%. Monteiro et al. (2019) also say that they see a similar result as 'Miarka et al. 2012' in their study.

Another factor affecting performance in judo is the pace of the match (Franchini et al. 2019), something that has been demonstrated in other high-intensity intermittent sports such as: running (Hanley 2016), cycling (Abbiss et al. 2016), triathlon (Wu et al 2015), swimming (McGibbon et al 2018) and football (Link & Lorenzo 2016). As in other high-intensity intermittent sports (Link & Lorenzo 2016), the tempo in judo depends on a combination of other factors such as technical-tactical, physical as well as psychological factors such as: characteristics of the performer in comparison to his/her opponent, the result on the scoreboard at the specific time, and the time left until the end of the match (Franchini et al. 2019).

### 1.2. Physical requirements of the judo practitioner

After some 40 years of physiological research specific to judo, it is still difficult to describe a single physiological model for judo practitioners. This is due to a large number of variables to take into account: a) difficulties in quantifying effort during matches; b) weight classes; c) non-cyclical nature: where match duration can vary from a few seconds to about 10 minutes;
d) multiple matches per day; e) differences in physical and tactical characteristics of opponents (Castarlenas & Solé 1997).

Several studies such as Gariod et al. (1995); Franchini et al. (2005a); Franchini et al. (2005b); Kubo et al. (2006); Franchini et al. (2007); Franchini et al. (2011a); Franchini et al. (2011b); Kim et al. (2011) show that a certain physique in concert with certain anthropometric variables is necessary for high performance in judo.

Much research has been conducted on the aerobic fitness of judo athletes, the aerobic power has mainly been measured in terms of VO2max or highest measured oxygen uptake (VO2peak), while the aerobic capacity has been measured in terms of anaerobic threshold (Franchini et al. 2011b) where many studies have been based on the protocol according to Heck et al (1985).

Research shows that both aerobic power and aerobic capacity are important for judo athletes in the match, these influence the athletes by allowing them to maintain a higher intensity during the matches as well as delaying the accumulation of metabolites linked to the fatigue process, and hypothetically this should lead to better recovery between two subsequent matches (Gariod et al. 1995, Castarlenas & Solé 1997, Franchini et al. 2011b).

Many studies report VO2max values for male judo athletes between 50-60 ml/kg/min, while women have values between 40-50 ml/kg/min (Franchini et al. 2011b). In a study in which researchers examined the VO2max of untrained students compared to trained runners, they found that untrained students had a VO2max value of 48.9 ± 5.21 ml/kg/min for males and
43.5 ± 3.33 ml/kg/min for females (Zhou 2004a, Zhou 2004b) Based on these values, the VO2max of trained judo athletes is not significantly different versus untrained individuals.

Regarding the anaerobic capacity of judo practitioners, this is a more complex capacity to measure as there are no good methods, however, researchers in judo-specific research have chosen to use the Wingate test to investigate the anaerobic capacity of judo practitioners. A Wingate test is a sprint test on a bicycle in which subjects perform a maximum workload lasting 30 seconds, with a load equivalent to 7.5% of the participants' body weight.

These have then been reported as peak power, mean power and fatigue index. In judo research, Wingate tests have also been performed on both the lower body and the upper body. However, in sports such as judo and wrestling, tests on the upper body are more represented, as these sports place higher demands on anaerobic capacity mainly in the upper body (Franchini et al. 2011b).

The anaerobic performance of the upper body has a correlation between the number of matches won at European World Cup competitions for Peak power (r=0.66) and mean power (r=0.68) in the upper body Wingate test. There is also a correlation (r=0.76) between total performance between two consecutive Wingate tests for the upper body, these separated by 3 minutes of rest, and the number of attacks performed by the practitioners during simulated matches (Franchini et al. 2011b).

Competition judo places high demands on the practitioners, both on the anaerobic and aerobic systems. Where the anaerobic system assists in short max work during matches, while the aerobic system assists in maintaining a higher intensity during matches (Franchini et al. 2003), while delaying the accumulation of metabolites associated with the exhaustion process, as well as enhancing recovery between matches (Gariod et al. 1995; Lech et al. 2010; Palka et al 2013).

### 1.3. Special Judo Fitness Test

As judo is a complex sport that does not have a definite physiological model (Castarlenas & Solé 1997), it is necessary to be able to test its practitioners anyway, in order to get an accurate picture of the athlete's performance in relation to judo. Hence, several judo-specific tests have been developed to investigate this (Santos et al. 2010, Sbriccoli et al. 2007).

There is only one judo-specific test on which most research has been done (Drid et al. 2012), which has high reliability (r = 0.97) with a low chance of measurement error (Sterkowichz 1995: Franchini et al. 2010). It is the Special Judo Fitness Test (SJFT), the test created by Dr. Stanisław Sterkowicz in 1995 (see Sterkowicz 1995) in search of a high-intensity intermittent judo specific test (Franchini et al. 2010).

This is also a test that has high applicability by trainers as one does not need expensive equipment, the test also works for elite practitioners (Drid et al. 2012). The SJFT also shows clear differences between judo practitioners with different physical levels (Franchini et al.2005a). The test has also a high correlation with advanced laboratory tests (Drid et al. 2012, Franchini et al.

2010) and has a high positive correlation with the number of throwing attempts during judo games (Franchini et al. 2005b) and VO2max (Franchini et al, 2007). There is a correlation between frequency in number of throw attempts during judo matches and different level of judo practitioners such as Super Elite Judo practitioners (9±6throws/match) and Elite Judo practitioners (6 ± 4 throws/match) ($p<0.05$)(Franchini et al. 2008; Miarka 2016).

The test is divided into three active intervals (A) 15 sec, (B) 30 sec and (C) 30 sec, between the active intervals 10 seconds of rest are performed. During the test, the test person (called Tori) stands 3 meters away from the persons the Tori is going to throw (called Uke). Uke A and B stand with a total distance of 6 meters from each other (see figure 1). During the active intervals (A,B & C) the tori should run as fast as possible to uke A and throw the ippon-seoi- nage (see figure 2). Then the tori runs directly to uke B and throws the same throw. During the active intervals, tori should have time to throw uke A and uke B on as many throws (of ippon-seoi-nage) as possible (Franchini et al. 2010, Drid et al. 2012).

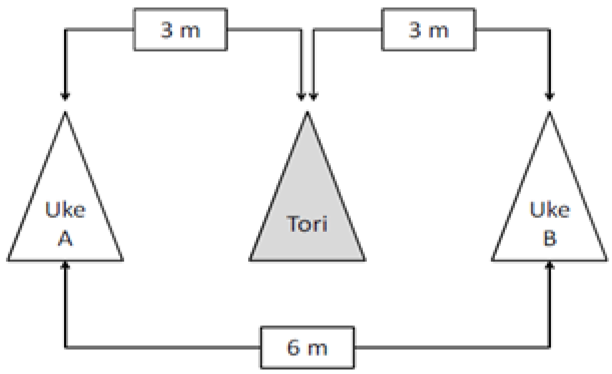


**Figure 1 Positioning for the Special Judo Fitness Test, according to Drid et al. (2012, p. 119).**

**Figure 2: The ippon-seoi-nage throw, according to Drid et al. (2012, p. 119).**

Performance is determined by the number of throws for each period (A, B, C) summed to the total number of throws completed during the test (N); the test measures heart rate immediately (HRimm) after the last performance period and heart rate 1 minute after performance (HR1min) (Franchini et al. 2010; Miarka et al. 2011; and Drid et al. 2012). These values are then inserted into the formula of Sterkowichz (1995) the same calculation has also been used in these studies (Franchini et al. 2007, Franchini et al. 2010; Miarka et al. 2011; Drid et al. 2012).

$$SJFT\ Index = \frac{HRimm + HR1min)\ (A + B + C)}{(HRimm + HR1min)}$$

In implementing the SJFT, the lactic energy system contributes a higher energy contribution 86.8 ± 23.6 kJ or 42.3 ± 5.9% ($p<0.001$) this in comparison to both the lactic acid energy system contributing 58.9 ± 12.1 kJ or 29.5 ± 6.2% and the aerobic energy system 57.1 ± 11.3 kJ or 28.2 ± 2.9% (Franchini et al. 2011c).

