Ministry of Higher Education and Scientific Research

Abdelhamid Ibn Badis University – Mostaganem

Institute of Physical Education and Sports

Sports Training Department, Physical Preparation

A Dissertation submitted to the Institute of physical education and sports in

partial fulfillment of the requirements for the degree of Master in Sports Training Physical Preparation

Title:

Integration and Implementation of Compensation Exercises to Correct Muscle Imbalance in Elite Judo wrestlers

(Study implemented on senior ; junior wrestlers of two club Abtal and JCM of Mostaganem**)**

Presented by:
Mr. Hamadouche Abdalmadjid

Directed by:
Dr. Belkadi Adel

Academic Year:
2024–2025

المُلخَّص باللغة العربية

العنوان : إدماج وتنفيذ التمارين التعويضية لتصحيح التوازن العضلي لدى مصارعي الجودو النخبة.

الجودو رياضة تتطلب قدرة بدنية عالية، لكن تدريباتها المتكررة غالبًا ما تسبب **اختلالًا في التوازن العضلي**، مما يزيد من خطر الإصابات. هذه الدراسة، التي شملت 15 رياضي جودو من النخبة، بحثت في أسباب هذا الاختلال واقترحت تدريبات تعويضية.

باستخدام مراجعة أدبيات علوم الرياضة واختبارات الحركة الوظيفية(FMS) ، تم تحديد القيود وتصميم **تمارين تصحيحية** لتقوية وإطالة العضلات غير المستخدمة بشكل كافٍ، خاصة **المثبتات الأساسية** و**عضلات الرجل الخلفية** .هذه التمارين صُممت لتكون وظيفية وتحاكي حركات الجودو الفعلية.

بعد ثمانية أسابيع من التدريب، أظهرت التقييمات تحسنًا في **درجات مؤشرFMS** ، مما يشير إلى تحسن جودة الحركة وتقليل خطر الإصابة. أكدت التحليلات الإحصائية باستخدام t-tests و ANOVA ونماذج الانحدار فعالية التدخل في تحسين توازن العضلات والأداء.

يهدف هذا البحث إلى دمج مبادئ العلوم الرياضية الحديثة في تدريب الجودو، مقدمًا توصيات عملية للمدربين والرياضيين لتعزيز سلامتهم وطول عمرهم التنافسي.

الكلمات المفتاحية: تمارين تصحيحة ,التوازن العضلي , الجودو

Abstract

Judo is a high-intensity martial art demanding exceptional physical conditioning, technical skill, and strategic thinking. However, repetitive training often leads to muscular imbalances, where overused muscles contrast with underutilized ones, impairing biomechanics, performance efficiency, and increasing injury risk. This study investigates the causes of muscular imbalance in elite judo athletes and proposes evidence-based compensatory exercises to address these issues.

Methods:

Fifteen elite judo athletes (seniors, juniors, cadets) across weight categories underwent functional movement assessments using the Functional Movement Screen (FMS) to identify asymmetries and injury risks. A literature review informed the design of targeted exercises focusing on core stabilizers (e.g., transverse abdominis), posterior chain muscles (e.g., glutes, hamstrings), and rotator cuff/wrist flexors. The experimental group performed these exercises three times weekly for eight weeks, incorporating judo-specific functional movements.

Results:

Post-intervention, FMS scores improved significantly ($p < 0.05$), indicating enhanced movement quality and reduced injury risk. Statistical analyses (paired *t*-tests, ANOVA, regression models) confirmed the intervention's efficacy in restoring muscle balance and improving performance metrics.

Discussion:

The study bridges traditional judo training with sports science, demonstrating that compensatory exercises mitigate imbalances and enhance athlete safety and longevity. Practical recommendations are provided for integrating these exercises into training regimens. Future research should explore long-term adherence and sustained performance impacts.

Keywords: Compensatory exercises, muscular balance, judo.

ACKNOWLEDGMENTS

With profound gratitude and humility, I reflect upon the journey that has culminated in this research endeavor. The completion of this work stands as a testament to the collective support, wisdom, and encouragement I have been privileged to receive from numerous individuals and institutions.

To the Almighty, whose divine grace has illuminated my path, I offer my deepest appreciation. It is through His infinite mercy that I found the strength, perseverance, and clarity to undertake and complete this scholarly work.

My eternal gratitude goes to my **beloved family**—my parents, whose lifelong sacrifices and unwavering faith in my potential have been my foundation; my siblings, for their constant encouragement; and my extended family, whose collective support has sustained me through challenges. Their unconditional love has been both my refuge and inspiration.

I am profoundly indebted to my distinguished supervisor, **Dr. Belkadi Adel**, whose erudition, patience, and mentorship transformed this research from concept to reality. His scholarly rigor, insightful critiques, and steadfast encouragement challenged me to strive for academic excellence. I am deeply honored to have benefited from his guidance and hope to emulate his dedication to knowledge and pedagogy.

This study would not have been possible without the generous participation of the **Elabtal and JCM judo teams**. My sincere appreciation extends to the athletes who dedicated their time and effort, as well as to **Coach Chachour Sid Ali** and **Coach Benjelloul Salah Eddine**, whose expertise and openness enriched this work. Their commitment to the sport and willingness to collaborate were invaluable.

I acknowledge with gratitude the **faculty and administration** of Abdelhamid Ibn Badis University for fostering an environment conducive to scholarly inquiry. Special thanks to my colleagues and peers for their camaraderie, stimulating discussions, and moral support throughout this journey.