# Chapter II: Energy System

## 2. Introduction to energy system

Usually, the body's energy system is divided into two parts - the aerobic and anaerobic systems. The aerobic system creates energy using oxygen and the anaerobic system creates energy in the case of hypoxia or so-called oxygen deficiency. In this case, it is more appropriate to divide the energy system into three different parts, see Figure 3, a form also chosen by Aasen et al. (2006) and McArdle et al. (2005) in their books. Where they divide energy systems into these **three parts:**

**(1) Immediate energy systems,**

**(2) Short-term energy systems,**

**(3) Long-term energy systems.**

These in turn interact with each other to varying degrees depending on the intensity and duration of the work (Aasen et al. 2006; McArdle et al. 2005)

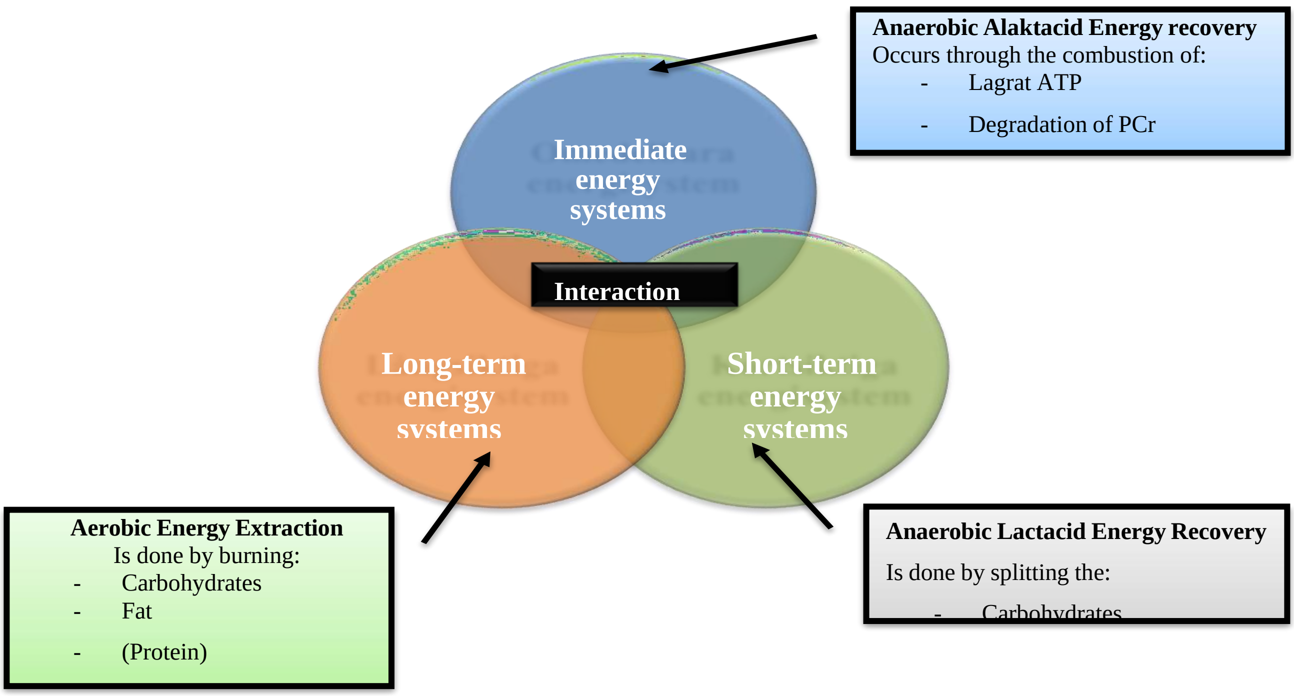


**Figure 3: Model for specific & general concepts of the body's three interacting energy systems (Modified from McArdle et al. 2005, p.224).**

## 2.1. Immediate energy systems:

During a performance that is short in duration and high in intensity, the immediate energy system contributes energy during the performance (McArdle et al. 2005, p.204, Aasen et al. 2006, p.21). The immediate energy system is a process that occurs without oxygen and without the formation of lactate, therefore another name for this process is the anaerobic alaktacidal energy process (Aasen et al. 2006, p.21).

This process has mainly two active substances released, these are Adenosine triphosphate (ATP) and Creatine phosphate (PCr). They are primarily released from the muscle fibre depots, where there is a store of ATP and PCr sufficient for 6-10 seconds of work at maximum intensity (in some extremely trained individuals, the stores may last up to 15 seconds) (Aasen et al. 2006, p.21).

The PCr process is the fastest energy process in the body to rebuild the most ATP, as the rebuilding is immediate. Therefore, the PCr process enables the athlete to perform very intense work in a short period of time (Aasen et al. 2006, p.21-22). Many athletes in sports such as wrestling, weightlifting, gymnastics, many athletics, baseball and volleyball rely almost exclusively on being able to generate energy quickly from the PCr process. Since in these sports short maximal efforts are performed (McArdle et al. 2005, p.204).

However, high-energy phosphates are used in all movements, but stored carbohydrates, fats and proteins are also needed to provide the energy necessary to recharge the high-energy phosphate store (McArdle et al. 2005, p.204).

## 2.2. Short-term energy systems

The short-term energy system starts up within half a second after high-intensity work has begun (Aasen et al. 2006, p.22). This is because the immediate energy system can only supply the body with energy for 6-10 seconds according to Aasen et al. (2006, p.21). The short-term energy system or anaerobic lactate energy process is a process that occurs without oxygen but produces lactate (colloquially called lactic acid).

During high-intensity intermittent work, lactate accumulation will progressively increase, as the athlete works harder and harder, and thus accumulation will accelerate (Gladden, 2004). As the athlete works harder and harder, the energy demand will increase and thus the rate of glycolysis will accelerate. One result of this is that the stored glycogen in the muscle fibres or glycose from the blood becomes available in anaerobic glycolysis (McArdle et al. 2005).

Through anaerobic glycolysis, the glycogen or glycose is gradually broken down into pyruvate (this occurs through 10 different steps) see McArdle et al. (2015, p.186, Figure 5.12). Through this process, ADP (Adenosine diphosphate) is phosphorylated, thus forming ATP (Adenosine triphosphate) which can be used as energy in the body (McArdle et al. 2005, p.204). As the energy demand in the body now exceeds the oxygen supply to the tissues, this now leads to oxygen deficiency in glycolysis, known as hypoxia (McArdle et al, 2005).

This leads to the electron transport chain not being able to process all the hydrogen now present in glycolysis, as the limiting factor here is the availability of NAD+ . As the majority of the hydrogen has now bound to NAD+ and formed NADH (with a hydrogen ion). As anaerobic glycolysis is entirely dependent on the availability of NAD+ in the oxidation of glyceraldehyde-3-phosphate (step 6 of 10) see McArdle et al. (2005, p.186, Figure 5.12), this process is now at risk of being completely halted (McArdle et al. 2005, p.186). As a result, adaptations have taken place in anaerobic glycolysis where NAD+ now binds to two hydrogen ions (2H) instead of one hydrogen ion as before.