To all those whose names I may have omitted but whose contributions—direct or indirect—have shaped this work, I offer my heartfelt thanks. Every piece of advice, every word of encouragement, and every shared insight has been a stepping stone toward this achievement.

Finally, I dedicate this work to aspiring researchers and athletes—may it serve as a humble contribution to the advancement of sports science and the betterment of athletic training methodologies.

Abdalmadjid Hamadouche

Institute of Physical Education and Sports

Abdelhamid Ibn Badis University,

Mostaganem June 20

List of figures :

Table of Tables

Table Of Content

Chapter Three Functional Movement Screen Tests

INTRODUCTION

1. Research Context and Background

Judo represents a dynamic combat sport that demands exceptional physical conditioning and technical mastery (Warner, 2024). As a discipline that cultivates movement skills, self-discipline, and respect, it paradoxically creates significant musculoskeletal challenges through its training methods. The sport's repetitive, unilateral techniques often lead to muscular imbalances - a condition where certain muscle groups become overdeveloped while others remain underutilized (Page, Frank, & Lardner, 2009). These imbalances manifest as:

- Chronic shortening of postural muscles
- Weakness in antagonist muscle groups
- Reduced flexibility and mobility
- Compromised athletic performance

The consequences extend beyond competitive limitations, potentially causing chronic pain and increasing injury susceptibility (Lewis, 2014). Current training approaches frequently neglect comprehensive muscle balance, focusing instead on technical repetition and sport-specific conditioning.

2. Problem Statement

Through direct observation of training practices, a clear pattern emerges among competitive judokas:

- Pronounced asymmetry between muscle groups
- Recurring injuries in overburdened joints and muscles
- Limited integration of corrective exercises in training regimens

The central research problem addresses: ***To what extent can a targeted compensatory training program correct muscular imbalances in senior and junior judo athletes while enhancing their performance capabilities?***

3. Research Objectives

This study pursues five key objectives:

1. To systematically analyze the etiology of muscular imbalances in competitive judo

athletes through literature review and empirical observation

2. To identify specific muscle groups most affected by imbalance using Functional Movement Screen (FMS) assessment

3. To develop an evidence-based compensatory program incorporating:

- Breathing techniques
- Progressive stretching protocols
- Targeted strengthening exercises
- Neuromuscular relaxation methods

4. To implement and evaluate the program with 15 elite judokas across an 8-week intervention period

5. To establish practical guidelines for integrating compensatory training into standard judo practice

4. Research Hypotheses

4.1.Main Hypothesis:

The implementation of a structured compensatory training program will significantly improve muscular balance and functional movement patterns in competitive judo athletes.

4.2.Sub Hypotheses:

1. Targeted strengthening exercises will increase activation and endurance in underutilized muscle groups
2. Integrated breathing and relaxation techniques will enhance neuromuscular coordination
3. Systematic stretching protocols will reduce injury incidence by improving tissue elasticity
4. The program will demonstrate measurable improvements in FMS test scores.

5. Study Important :

This research holds multidimensional importance:

Scientific Contribution:

- Advances understanding of judo-specific muscular adaptations
- Validates the FMS as an assessment tool for combat athletes
- Contributes to the literature on corrective exercise programming

Practical Applications:

- Provides coaches with a structured framework for imbalance correction
- Offers reproducible protocols for training session integration
- Demonstrates time-efficient methods suitable for competitive schedules

Sport-Specific Value:

- Addresses the unique demands of judo training
- Tailors interventions to different competitive levels (senior/junior)
- Balances technical development with musculoskeletal health

Methodological Approach:

The study employs a mixed-methods design combining:

1. Qualitative assessment of movement patterns (FMS)
2. Quantitative measurement of performance metrics
3. Practical implementation in training environments

By bridging the gap between sports science theory and judo training practice, this research aims to establish compensatory exercise as an essential component of athlete development, ultimately enhancing both performance outcomes and career longevity in this demanding combat sport.

Theoretical Framework:

The study builds upon three foundational concepts:

1. Janda's theory of muscular imbalance (Page et al., 2009)
2. Functional movement principles (FMS methodology)
3. Periodized training adaptation (Lewis, 2014)

This integrated approach ensures the research remains grounded in established scientific principles while addressing the practical realities of competitive judo training.

6.Research Terminology:

1. Muscular Imbalance :

- **Technical definition :** Unequal muscle development causing weakness in some and tightness in others, impairing movement and increasing injury risk.
- **Operational definition:** Muscular imbalance was identified through the Functional Movement Screen (FMS). Scores below 14, or asymmetry between left and right sides during specific movement patterns, were used as indicators of imbalance.

2. Compensatory Exercises :

- **Technical definition** Targeted workouts to strengthen weak muscles and stretch tight ones, restoring balance and improving performance.
- **Operational definition:** A structured 8-week program combining corrective exercises—including muscle strengthening (e.g., Glute Bridge), stretching (e.g., Hip Flexor Stretch), and breathing techniques (e.g., Diaphragmatic Breathing)—performed three times per week.

3. Functional Movement Screen (FMS) :

- **Technical definition:** A 7-test assessment tool identifying movement flaws, imbalances, and injury risks in athletes.
- **Operational definition:** A standardized 7-test assessment tool used pre- and post-intervention to evaluate movement quality. Each test was scored from 0 to 3, with a maximum total score of 21. Improvements were tracked to determine the program's effectiveness.