This thus leads to the formation of NADH2 (NAD+ + 2H → NADH2). With the help of the enzyme lactate dehydrogenase, NADH2 will temporarily bind to pyruvate, thus forming the acid lactate (commonly called lactic acid) (McArdle et al. 2005, p. 187).

In the anaerobic lactate energy process, the amount of carbohydrates stored in the body is not the limiting factor (Aasen et al. 2006, p.22), but now that lactate has been formed, the acidity of the muscles has increased, this has negative effects on the intracellular environment of the muscles and something that affects the contractile capacity of the active muscles (McArdle et al. 2005). There are several factors that cause this but one factor may be the increase in the concentration of H+ (hydrogen ions) in the cells, which in turn reduces the function of the muscle proteins myosin and actin. Another cause may be the depletion of ATP and PCr stores, which leads to impaired force development after 15-30 seconds at maximal work (Aasen et al. 2006, p.22).

Why the concentration of H+ increases in the cells: is because the lactate formed in the cells by anaerobic glycolysis is now cleaved down to the ions La- and H+ (where the ions have a 1:1 ratio, i.e. one La- ion to one H+ ion). These ions are then transported out of the cells into the blood, this is done to reduce the negative consequences in the cells. As a consequence, the concentration of H+ in the blood will increase and through this the acidity of the blood will increase and something that lowers the pH of the blood (Aasen et al. 2006, p.22). With the release of La- into the blood, these ions can now be transported to nearby muscle fibres or other muscle fibres in the body that are less active. These in turn can break down La- into energy through the aerobic energy process, as La- contains a high amount of energy (Aasen et al. 2006, p.21-22, McArdle et al. 2005). As a result, lactate elimination becomes dependent on redistribution of the blood to nearby tissues (McArdle et al. 2005). For La- uptake to work in the less active muscles, athletes need to lower the intensity of the work, so that the lowering of La- in the blood will work (McArdle et al. During recovery, this requires the intensity to be lowered below the lactate threshold for elimination to be more efficient than production (McArdle et al. 2005).

## 2.3.Long-term energy systems

The body's long-term energy system is the aerobic energy process; this energy system contributes the most energy production to performances longer than 2 to 3 minutes. Despite the fact that glycolysis rapidly releases anaerobic energy, only small amounts of ATP are produced from the anaerobic process (McArdle et al. 2005, p. 206). After about 1 minute after starting maximal work, the aerobic energy system contributes about 50% of ATP production (Aasen et al. 2006, p.24).

The aerobic energy system mainly burns carbohydrates to ATP, however, this burning is influenced by the intensity of performance, total performance time and the size of the carbohydrate stores in the body. A more fit person can store more carbohydrates in the body in comparison with an untrained person. At maximum performance over a longer period of time, more of the energy will come from the aerobic energy process, and if the work goes on even longer, more and more energy will also come from the burning of fat (Aasen et al. 2006, p.24).

# Chapter III: Recovery Methods

## 3. Defining recovery:

Recovery as a concept is broad, as there are many different definitions. Previously, there was no clear or established definition of recovery as a phenomenon (Kenttä, 2008). However, since 2018, it can be said that there is a definition that is broad for recovery based on the consensus statement made by Kellman et al (2018). They chose to define recovery as follows:

"Recovery can be said to be a multifaceted field that is, for example, physiological and psychological, primarily concerned with a rebuilding process in relation to time" (Kellman et al. 2018, p.1).

Kellman et al (2018) also write that an individual's recovery status (or biopsychosocial balance) can be disrupted by internal and external factors, leading to the person developing fatigue as a result of physical or mental exertion. Thus, through recovery, practitioners can recover from the fatigue created by allostatic load (the change from the normal in the body for example in blood pressure, respiratory rate, hormone levels, etc.). This is done by restoring balance to an equilibrium state known as homeostasis. This from both a psychological and a physiological perspective.

### 3.1. Defining physiological recovery

Physiological recovery is mainly about the regeneration of metabolites, tissues, neurological recovery, etc. This is a result of fatigue created by training or competition, from which the practitioners thus need to recover. This form of recovery is usually divided into three forms of recovery: passive, active and proactive recovery (Kellman et al 2018).

### 3.2. Various forms of physical recovery

**3.2.1. Passive recovery (PR)** : can refer to anything from being completely inactive to using external methods such as massage, cold water baths, sleeping, resting on the couch or bonding (Kellman et al 2018, Kenttä, 2008).

**3.2.2. Active recovery (AR):** refers primarily to any form of physical activity aimed at recovering the direct metabolic stress of physical fatigue. This could be activities such as running, walking, cycling or similar (Kellman et al 2018, Kenttä, 2008). Kenttä (2008) writes that active recovery can be further divided into two forms such as general (non- specific) or sport-related (specific). Where sport-related (specific) recovery can be conducted with a focus on the type of fatigue that the practitioner has 'the nature of the need' and how much the practitioner needs to recover from 'the magnitude of the need' (Kenttä 2008).

**3.2.3. Proactive recovery**: The least talked about form of recovery, this form of recovery is about choosing activities tailored to individual needs or preferences. Such as various forms of social activities (Kellman et al 2018) for example hanging out with friends.

### 3.3. The physiological recovery process:

Performance in all its forms affects the body physiologically, by putting stress on tissues and systems (Marklund et al. 2008). This is mainly through metabolic and mechanical stress (White & Wells, 2013). Something that often leads to the deterioration of the capacity of these systems. After a performance, there is a recovery phase, where the systems and tissues that have been stressed are given a chance to regain their normal capacity (Marklund et al. 2008).

What practitioners want to recover from after training or competition is mainly fatigue. This is in the form of so-called residual products left over after the training load. An example of a residue left after a performance is blood lactate, which is one of the main markers used to examine whether athletes are recovered (Kenttä 2008). In many studies, such as for swimming (Greenwood et al. 2008), judo (Franchini et al. 2003; Franchini et al. 2005), running (Menzies et al. 2010), climbing (Watts et al. 2000), football (Baldari et al. 2004) and triathlon (Baldari et al. 2007), this residual is used to analyse recovery.

It is also important to be able to recover these residues as quickly as possible, especially in sports where there are several performances/matches per day and the recovery time is short between the different performances/matches (Kenttä 2008). Therefore, this form of recovery aims to restore the body to an anabolic environment, by eliminating the residues formed and therefore making the body ready for the next performance (Svensson 2008; McArdle et al. 2005). Otherwise, the performance outcome may deteriorate after one match, and further after one more match (Marklund et al. 2008).

The length of recovery of different tissues and systems can vary, ranging from a few minutes to several days until they have returned to a normal level. If the performance load is sufficient over a period of time, and the recovery is adequate, the systems will recover better (Marklund et al. 2008).

In a study by Monedero & Donne (2000), they found that the difference in mean blood lactate elimination was significantly greater in AR than PR between recovery times of 0-3 minutes ($p<0.05$), 6-9 minutes ($p<0.05$) and 9-12 minutes ($p<0.01$). However, they found no significant differences in blood lactate elimination between PR and AR recovery at 3-6 minutes and 12-15 minutes. In this study, it was observed that the heart rate for AR recovery was around 130-140 beats/minute while the heart rate for PR recovery was around 95-110 beats/minute. As a result, they concluded that AR post-exercise is a more effective recovery method in comparison to PR, as active recovery increases performance, eliminates larger amounts of blood lactate and there are differences in observed heart rate in comparison to passive recovery (Monedero & Donne 2000).