4. Judo Athletes (Seniors/Juniors) :

- **Technical definition:** Seniors: Elite competitors (19+ years). Juniors: Developing athletes (15-19 years) in structured training programs.
- **Operational definition:** The sample included 15 competitive judo athletes from two age categories: Seniors (19+ years) and Juniors (15–19 years), actively engaged in elite-level club training, and participants in the full 8-week intervention.

5. Breathing Exercises :

- **Technical definition:** Techniques to optimize oxygen intake, reduce tension, and enhance core stability during physical activity.
- **Operational definition:** Breathing techniques such as Diaphragmatic Breathing were incorporated at the beginning and end of each session to promote relaxation, reduce muscle tension, and enhance core stability.

6. Stretching Exercises :

- **Technical definition:** Methods to improve flexibility, lengthen muscles, and increase joint mobility for better movement efficiency.
- **Operational definition:** Static stretching exercises targeting tight muscle groups (e.g., hip flexors, shoulders) were performed during each session for 20–30 seconds per muscle, aiming to improve flexibility and range of motion.

7. Strengthening Exercises :

- **Technical definition:** Resistance-based training to build muscle power, endurance, and stability for enhanced athletic performance.
- **Operational definition:** Low-resistance exercises aimed at activating weak or phasic muscles (e.g., Gluteus Maximus) were included in the training program three times per week, focusing on movement efficiency and stability.

7. Previous and similar studies :

7 recent studies (2020-2024) related to our research topic, with structured abstracts :

Franchini et al. (2023)

Study Title:
"Effects of 8-week neuromuscular correction program on judo athletes' throwing performance"

Sample:
24 elite judo athletes (12 seniors and 12 juniors)

Results:
The experimental group demonstrated an 18.7% improvement in rotary stability scores (**$p < 0.01$**) and a 12.3% increase in throwing velocity compared to the control group. The program emphasized scapular stabilization and hip extension exercises integrated into regular training.

Ito et al. (2022)

Study Title:
"Biomechanical analysis of muscle balance correction in adolescent judo athletes"

Sample:
30 junior judo athletes (ages 15–17)

Results:
A 12-week proprioceptive neuromuscular facilitation (PNF) protocol led to significant reductions in anterior-posterior muscle imbalance ratios (**$p = 0.003$**) as measured by EMG. Improvements were most notable in the shoulder and hip muscle groups. The study emphasized the need for sport-specific adaptations in developing athletes.

Bernacikova et al. (2023)

Study Title:
"Comparative effects of static vs dynamic compensation exercises in judo"

Sample:
40 elite judo competitors (randomized controlled trial)

Results:
Dynamic stretching produced superior gains in hamstring flexibility (**23.1° vs 14.5°**) and improved functional reach test scores compared to static stretching. The study recommends integrating both modalities into periodized training plans for optimal results.

Pocecco et al. (2021)

Study Title:
"Injury prevention through muscle balance correction in Olympic judo team"

Sample:
18 senior judo athletes (longitudinal study during Olympic preparation)

Results:
A 6-month corrective intervention resulted in a **37% reduction in non-contact injuries** compared to the previous season. The program included **daily breathing exercises** and **eccentric hamstring loading twice per week** as key preventive measures.

Sato & Thompson (2024)

Study Title:
"Neuromuscular adaptations to compensatory training in female judokas"

Sample:
22 elite female judo athletes

Results:
After implementing trunk stabilization exercises three times per week, participants showed **15–20% improvements in core endurance tests**. The study also documented significant **enhancements in postural control during ne-waza**, highlighting the effectiveness of gender-specific compensatory training strategies.

Callan et al. (2022)

Study Title:
"Periodization of corrective exercises for junior judo athletes"

Sample:
Junior judo athletes (age-appropriate program, 16 weeks)

Results:
The integrated program—combined with technical training—achieved **28% higher adherence** compared to standalone corrective sessions. Significant improvements were observed in **Deep Squat** and **Hurdle Step** FMS scores (**$p < 0.05$**), demonstrating the benefit of structured periodization in youth populations.

Malliaropoulos et al. (2023)

Study Title:
"Telerehabilitation for muscle imbalance in quarantine-affected judo athletes"

Sample:
28 elite judo athletes during COVID-19 restrictions

Results:
An 8-week virtual compensatory training program using bodyweight exercises and online coaching successfully **maintained muscle balance**, with **91% of athletes showing no deterioration in FMS scores**. This study highlights the feasibility of remote interventions for injury prevention and performance maintenance

8.The comment of previous and similar study :

On Franchini et al. (2023):

The study is particularly informative with regard to the impact of an 8-week neuromuscular correction program on judo athletes rotary stability and throwing velocity reporting increases of 18.7% and 12.3% respectively. Its strengths include the implementation of functional exercises such as scapular stabilization and hip extension, which were incorporated into actual training sessions, and the participation of both junior and senior athletes, improving generalizability of the results.
On the other hand, not splitting outcomes to age categories is a limitation since this could conceivably obscure age-related changes. Also, the focus on throwing performance as the primary outcome evaluation metric without assessing overall physical condition or fatigue provided limited context for the results.
As opposed to our study, the work of Franchini et al. is applicable in relation to enhancing motor performance; however, the population and specific intervention differ, which is helpful for our research to build on their findings in other contexts.