Menzies et al. (2010) found that a recovery intensity between 80-100% of the lactate threshold, was most effective in the recovery of blood lactate. However, there were still significant differences in blood lactate elimination at intensities 40 and 60% of the lactate threshold, compared to PR. The same study also found significant differences in heart rate between all the different intensities used in the study (PR, 40, 60, 80 & 100% of the lactate threshold, and a self-regulated recovery rate with a mean of 78.5 ± 4.7% of the lactate threshold). Baldari et al (2004) conducted a similar study where passive recovery was compared with different intensities of the ventilatory catabolic threshold. This study also found that AR was more effective than PR.

The state of research on active and passive recovery for judo Franchini et al. (2009) conducted a very comprehensive study in which the researchers conducted three sub-studies, see the study methodology used by the researchers in Figure 4.

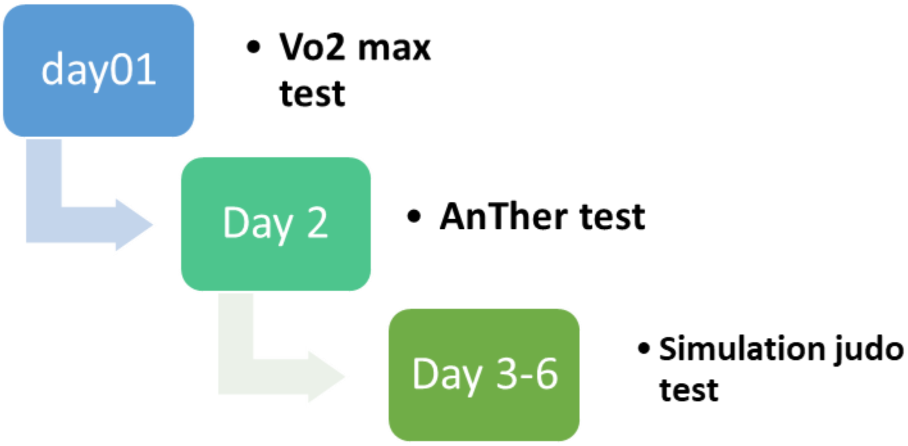


**Figure 4: Study design used in the study by Franchini et al. (2009).**

The results of their first sub-study showed no significant differences between test occasions (p>0.05) for the performance parameters of the wingate test such as peak power, mean power, fatigue index and time to reach peak power. Relative total work done for the control group (509.6+- 59.2 J/kg) PR (505.0 +- 73.0 J/kg) and AR (521.4 +- 79.9 J/kg) and no significant differences were observed between the different recovery methods (p > 0.05) (Franchini et al. 2009). For blood lactate concentration, there was a correlation between form of recovery and time of measurement (p < 0.001). Differences between recovery methods were observed at a significant level for 9, 12 and 15 minutes between AR and PR (p<0.001). They found significant differences between PR and AR for 12 minutes ($p<0.001$) and for 15 minutes ($p<0.001$), in both cases observing lower values in blood lactate concentration in AR compared to AR. They also observed lower blood lactate values for AR at 12 minutes compared to PR for 15 minutes ($p<0.001$) (Franchini et al. 2009)

In their second study, they found that the results showed no significant differences ($p>0.05$) in the total number of throws in SJFT (N) between the different test groups, the control group (26 ±), PR (26 ± 3) and AR (27 ± 1). They observed a trend in higher HRimm in AR compared to the control group ($p=0.077$), but found no significant differences in HR1min ($P > 0.05$) (Franchini et al. 2009). In study 2, the researchers found a correlation between form of recovery and time of measurement for blood lactate concentration ($p < 0.05$). Blood lactate concentration for AR at 10 and 15 minutes was significantly lower than at the same time for PR ($p<0.001$).

The same method used in study 1 by Franchini et al. (2009) was used in a previous study by Franchini et al. (2003) in this study they were able to observe that there were no significant differences between the PR and AR for Peak Power ($P >0.05$), at the same time they saw that there was a progressive deterioration of peak power over time when the practitioners performed 4 upper body wingate tests ($p<0.001$), however they could not see any effect of the recovery method. They further observed differences in Mean power performance between the different test sessions for different test groups A (competing at national/international level) and B (competing at regional level) performed right values than test group C (competing at city level). Mean power differed between the different performances of the 4 upper body wingate there (trials W1>W2>W3>W4). As a consequence, overall performance differed between groups ($p < 0.05$) (Franchini et al. 2003). In this study, no significant difference was observed for blood lactate between the different experimental groups and type of recovery method ($p > 0.05$). However, significant differences in blood lactate concentration were observed for the time of measurement and for the type of recovery method (Franchini et al. 2003).

In another study by Touguinha et al. (2011), they used a completely different test procedure in comparison to Franchini et al. (2003) and Franchini et al. (2009). Their results showed that blood lactate concentration in the blood increased significantly with the uchi-komi (repeated inputs of a throw) exercise where the blood lactate value was increased almost 4 times from about 2 mmol/l to about 8 mmol/l ($p=0.05$). During the test, the subjects achieved a heart rate value equivalent to 86.3% of maximal HR an increase of 2.5 times from about 35% ($p=0.05$). The researchers also observed differences in blood lactate values between PR and AR after 9 minutes ($p = 0.05$) with PR having higher blood lactate values. However, no significant differences were observed between the different recovery methods ($p>0.05$) (Touguinha et al. 2011).

# Second Party :

# Research Methodology

# Chapter I: Field Procedures

## 1. Selection:

Approximately one fifty tow forms were distributed to participants at a training camp in 2014, this in connection with the first training session, see Annex 2. Thereafter, practitioners were asked to volunteer for the study, 32 people responded to the form, each of 26 people met the criteria that the study set for the participants. The forms were then numbered and a sample group was randomised from the 26 people who met the criteria. This study involved 12 judo practitioners from different clubs around Sweden. During the course of the study there was a dropout of 5 people (42%) due to illness/injury, clashes in the calendar and loss of interest. This in turn meant that a total of 7 people completed the entire study.

During the study, certain criteria were set for the participants: 1) that subjects were male between 15 and 25 years of age; 2) practicing judo at least 3 times a week; 3) having competed in judo in the last month and having competed internationally in the last 3 months;

being healthy from diseases; 5) completed health declaration and informed consent, and if required, informed consent must be signed by the guardian; 6) have at least a blue belt (2 kyu) or higher; 7) do not compete below the -60kg category and do not compete above the -90kg category, this is to ensure they have a similar body composition.

### 1.1. The rules of conduct applied during the study were:

- Participants were not allowed to consume nicotine, caffeine, protein supplements, 2 hours before test.
- Participants were allowed to complete their regular training during the study.
- Participants were not allowed to acutely lose weight (reduce weight by lowering the water concentration in the body) during the study.

These approaches were chosen to ensure that the athletes were ready for the physical demands placed on them by the study, to enable the athletes to demonstrate their actual performance, and to help the participants perform as close to their maximum performance as possible. As the tests were conducted at different training camps in the spring of 2014, I as the test supervisor as well as other coaches were able to monitor so that the subjects were able to follow the rules of conduct that the study asked of them.

| atheltes | Age (years) | Weight (kg) | Height (cm) | Number of years trained (years) |
|---|---|---|---|---|
| 1 | 18 | 68,5 | 175,5 | 10 |
| 2 | 18 | 72,2 | 170,1 | 12 |
| 3 | 19 | 66,8 | 176,9 | 9 |
| 4 | 16 | 71,3 | 171,3 | 11 |
| 5 | 18 | 73,2 | 175,8 | 10 |
| 6 | 20 | 69,5 | 173,5 | 12 |
| 7 | 17 | 71 | 175,1 | 9 |
| 8 | 19 | 71,9 | 174,2 | 11 |
| 9 | 17 | 68,3 | 176 | 10 |
| 10 | 18 | 68,9 | 175,6 | 9 |
| 11 | 20 | 69,2 | 175 | 8 |
| 12 | 16 | 69,8 | 173,9 | 12 |
| 13 | 18 | 71,6 | 172,9 | 10 |
| 14 | 17 | 72,1 | 175,5 | 11 |
| 15 | 19 | 70,2 | 173,1 | 10 |
| 16 | 21 | 72,3 | 175,3 | 13 |
| 17 | 16 | 69,4 | 173,6 | 9 |
| 18 | 20 | 70,1 | 174,7 | 11 |
| 19 | 18 | 72,7 | 174 | 12 |
| 20 | 17 | 69,3 | 174,2 | 10 |
| 21 | 19 | 70,9 | 174,9 | 11 |

**Table 1: presents the main characteristics of the judo athletes participating in the study in terms of: age, weight, height, number of years trained.**

### 1.2.Study design and procedure :

This study was a crossover study, in which all subjects had to perform all three forms of recovery such as passive (PR), active (AR) and judo-specific (JSR). Each recovery method was randomized, so that the order was randomized for the subjects participating in the study, this to reduce the risk of learning effects during the study.

The study lasted for 4 days, where subjects had to perform anthropometric measurements and a lactate threshold test (LT4 Test) on the first day, on the second day subjects had to start with the Special Judo Fitness Test (SJFT) where the choice of recovery method has been randomized. All tests were performed in the afternoon around the same times. Table 2 below presents the study design for the entire study period.

| Day 1 | Day 2 | Day 3 | Day 4 |
|---|---|---|---|
| **Anthropometry LT4 test** | SJFT RecoverySJFT | SJFT RecoverySJFT | SJFT RecoverySJFT |

**Table 2 :Study design for the entire study period.**

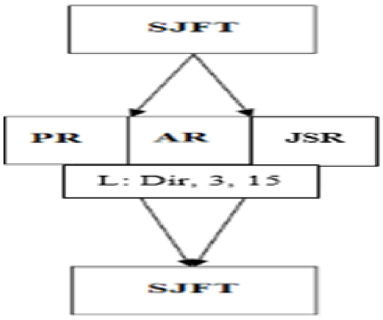


**Figure 5 : presents the study design for the judo-specific testing sessions conducted in the study Franchini et al (2009)**

Figure 5 Study design for the judo-specific test sessions, where first a Special Judo Fitness Test is performed, then a random form of recovery is performed where lactate tests were taken immediately after completion of the test (LA0), 3 minutes (LA3) after and 15 minutes after (LA15) and then the Special Judo Fitness Test is performed again.

### 1.3.Anthropometric measurements:

During the study, measurements were taken for both height and weight in order to account for the characteristics of the study group. Weight was weighed using the Senso personal scale (Model No: 47105, East import) and measured in kilograms (kg) to one decimal place, as follows 00.0. The length was measured with a fiberglass measuring tape of 20 meters (Art. No. 16-223, Biltema) the measurements were taken in whole centimetres (cm).

### 1.4.Lactate Threshold Test :

This test was performed according to the protocol developed by Heck et al. (1985) to determine the 4mmol/l lactate threshold (LT4). This is a common protocol used in studies with judo athletes several times Detanico et al. (2012); Franchini et al. (2003); Franchini et al. (2005a); Franchini et al. (2009). The protocol is a progressive treadmill test where the subject starts at a speed of 6 km/h, and where the speed is increased by 1.2 km/h every 3 min, with 30 sec rest between increases. During the rest period, heart rate and blood lactate were measured. The whole test is performed up to and including two values higher than 3,5 mmol/l. Then the

lactate threshold was calculated to be the heart rate corresponding to 4 mmol/l, so called LT4.

## 1.5. Special Judo Fitness Test:

### 1.5.1. Heating:

Subjects performed a warm-up, running at an intensity equivalent to 70% of LT4 on the judo mat, for 5 minutes, followed by 3 minutes of rest (passive recovery) before the test, which was performed before each test session. This procedure is similar to the one used by Franchini et al. (2009).

## 1.6.Test procedure for the Special Judo Fitness Test:

This test was carried out according to the method previously presented in the introduction (under the heading1.1.3 Special Judo Fitness Test).

The test person (so called Tori, the thrower) stands at a distance of 3m from the two other participants (so called Uke, the thrower) (see figure 1). On a signal, the tori runs to uke A and throws the ippon-seoi-nage (see figure 2). Then the tori runs to uke B and throws the ippon- seoi nage. Tori should be able to throw as many throws as possible during the active time. The test is performed in three active intervals A=15 seconds, B=30 seconds and C=30 seconds, separated by 10 seconds rest.

## 1.7.Recovery methods :

### 1.7.1. Passive recovery :

This form of recovery is performed sitting still on the judo mat, with the test leader coming to the subject to measure blood lactate and heart rate. Blood lactate measurements were taken immediately after completion of the test (LA0), 3 minutes after (LA3) and 15 minutes after (LA15). Heart rate was instead read immediately after completion of the test, 1, 3, 5, 10, 15 minutes after to ensure that the subject was performing the correct recovery procedure (see Table 1). This procedure was performed similarly to the procedure used by Franchini et al. (2009).

### 1.7.2. Active recovery :

This form of recovery is carried out by subjects running on the judo mat with a heart rate equivalent to 80% of LT4 (Menzies et al, 2010). The heart rate was calculated as the predicted heart rate at LT4 multiplied by 0.8 to get 80% of LT4. Subjects only stop their recovery when

the test leader comes up to them to measure blood lactate and heart rate. Blood lactate measurements were performed immediately after completion of the test (LA0), 3 minutes after (LA3) and 15 minutes after (LA15). Instead, heart rate was read immediately after completion of the test, 1, 3, 5, 10, 15 minutes after to ensure that the subject was performing the correct recovery method (see Table 1). This procedure was performed similarly to the procedure used by Franchini et al. (2009).

### 1.7.3. Judo-specific recovery

This form of recovery was performed according to the protocol of Touguinha et al. (2011) by subjects performing uchi-komi (repeated inputs of a throw), between 60- 70% of maximal load at uchi-komi. In this study, recovery was modified to be the pulse equivalent to 80-100% of LT4, which according to Menzies et al. (2010) should be the most effective range to eliminate blood lactate. The pulse was obtained by LT4 test and predicted for 100% of LT4, then 80% of LT4 was calculated by multiplying by 0.8, then the pulse zone 80-100% LT4 was obtained for each individual. Subjects only stopped their recovery when the test leader approached them to measure blood lactate and heart rate. Blood lactate measurements were performed immediately after completion of the test (LA0), 3 minutes after (LA3) and 15 minutes after (LA15). Heart rate was instead read immediately after completion of the test, 1, 3, 5, 10, 15 minutes after to ensure that the subject was performing the correct recovery procedure (see Table 1).