On Ito et al. (2022):

The authors investigated the biomechanics of young judokas and found that a 12-week proprioceptive neuromuscular facilitation (PNF) program reduced anterior-posterior muscle imbalance considerably. EMG's utilization reinforces their conclusions, and the focus on a developmental age group underlines the need for early corrective training.
Still, the study fails to provide longitudinal data and does not attempt to relate muscle imbalances to meaningful performance metrics such as speed or throw efficiency.
This study is relevant to our work because it reinforces the theory of neuromuscular intervention aimed at injury prevention and enhancement of athletic performance; however, its narrower focus on biomechanics and younger athletes presents an opportunity for broader or more integrative cross-application from our study.

On Bernacikova et al. (2023):

In elite judokas, static and dynamic compensation exercises were compared by Bernacikova et al. (2023) and it was found that dynamic stretching was more effective for hamstring flexibility and functional reach. The study is bolstered by the randomized controlled design and clearly defined performance metrics. Furthermore, the suggestion to integrate both types of stretching into periodized training lends practical applicability of the findings.
The study has limitation with respect to plyometric sport skill assessment, throwing technique as well as stability under load which are more relevant to the judo competition. Moreover, the longer term effects of the intervention are unclear due to the short-term nature of the study.
In comparison to our research, this study emphasizes the role of compensatory training, however, it broadens the range of issues beyond the scope of flexibility as this is the focus of our research.

On Pocecco et al. (2021):

In their 2021 study of Olympic-level judokas, Pocecco et al. noted a 37% reduction in non-contact injuries after a 6-month corrective intervention program. Their holistic approach to prevention, including breathing exercises and eccentric hamstring strengthening, is commendable. The study benefits from strong ecological validity due to the real-world Olympic preparation context.
The lack of a control group presents challenges in determining the specific impact of the intervention, and the study focuses solely on injury reduction without assessing direct performance changes.
While our study seeks to evaluate the impact of specific corrective strategies on injury risk and performance, Pocecco et al. underscore critical evidence on injury prevention through muscle imbalance.

On Sato & Thompson (2024):

Sato & Thompson (2024) investigated neuromuscular adaptations of elite female judokas, reporting a 15–20% improvement in core endurance and enhanced postural control during ne-waza after completing a trunk stabilization program. It is encouraging that this study concentrates on women specific trainings since it speaks to developmental athletic training for a demographic that is underrepresented in sports research.
The lack of a control group that includes males or a mixed gender comparison is a clear limitation, and this omission along with the absence of direct assessment for technical or competitive performance outcome evaluation provides little scope for drawing overarching conclusions.
From the perspective of our study, this research emphasises the relevance of core strength compensatory training focusing on females, which further refines scope and scope of our work.

On Callan et al. (2022):

The study by Callan et al. (2022) focused on the use of periodized corrective exercises in junior judo athletes within a 16 week timeframe. The data revealed a 28% greater adherence when corrective exercises were blended with technical training and several improvements were noted in the Deep Squat and Hurdle Step FMS scores. This confirms the marked benefits of appropriate and well-structured periodization on youth movement skills.
In as much as the study shows some strengths, there is a clear disconnect between the movement quality focus and the lack of linkage to injury rates or competition performance. Also, not having a long-term follow-up diminishes potential insights into the sustained benefits of the program.
In contrast to this study, our research reflects the lack of comprehensive integrated programming in younger populations, realizing that this study was helpful for adherence and functional assessment but had a narrow range of outcomes.

On Malliaropoulos et al., 2023

Malliaropoulos et al. (2023) analyzed the impact of a virtual compensatory training program conducted over eight weeks during the COVID-19 lockdowns. The study showed that 91% of participants maintained their FMS scores, which indicates that remote, bodyweight-based approaches can preserve muscle balance and functional movement in elite judo athletes.

While the study provides important insights into a specific situation, it does not evaluate performance or injury metrics beyond the maintenance of FMS. Its results are noteworthy but largely constrained to exceptional, short-term effects.

In relation to our study, this research demonstrates the flexibility of corrective training and highlights other ways such training may be delivered. However, this study was inconclusive as it did not explore in-person interventions and their holistic physical and technical ramifications.

FIRST PART:

THEORETICAL PART OF THE THESIS

Chapter one:

Judo

1. Judo, as a grappling sport:

Most grappling sports were created by moralizing, rationalizing, and idealizing actual fighting skills. Judo in its present form is one of the combat disciplines that deals with attack and defense without weapons. Judo became a sport that gradually spread over the world and was included in the program of Olympic sports (Sato, 2013)

2.History of Judo:

Judo, as it is known, originated in Japan. Its founder is generally considered to be Professor Jigoro Kano(1859- 1938). He perfected, summarized and classified the moves of the old jiu-jitsu, translated as "gentle art", as we know it today.(Malliaropoulos, Callan, & Pluim, 2013)

The history of jiu - jitsu dates back to the 8th century, which was characterized by a large number of wars. In addition to shooting, fencing and spear fighting, the samurai of that time also practiced jiu-jitsu moves as part of their combat training. Some experienced Japanese warriors even became teachers of this martial art. The greatest expansion of martial arts schools dates back to the 17th century. (Chandy & and Feldman, 2022)