**1.8.Lactate measurement :**

Blood lactate measurements were performed by sampling in the finger with the lancet Safty- Lancet- Normal with a penetration depth of 1.8mm (Sarstedt AG & CO, Germany) and the lactate amount was analysed with Lactate Pro, 5µL (Arkray. Inc, Japan). The lactate measurement was carried out immediately after Pulse measurement Heart rate was measured using the Polar OH 1 model 2L heart rate monitor (Polar Electro Oy, Finland) and accompanying heart rate strap. The maximum heart rate was calculated based on Karvonen's formula 220 minus (-) the age, to further ensure the correct heart rate zones we also used the measured heart rate we 4LT test and calculated to produce a relevant heart rate zone for the different recovery methods.

**1.9.Statistical analysis :**

All analyses in this study were conducted using the IMD SPSS Statistics computer program (version 22.0, Chicago, USA). Data are reported as means and standard deviations (SD) in this study.

For the data analysis, a Descriptive Statistics analysis was first performed on all data, to obtain means and standard deviation (SD). There the Descriptive Statistics analysis was performed for the characteristics of the subjects, where the variables age, weight, height and number of years trained, LT4 (km/h), LT4 (beats/min)were analyzed, and presented in a table (Table 1). Thereafter, analysis was performed for each variable of lactate (LA0, LA3, LA15) and performance at first and second SJFT (A, B, C; N; HRimm; HR1min and SJFTIndex) this depending on the recovery method. The data distribution was analysed using a Shapiro- Wilk test, and the result showed a normally distributed Gaussian curve.

To examine whether there were any significant differences, for the performance variables total number of throws (N), HRimm; HR1min and SJFT Index. Before-After SJFT within the specific recovery methods, Paired t-tests were performed between before and after for each of the recovery methods PR, AR and JSR.

In order to check whether the relationships between the different test occasions were similar, the performance variables total number of throws (N), HRimm; HR1min and SJFTIndex were compared before SJFT with a one-way ANOVA test, after which the same investigation was carried out for the performance after SJFT. If the ANOVA test showed significance, it was followed by a Bonferroni-type post hoc test.

To further investigate whether there were any significant differences, for the performance variables total number of throws (N), HRimm; HR1min and SJFTIndex.. After SJFT between the specific recovery methods, a Repeated Measures ANOVA test was performed for the different recovery methods, if the ANOVA test showed significance it was followed by a Post-Hoc test of the Bonferroni type.

To further investigate whether there were any significant differences, for blood lactate values after SJFT, LA0 LA3, LA15 were analysed. This was first performed with a One-way ANOVA test for the different recovery methods. If the ANOVA test showed significance, it was followed by a Bonferroni-type post hoc test.

The values were then analysed using a Repeated Measures ANOVA test for the different recovery methods, followed by a Bonferroni type post-hoc test if the ANOVA test showed significance.

The statistical significance level in this study was at $p<0.05$ as standard, unless otherwise presented.

### 1.10. Ethical considerations:

In this study, subjects who are not of legal age participated, thus requiring that clear information was given to both subjects and any guardians about what the study would entail and that participation in the study was voluntary at all times. During the course of the study, lactate values were taken several times by pricking the finger, and in addition to this, the study required that subjects were prepared to reach maximum exhaustion several times. In addition, it was informed that no subjects will be identifiable from the study, and therefore individual results are not reported and that all results obtained during the course of the study will be used only for this study.

# Chapter Two: Presentation and Discussion of Results

## 2. Presentation and analysis of results

Performance Before and After a Specific Recovery Method

A paired t-test was used to examine SJFT performance before and after the three different recovery methods. This for the variables total number of throws at SJFT, HRimm, HR1min and SJFT index

### 2.1.SJFT index :

The results show that performance in SJFT before and after the recovery form PR has a significant difference (p=0.011*) where the value of SJFT index increases, the performance deteriorates. While performance of AR and JSR is not significant in performance before or after, but there is a trend of difference even these, see Table 3.

| *SJFT Index* | *M±SD (Before)* | *M±SD (After)* | *M±SD Dif. (Before-After)* | *t (df. 6)* | ***Sig. (Before-After)*** |
|---|---|---|---|---|---|
| *PR* | 14 ± 1 | 15 ± 1 | -1 ± 1 | -3,63 | 0,011* |
| *AR* | 14 ± 1 | 14 ± 1 | -0 ± 0 | -2,44 | 0,050 |
| ***JSR*** | 14 ± 1 | 15 ± 1 | -1 ± 1 | -2,37 | 0,055 |

p < 0.05; ** significant when p < 0.01.

**Table 3: shows the performance of the SJFT before and after recovery for all recovery methods.**

### 2.2.Total number of throws at SJFT (N):

For the variable number of throws at SJFT before and after recovery, the results show for: PR (p = 0.013*), AR (p = 0.018*) and for JSR (p = 0.038*). This result shows that there is a significant difference for the variable number of throws at SJFT before and after recovery methods, see Table 4.

| *Total number cabinet* | *M±SD (Before)* | *M±SD (After)* | *M±SD Dif. (Before-After)* | *t (df. 6)* | ***Sig. (Before-After)*** |
|---|---|---|---|---|---|
| *PR* | 23 ± 2 | 21 ± 2 | 2 ± 2 | 3,46 | 0,013* |
| *AR* | 23 ± 2 | 22 ± 1 | 1 ± 1 | 3,24 | 0,018* |
| ***JSR*** | 23 ± 2 | 22 ± 1 | 1 ± 1 | 2,65 | 0,038* |

significant when p < 0.05; ** significant when p < 0.01.

**Table 4: shows the performance of SJFT before and after recovery within each recovery method, where thedifference of the mean number of throws at SJFT before and after is reported for all recovery methods**.

### 2.3.HRimm at SJFT :

For the variable HRimm at SJFT before and after recovery, the results show for: PR (p = 0.504), AR (p = 0.268) and for JSR (p = 0.901). This result shows that there is no significant difference for the variable HRimm at SJFT before and after all recovery methods, see Table 5.

| *HRimm (strokes/min)* | *M±SD (Before)* | *M±SD (After)* | *M±SD Dif. (Before-After)* | *t (df. 6)* | ***Sig. (Before-After)*** |
|---|---|---|---|---|---|
| *PR* | 189 ± 4 | 190 ± 3 | -1 ± 4 | 0,72 | 0,504 |
| *AR* | 188 ± 7 | 187 ± 6 | 2 ± 4 | 1,17 | 0,286 |
| ***JSR*** | 188 ± 5 | 188 ± 5 | -0 ± 3 | - 0,13 | 0,901 |

p < 0.05; ** significant when p < 0.01.

**Table 5 shows the results for pre and post recovery SJFT heart rate values within each recovery method**

### 2.4.HR1min at SJFT :

For the variable HR1min at SJFT before and after recovery, the results show for: PR (p = 0.041*), AR (p = 0.031) and for JSR (p = 0.731). This result shows that there is a significant difference for the variable HR1min at SJFT before and after for recovery methods such as PR and AR but not for JSR, see Table 6.

| *HR1min (strokes/min )* | *M±SD (Before)* | *M±SD (After)* | *M±SD Dif. (Before-After)* | *t (df. 6)* | ***Sig. (Before-After)*** |
|---|---|---|---|---|---|
| *PR* | 138 ± 6 | 133 ± 6 | 4 ± 5 | 2,60 | 0,041* |
| *AR* | 136 ± 4 | 133 ± 5 | 3 ± 3 | 2,81 | 0,031* |
| ***JSR*** | 133 ± 7 | 134 ± 6 | -1 ± 4 | -0,36 | 0,731 |

p < 0.05; ** significant when p < 0.01.