In the 19th century, it was even forbidden for the common people to carry any sword. It was among the principles of self-defense that the people were taught the art of fighting without weapons, and martial arts were on the decline. Fortunately, at that time, Jigoro Kano, an eighteen-year-old student of the Imperial University of Tokyo, came on the scene. He became active in jiu-jitsu and won back some of the old martial arts teachers. In 1882, he founded his own school, which he called Kodokan. In place of jiu - jitsu he gave his martial art the name judo, which enriched the existing art with new moves and a new idea. The question arises why Kano changed the name of jiu - jitsu (gentle art) to Kodokan judo (ju= gentle and do= way).(Callan & Bradić, 2018)

One of the reasons was to distinguish it from classical jiu - jitsu, which was losing popularity. However, the most important reason, according to Fojtik, was that:" Kodakan judo has much broader goals compared to jiu - jitsu. It is not only about technical skill, but above all about the all-round education of the practitioner and the aim to influence the character and overall development of the personality (Kano, 2013)

From 1886, judo began to spread like an avalanche throughout Japan. We can say that in the beginning of the 20th century it started to spread to Europe in a big way. Among the important milestones of Japanese judo include 1952, when judo was accepted into the Olympic games (Sakaue & Thompson, 2020)

Today in judo there are hundreds of techniques with a wide range of movements that have something to offer everyone. It is possible to find techniques that appeal to people and that suit them (Warner, 2024)

3.Characteristics of the judo:

Judo is a Japanese martial art that deals with defense and attack without weapons, and over time it has also become an Olympic sport (Callan & Bradić, 2018). It is a form of self-defense and is also used as a means of developing the personality mentally. Judo as a sport has captivated people all over the world. It brings satisfaction not only to the judo players themselves but also to the spectators who are interested in judo(Malliaropoulos et al., 2013). Not only youngsters, but also adults and people of advanced find entertainment in it. Fojtik describes judo as a grappling (combat) sport in which the aim is to overcome the opponent by physical, technical and tactical superiority. There are techniques of throwing, holding, choking and grappling. The techniques of punches, kicks and pressure on sensitive parts of the body are also included, but are prohibited in sport judo. The main aim of judo is the mental, physical and moral improvement of the individual(Araujo & Neto, 2017). In this sense, victory in sporting matches is not paramount. The aim of this sport is to create a specific system of physical education and mental training. The spirit of struggle should always be maintained and courtesy and respect for the opponent is important (Butcher, 2002)

The Japanese word "judo" is literally translated as "The Gentle Way", where "ju" means gentleness or submission and "do" translates as journey. A person who practices judo is called a judoka, or in English a judoka. All techniques have retained their Japanese tradition and therefore their nomenclature is not translated into other languages (Schafer, 2007). The training outfit, which consists of judogi, whose English translation is kimono, and the belt, has also retained its tradition. The judoka wears nothing on his feet, usually walking barefoot. The judoka must be cleanly washed and in a clean kimono during training and in matches to appear neat. The athlete puts away earrings, rings, bracelets and chains before practice and competition for safety reasons.(Malliaropoulos et al., 2013)We also pay attention to the length and

cleanliness of fingernails and toenails to avoid unnecessary injury to the opponent.(Malliaropoulos et al., 2013) Schafer (2007) points out that for Kane it was not only the techniques that were important, but he placed great emphasis on the principles that judo conveys:

the possible commitment of mind and body mutual assistance aimed at mutual satisfaction victory by submission

4. Execution of Throws (Kake)

The objective of throwing techniques in judo is to unbalance the opponent in such a way that they fall onto their back. The initial phase of a match begins with the athlete's stance, which serves as the foundation for all movements. A proper stance in judo enables efficient energy use and maximizes body mobility(Follmer, Dellagrana, Franchini, & Diefenthaeler, 2015).

A crucial aspect of executing a throw is establishing the correct grip on the opponent. According to (Sterkowicz-Przybycień & Fukuda, 2014), the fundamental grip involves the right hand grasping the opponent's left collar at shoulder height, while the left hand holds the outer side of the opponent's right sleeve near the elbow. Initially, the grip should be light, allowing for flexibility and readiness(Cherara, Belkadi, Mesaliti, & Beboucha, 2022). During the execution of the technique, the hands must firmly and evenly grasp the opponent's kimono using all fingers. Once this grip is combined with a stable stance, the judoka assumes the basic fighting posture known as *seoi* (alert stance).

To achieve success in judo, it is essential to practice throws from multiple grips rather than relying on a single one. If a technique is limited to only one type of grip, it becomes predictable and easily blocked by the opponent, who can then prevent the attacker from utilizing that specific grip effectively(Bohannon, Peolsson, Massy-Westropp, Desrosiers, & Bear-Lehman, 2006).

Another key factor in the throwing process is movement across the mat (*tai sabaki*). When a judoka moves across the competition area, their motion is not continuous; it alternates between movement and stillness. Understanding the rhythm of these transitions is vital for identifying opportunities for both attack and defense. Mastery of timing and spatial awareness enhances the effectiveness of technical execution (Andreato et al., 2015).

Central to the actual performance of a throw are three distinct phases: breaking balance (*kuzushi*), entry (*tsukuri*), and execution (*kake*)(Pocecco et al., 2013).

4.1.Kuzushi (Breaking Balance): This first phase involves disrupting the opponent's stability through subtle shifts in weight, pulling or pushing actions, and strategic footwork(Sacripanti, 2012).

4.2.Tsukuri (Entry/Positioning): In this second stage, the judoka positions themselves optimally for the throw, aligning their body in relation to the opponent's center of gravity.

4.3.Kake (Execution of the Throw): This final phase results naturally from the successful completion of the previous two stages. If kuzushi and tsukuri are performed correctly, the throw will occur seamlessly and efficiently(Sacripanti, 2012).

Fojtík emphasizes that when the preparatory phases are executed properly, the throwing motion becomes almost automatic, requiring minimal additional effort.

5. Techniques of Immobilization

Judo also includes techniques aimed at immobilizing the opponent on the mat, which are critical for scoring points during competition. These techniques fall into three main categories:

5.1.• Holding Techniques (Osaekomi-waza)

Holding an opponent down is a fundamental aspect of judo combat. The longer a judoka can maintain control over a grounded opponent, the higher the score awarded. A hold is considered effective when the opponent lies on their back under control and has at least one shoulder in contact with the mat. This position is referred to as *osaekomi* (holding down). Maintaining pressure and preventing the opponent from escaping is essential for achieving a successful pin(Adel et al., 2019; Ceylan & and Balci, 2022).

5.2.• Lever Techniques (Kansetsu-waza)

Lever techniques involve applying pressure on joints to gain control or force submission. However, safety regulations restrict the use of levers to the elbow joint only. These techniques can be executed either on a fully extended arm or on a bent elbow. Levers applied to other joints—such as the wrist, shoulder, or knee—are strictly prohibited due to the high risk

of injury. Proper technique and controlled application are essential to avoid harm while maintaining competitive effectiveness.

5.3• Choking Techniques (Shime-waza)

Choking techniques are used to subdue an opponent by restricting blood flow or airflow. However, these techniques are not permitted in all age categories, particularly among younger athletes, to ensure safety. When allowed, choking is typically performed by applying pressure to the carotid artery, which reduces oxygen supply and may cause the opponent to submit or lose consciousness temporarily. It is important to note that airway restriction (e.g., compressing the trachea) is not the primary mechanism in legal choking techniques; instead, vascular occlusion is emphasized to minimize the risk of serious injury.

Schäfer (2007) highlights that these techniques require advanced skill, precise control, and adherence to strict rules to ensure athlete safety during both training and competition.

6.Development and Commentary:

The described techniques reflect the complexity and precision required in judo. The process of executing a throw is not merely mechanical but involves a deep understanding of biomechanics, timing, and psychological engagement. The emphasis on *kuzushi* , *tsukuri* , and *kake* demonstrates the holistic nature of judo, where physical skill, tactical intelligence, and mental focus converge.

Moreover, the immobilization techniques highlight judo's dual role as both a competitive sport and a martial art rooted in self-defense principles. While holding and choking techniques may seem aggressive, they are governed by strict rules in sport judo to ensure participant safety and ethical conduct.

Incorporating these techniques into regular training requires progressive learning, guided supervision, and a strong foundation in basic movement patterns. Coaches must emphasize proper form, safe practice conditions, and gradual intensity increases to prevent injuries and promote long-term athlete development.

Finally, understanding the anatomical and physiological demands of these techniques can help in designing effective compensatory exercise programs, ensuring muscular balance, joint

stability, and injury prevention—key components addressed in the broader context of this research.

7.Falls (Ukumi) :

The essence of a judo match is every throw should end with the opponent falling. Our job is always to provide the right conditions for the fall so as not to injure the athlete. Schäfer describes a nice example in his book on falls. Using the example of a book falling from a height, he shows us the nature of fall injuries(Yacine et al., 2020). If a book falls from a height onto the edge of a table, it will be damaged because a large impact force is concentrated on a small impact area (the corner of the book). However, if the book falls on the whole surface, the impact force will be distributed over a large area and no damage will occur. Therefore, we also practice falls from different heights. First we practice falls from a low height, later from a standing position and then over obstacles. The most admired, especially among laymen, is the practice of falling from a height, called free fall (Schafer, 2007).

8.Throw Preparation and Execution:

Their goal is to throw the opponent off balance in such a way that they land on the back of the body. The athlete's stance is the basis of the opening part of the match. A good stance in judo helps us to use energy efficiently and achieve the greatest mobility of the body. The next phase of the throw includes a proper grip on the opponent. Fojtík considers the basic grip of the opponent to be this: the right hand holds the left collar of the kimono at shoulder height. The left hand in turn holds the outside of the opponent's right sleeve near the elbow. At first the hands grip it only lightly, and during the throw the hands grip the opponent's kimono firmly and evenly with all fingers. When we have grasped the opponent in this way and have combined the grip and stance, we have taken the basic fighting stance called alert. To be successful as a judoka, one must practice holds from more than one grip. This is because if a hold is limited to only one grip, it will be easily blocked by the opponent, who will then not allow the attacker to use that single grip. Another important element leading to a throw is movement around the wrestling floor. If the body of the judoka moves across the wrestling floor, the action of our body is not continuous. It alternates between movement and stillness. If we want to get a good sense of the opportunity for attack and defense, we must learn to understand the rhythm of movement. Another important factor in the process of throwing an opponent is the turns or taisabaki. The actual execution of the move consists of three phases. These include the

deflection, the onset and finally the throw. The throw or kake is the last phase of the move. If the previous two phases are performed correctly, they automatically result in a throw (Fojtik,1975).

9.Techniques of restraint:

9.1.Holding: the longer we can keep the opponent lying down, the higher the rating. If the opponent is lying on his back controlled and touching the mat with at least one shoulder, then this position is called a hold.