**Table .6: shows the results for pre- and post-recovery heart rate values in SJFT.**

### 2.5.Performance in SJFT before recovery :

To examine the baseline SJFT pre-recovery performance for the different test occasions, a One-Way ANOVA test was used. This was done for the variables total number of throws at SJFT, HRimm, HR1min and SJFT index. Table 7 presents the mean and standard deviation for the variables analysed. The results show that the baseline SJFT pre-recovery performance values for the different test occasions did not show any significant differences for all variables.

| *SJFT* | *PR (M ± SD)* | *AR (M ± SD)* | *JSR (M ± SD)* | *Total (M ± SD)* | ***Sig.*** |
|---|---|---|---|---|---|
| *Total number of throws* | 23 ± 2 | 23 ± 2 | 23 ± 2 | 23 ± 2 | 0,952 |
| *HRimm* | 189 ± 4 | 188 ± 7 | 188 ± 5 | 188 ± 5 | 0,934 |
| *HR1min* | 138 ± 6 | 136 ± 4 | 133 ± 7 | 136 ± 6 | 0,339 |
| ***SJFT Index*** | 14 ± 1 | 14 ± 1 | 14 ± 1 | 14 ± 1 | 0,795 |

**Table 7: Mean and standard deviation of the variables in SJFT performance before recovery, between different recovery methods.**

## 2.6.Performance in SJFT after recovery

To examine the values of performance in the SJFT after recovery for different test occasions, a One-Way ANOVA test was used. This was done for the variables total number of throws at SJFT, HRimm, HR1min and SJFT index. Table 8 presents the mean and standard deviation for the variables analysed. The results also show that the values at performance in SJFT after recovery for the different test occasions did not show any significant differences for all variables.

| *SJFT* | *PR (M ± SD)* | *AR (M ± SD)* | *JSR (M ± SD)* | *Total (M ± SD)* | ***Sig.*** |
|---|---|---|---|---|---|
| *Total number of throws* | 21 ± 2 | 22 ± 1 | 22 ± 1 | 22 ± 1 | 0,189 |
| *HRimm* | 187 ± 3 | 187 ± 6 | 188 ± 5 | 188 ± 5 | 0,479 |
| *HR1min* | 133 ± 6 | 133 ± 5 | 134 ± 6 | 135 ± 5 | 0,908 |
| ***SJFT Index*** | 15 ± 1 | 14 ± 1 | 15 ± 1 | 15 ± 1 | 0,109 |

**Table 8 Mean and standard deviation of the SJFT performance variables after recovery, between different recovery methods.**

## 2.7.Performance in SJFT Before and After recovery between different recovery methods:

A Repeated Measures ANOVA test was conducted to examine whether there were differences between the performance variables of the SJFT before and after recovery, and between the different recovery methods. This is because the difference between the performance variables in the SJFT before and after, was compared between the different recovery methods. The results show that there are no significant differences in the performance variables of SJFT before and after recovery, this for all variables: total number of throws ($p=0.645$), HRimm ($p=0.751$), HR1min (0.746) and SJFT index ($p = 0.351$).

### 2.8. Elimination of blood lactate:

To examine the blood lactate values at recovery for different measurement times, a One-Way ANOVA test was used. There were no significant differences in blood lactate at LA0 ($p = 0.290$), significant differences in blood lactate were found at LA3 ($p = 0.032$)* and LA15 ($p < 0.001$).

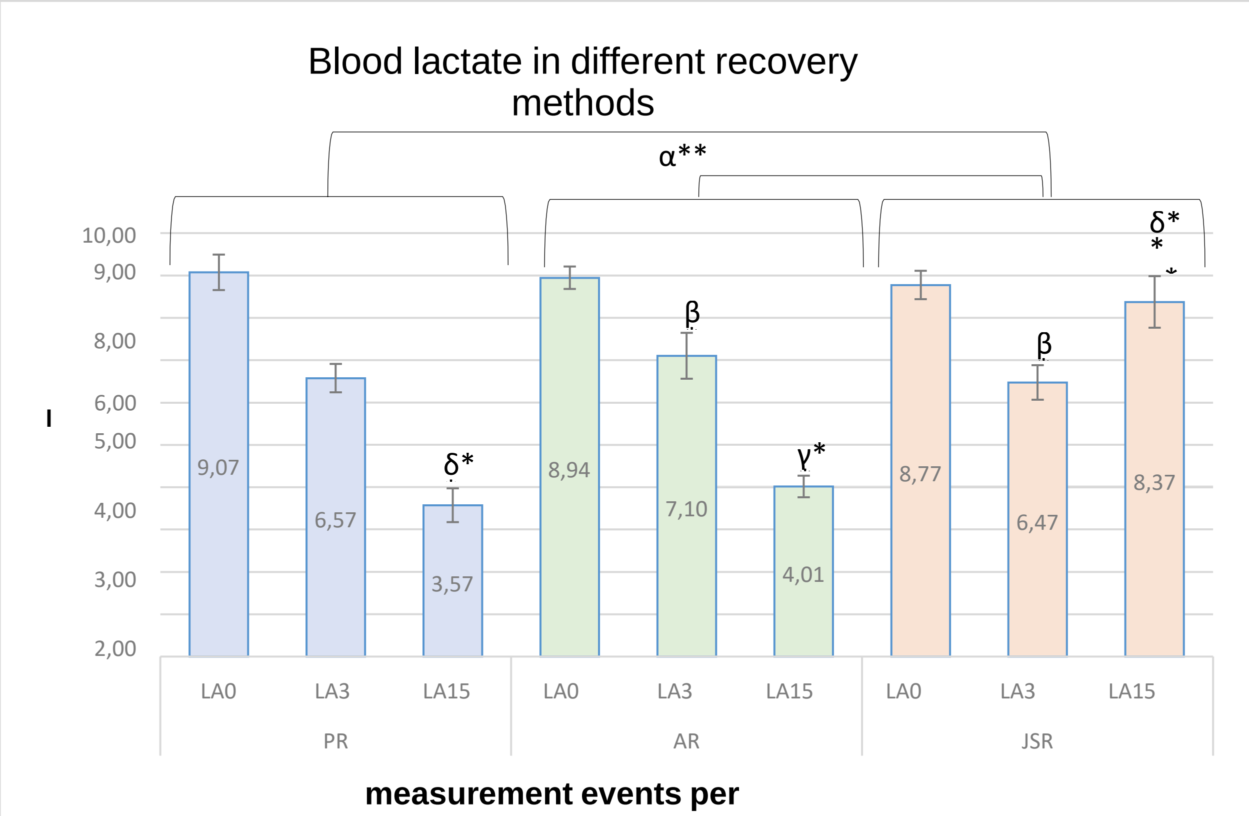


Figure 6 Shows blood lactate values for the different test times immediately, 3min and 15 min after, and between the different recovery methods. α - shows significance between PR and JSR $p < 0.001$, αα - shows significance between AR and JSR $p < 0.001$. For LA3, β - shows significant differences between AR-JSR $p=0.044$. LA15 shows δ - significant differences between PR-JSR $p < 0.001$, and where γ - shows significant differences between AR-JSR $p<0.001$.

Subsequent Bonferroni-type post hoc tests showed in more detail where the differences occurred at LA3; the significant differences were between AR-JSR ($p = 0.044$). At LA15, there were no significant differences between PR-AR (p=0.236) while significant differences were between PR-JSR ($p<0.001$) as well as AR-JSR ($p<0.001$), see Figure 6.