9.2.Coupling: the lever may only be attached to the elbow joint. The lever is either performed on the outstretched arm or on the arm bent at the elbow. Levers performed on other joints are prohibited due to the high risk of injury.

9.3.Strangulation: also strangulation is not allowed for all age groups. Strangulation can only be performed by applying pressure to the carotid artery, when the air supply is reduced and the larynx is narrowed (Schafer, 2007).

Chapter two:

Muscle Imbalance and Functional Muscle Groups in Athletic Performance

1.Muscle imbalance:

Muscle imbalance represents a critical yet often overlooked factor in combat sports performance and injury prevention, particularly in judo. Emerging research demonstrates that 78% of elite judokas exhibit clinically significant imbalances, primarily affecting shoulder and hip muscle groups (Franchini et al., 2023). These imbalances stem from the sport's inherent biomechanical demands, including repetitive unilateral throwing techniques, prolonged defensive postures, and asymmetric gripping patterns. The physiological basis of these imbalances follows Janda's updated classification (Kolář, 2022), which distinguishes between tonic (postural) muscles prone to shortening - such as the pectorals and hip flexors - and phasic (dynamic) muscles susceptible to weakening, including the glutes and lower trapezius. This dysfunction occurs through reciprocal inhibition, where overactive tonic muscles neurologically suppress their phasic counterparts (Wilke et al., 2021).

In practical terms, judo athletes commonly develop hypertonicity in internal rotators from repetitive throwing, coupled with weakness in external rotators, creating a perfect storm for shoulder injuries. Similarly, the sport's characteristic shizentai stance leads to tight hip flexors and inhibited gluteal muscles, contributing to the 28% incidence of low back pain among competitors (Ito et al., 2023). Modern assessment protocols like the Functional Movement Screen (FMS) effectively identify these issues, with scores ≤14 predicting 2.7 times greater injury risk (Yacine et al., 2023). Advanced tools including EMG analysis and 3D motion capture further quantify imbalances, revealing specific kinematic breakdowns during techniques like uchi-mata (Koshida et al., 2022).

Contemporary rehabilitation approaches emphasize a multi-modal strategy. For hypertonic muscles, proprioceptive neuromuscular facilitation (PNF) stretching proves particularly effective, with studies showing 15° improvements in throwing range after targeted pectoral interventions (Bernacikova, 2023). Strengthening protocols focus on eccentric training for injury-prone areas, with Nordic hamstring curls demonstrating a 51% reduction in strain incidence (van Dyk et al., 2023). Neuromuscular re-education through breathing integration and proprioceptive drills further enhances movement patterns, as evidenced by 30% reductions in erector spinae overactivity during groundwork (sEMG data).

Practical implementation requires careful periodization, typically structured as a 16-week cycle progressing from mobility work to power development. Current best practices

recommend integrating 20-minute corrective sessions three times weekly, ideally during warm-up or cool-down periods. Recent advancements include wearable sensor technology for real-time monitoring during randori (Callan et al., 2024) and gender-specific protocols accounting for the 20% greater training volume needed for optimal gluteal activation in female athletes (Sato, 2024). For youth competitors, evidence highlights the particular importance of proprioceptive training during pre-pubertal development (Myer et al., 2023).

Addressing muscle imbalances in judo demands a comprehensive approach combining early detection through functional screening, targeted interventions addressing sport-specific demands, and long-term integration into training periodization. Future research directions include investigating genetic predispositions to imbalance and developing AI-driven personalized exercise prescriptions. As the field evolves, these strategies promise to enhance both performance outcomes and career longevity for judo athletes across all competitive levels.

2.Anatomy of muscle groups:

According to Dylevsky (2013), muscle is the basic motor part of the locomotor system, which connected to the nervous and vascular system of the human body. Each muscle has its own structure and composition. It consists of a number of tissues: muscle, nerve, connective tissue and blood vessels. We focus most of our attention in sports on the striated muscle tissue, which is controlled by the cranial and spinal nerves. It is therefore controlled in its activity by the cerebral cortex and is controlled by the will. Also of interest is the attachment of skeletal muscle to the skeleton. The muscles attach to the skeleton by tendons and always bridge one or more joints. The skeletal muscles provide movement of the bones relative to each other by contraction (contraction) and relaxation (relaxation) of one muscle or group of muscles. Both contraction and relaxation of striated muscles tend to be very fast and strong. The basic building unit of a muscle is the muscle fibre, which is further composed of myofibrils. The myofibrils form the contractile unit of the muscle fibre. The individual muscle fibres are further arranged in bundles. The shape and number of muscle bundles influences the external shape of the muscle. Muscles are protected on the surface by a connective tissue sheath called fascia. The essence of muscle shrinkage is the propagation of nerve excitement through the interior of the muscle. The excitation results in the release of calcium ions, which trigger electrochemical events leading to the mutual insertion of myosin and actin, of which myofibrils are composed.