There after a Repeated Measures ANOVA test was performed showing that there were differences in blood lactate values between the different recovery methods PR-AR ($p = 0.189$), where significant differences were found between PR-JSR ($p < 0.0001$) as well as AR- JSR ($p < 0.0001$). See Figure 6, to see the different lactate values for the different measurement occasions as well as the recovery methods.

# Discussion of results by hypothesis

## 3. Discussion

Performance before and after SJFT in specific recovery method

The main finding of this study was that in each recovery method there were significant performance decreases when comparing performance before and after SJFT. For PRthis performance reduction was found for the variables total number of throws in SJFT (N),HR1min and SJFT index. While for AR this reduction was seen for the variables number of throws in SJFT (N) and HR1min, and for JSR for the variable total number of throws in SJFT (N). It can also be said that a tendency in performance deterioration in the variable SJFT index in both AR ($p = 0.050$) and JSR ($p = 0.055$) could be observed although not significantly.

Thus, this means that SJFT performance deteriorated between pre- and post-recovery SJFTs regardless of the recovery method. In a study by Lopes-Silva (2014), they studied performance between three repeated SJFTs with 5 minutes of rest between each test session. In this study, they could not see any significant differences in the number of throws at SJFT

(N) for each SJFT performance ($p>0.05$) and test session ($p>0.05$) or interaction effects ($p>0.05$). They also could not see any significant differences in performance for SJFT index for each SJFT performance ($p<0.05$) and test occasion ($p>0.05$) and interaction effects ($p>0.05$). The results as Lopes-Silva (2014) may vary with this study as the methods of the studies varied. In their study, it is not clear which recovery method was used between SJFTs, which may affect the results. Thus, the result of this study confirms the first (1) hypothesis. However, this area needs further investigation as few studies have been conducted in this area to confirm whether performance at SJFT is lowered or maintained at SJFT before and after recovery.

### 3.1.Differences between recovery methods in SJFT :

No significant differences were observed in the various performance variables for SJFT prior to the different recovery methods, thus indicating that there were no differences between the different test occasions in the study. When the performance variables for SJFT after the different recovery methods were analysed, again no significant differences were observed. When the performance variables for SJFT before and after recovery were analysed between the different recovery methods, again no significant differences in performance were observed between the different recovery methods.

In study 2 by Franchini et al. (2009), they did not observe any significant differences in the number of throws in SJFT (N) between the different recovery methods and the control group ($p>0.05$). They also observed a trend in higher HRimm between the AR and the control group, but no significant differences for HR1min. This is a result similar to that observed for the number of throws in SJFT (N) for the different recovery methods in this study. No trend could be observed for HRimm ($p=0.908$), however, the result for HR1min is consistent with the results of this study, where there are no significant differences. Furthermore, the result could be compared with the result observed by Franchini et al. (2003) in their study. Although their method differed from this study, they could not observe any significant differences in performance between the different recovery methods for peak power performance ($p>0.05$). Furthermore, they could not observe any significant differences in performance at mean power for the different test occasions, however, this result was not dependent on the recovery method but on the level of the different test groups' performers (Franchini et al. 2003). In that no significant differences in performance at SJFT before recovery were observed in this study, this may indicate that the test subjects participating in the study had an equivalent judo- physical level. In a similar study by Franchini et al. (2009), they also did not observe any significant differences between different recovery methods this for all performance parameters of 4 upper body wingate tests (p>0.05). They also studied whether there were differences in relative total work performed at the 4 upper body wingate test for the different recovery methods, no significant differences were observed (p > 0.05). This further demonstrates that performance of judo practitioners in both judo-specific and non-judo- specific performance related to recovery methods, is not dependent on the recovery method. The results of this study thus confirm the second (2) hypothesis.

### 3.2.Elimination of blood lactate between recovery methods:

In this study, significant blood lactate concentrations were observed at measurement time LA3 as well as LA15. However, there were only significant differences between some of the recovery methods; for LA3 there were significant differences between AR and JSR (p=0.044), with JSR being a more effective recovery method for lowering blood lactate at 3 minutes in comparison to AR. At LA15, significant differences were observed between PR and JSR (p<0.001) and for AR and JSR (p<0.001), with JSR having significantly higher blood lactate values 8.4 ± 0.6 compared to PR 3.6 ± 0.4 and AR 4.0 ± 0.3. There were also significant differences for the whole recovery course between PR and JSR (p<0.001) and AR and JSR (p<0.001), however, no significant differences between PR and AR were observed during the whole recovery. As the lactate value for JSR was much higher than for the other two recovery methods (PR and AR), one reason for this may be that the exercisers had a heart rate higher than 100% of LT4 between the different heart rate measurements and thus had a higher lactate production in relation to lactate elimination, and hence produced more lactate than that broken down and hence had higher blood lactate values at the lactate measurement for LA15.

As the results of this study showed no significant difference between PR and AR, and that together they were the most effective recovery methods for eliminating bleaching in comparison to JSR. This result contradicts previous research comparing PR with AR such as the studies Baldari et al. (2004);

Franchini et al. (2003); Franchini et al. (2005); Greenwood et al. (2008); Menzies et al. (2010) and Watts et al. (2000) which show that AR is a more effective recovery method in comparison to PR. The result in this study for AR may be due to the fact that the intensity in comparison to PR was too high, although the intensity for recovery had been calculated to be at 80% of LT4 as this level was below the most effective level to eliminate blood lactate which was between 80-100% of LT4 according to Menzies et al (2010) Few studies have examined JSR against other recovery methods, but in the study by Touguinha et al. (2011) they found that JSR was a more effective recovery method than PR in eliminating blood lactate, although this result was not significant but showed a trend ($p=0.05$). As this study shows that PR and AR were more effective recovery methods in comparison to JSR for lowering blood lactate concentration throughout the test, the results of this study differ with the result presented by Touguinha et al. (2011). Something that was more remarkable, especially the very large difference in blood lactate for JSR at 15 minutes in comparison with PR and AR. Where the values for JSR were almost twice as high in comparison to PR and AR. This large difference cannot be explained by any of the exercisers being outside their designated heart rate zone, in that recovery during JSR was performed at 70- 80% of HRmax which would correspond to 80-100% of LT4 and be the most effective range for eliminating blood lactate according to Menzies et al, (2010) something that the results of this study contradict.

In this study, only significant differences in blood lactate for the entire test course between recovery methods AR and JSR and PR and JSR were observed, which is remarkable as many other studies have observed differences between AR and PR in the elimination of blood lactate. The results of this study thus reject the third (3) hypothesis.

As no significant differences in performance between the different recovery methods were observed in this study, it can perhaps be assumed that blood lactate does not have a significant impact when talking about performance in SJFT. The relationship between blood lactate concentration after judo matches and SJFT has been investigated in studies by Artioli et al. (2005); Detanico et al. (2012) and Garbouj et al. (2015) these studies could not show any significant correlations between blood lactate concentration and one series in SJFT or three series in SJFT for both men and women.

# Conclusion:

***Conclusion:***

In conclusion, this study found that all three recovery methods (PR, AR, and JSR) resulted in significant performance decreases in the SJFT when comparing pre- and post-recovery SJFTs. However, there were no significant differences in SJFT performance between the different recovery methods. Furthermore, the study showed that PR and AR were the most effective recovery methods for eliminating blood lactate, in contrast to previous research. These findings suggest that coaches and athletes can use any of the three recovery methods studied without negatively impacting SJFT performance, but PR and AR may be more effective for lactate elimination. However, further research is needed to confirm these results and investigate other recovery methods for optimizing performance and recovery in judo athletes.

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# Annexe