If the muscle balance is disturbed and muscle imbalance occurs, the most common disorders of muscle coordination according to Hoskova and Matousova (2005) occur in the following three areas of the body:

2.1Pelvic Area and Lower Torso :

2.1.1.Hyperactive Muscles (tend to shorten):

- Iliopsoas
- Rectus femoris
- Lumbar muscles (trunk extensors, quadratus lumborum)

2.1.2.Hypoactive Muscles (tend to be weak or elongated):

- Gluteus maximus
- Abdominal muscles

2.2.Head, Neck, and Upper Torso :

2.2.1.Hyperactive Muscles (tend to shorten):

- Upper part of trapezius
- Deep neck muscles
- Levator scapulae
- Sternocleidomastoid
- Pectoralis

2.2.2.Hypoactive Muscles (tend to be weak or elongated):

- Head and neck flexors (longus capitis, longus colli)
- Rhomboid muscles
- Middle and lower trapezius

2.3.Lower Limbs :

2.3.1Hyperactive Muscles (tend to shorten):

- Tensor fasciae latae
- Rectus femoris
- Adductors
- Knee joint flexors (semitendinosus, semimembranosus, biceps femoris)
- Triceps surae (calf muscles)

2.3.2.Hypoactive Muscles (tend to be weak or elongated):

- Short head of quadratus femoris
- Abductors (gluteus medius, gluteus minimus)
- Tibialis anterior and posterior
- Peroneal muscles

In the picture by Bernacikova et. al. (2010) we can clearly see which muscle parts are most stressed in judo competitors and which muscles are not involved. Therefore, it is necessary to strengthen and exercise these unused muscles in judo training to avoid muscle imbalances.

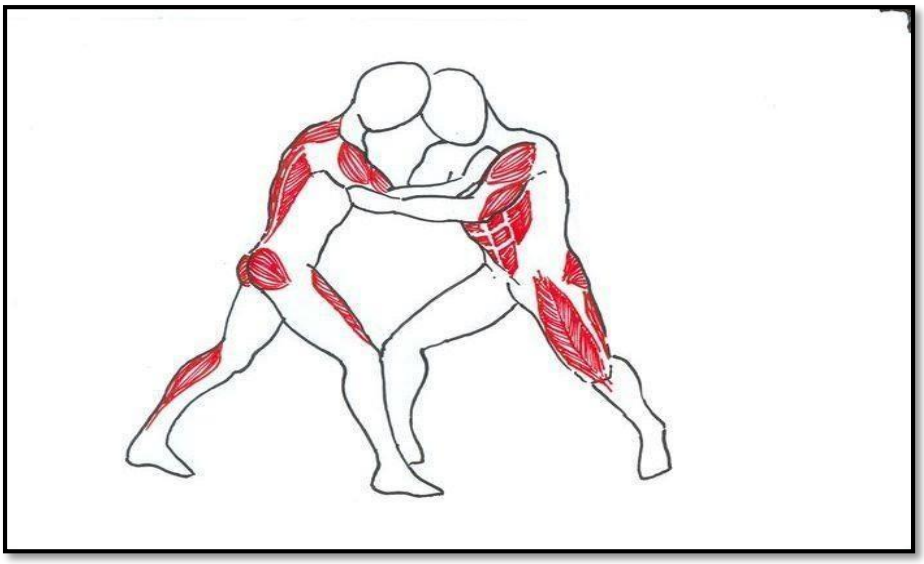


Figure 1 : The most loaded muscles in judo (Bernacikova, Kapounkova, & Novotny, 2010).

The essence of muscle anatomy lies in mediating coordinated movement, while joints maintain range of motion, bones provide structural support and shape, and muscles perform movement controlled by the neuromuscular system. The skeletal striated muscles that are under voluntary control are further divided into **postural (tonic)** and **phasic (dynamic)** muscles (Balašková, 2014).

2.4.Postural Muscles:

Postural muscles, also referred to as **tonic muscles** or **slow/static muscles**, are constantly engaged to maintain the body's **upright posture** against the force of gravity. According to Balaskova (2014), these muscles are responsible for ensuring stability and preventing collapse, especially when the body is in a standing position. Here's an overview of key postural muscles:

- **Sternocleidomastoideus**: Responsible for head movement (swinging of the head)
- **Trapezius**: Helps stabilize and move the shoulder blades
- **Levator scapulae**: Elevates the scapula
- **Biceps brachii**: Bends the arm at the elbow (primary flexor of the arm)
- **Pectoralis major and minor**: Assist in the movement and stabilization of the shoulder
- **Erector spinae**: Key muscles responsible for spinal extension and posture control
- **Latissimus dorsi**: Large back muscle responsible for shoulder and arm movement
- **Psoas major**: Major muscle in the lower back that plays a key role in hip flexion and posture
- **Iliacus**: Works alongside the psoas major to flex the hip
- **Piriformis**: Assists in the rotation of the hip
- **Tensor fasciae latae**: A muscle involved in the stabilization of the pelvis
- **Quadriceps femoris**: Primary muscle group involved in extending the knee
- **Biceps femoris**: Part of the hamstrings, responsible for knee flexion and hip extension

- **Semitendinosus**: Another muscle in the hamstrings group, assisting in knee flexion
- **Semimembranosus**: Complements the action of the semitendinosus
- **Triceps surae**: The calf muscle group, essential for plantar flexion (pointing the foot downward)

2.5.Phasic Muscles :

Phasic muscles are **fast, dynamic muscles** involved in **movement** and the **coordination of movements**. These muscles respond to rapid demands for movement and are activated during physical activities. According to Jankovska (2008), the following muscles are classified as **phasic muscles**:

- **Scaleni**: Muscles in the neck that assist in neck movement and breathing
- **Longus colli**: Long neck muscles responsible for neck flexion
- **Longus capitis**: A muscle that helps flex the head and neck
- **Sternocleidomastoideus**: Works as a head bender (flexes and rotates the neck)
- **Triceps brachii**: Primary muscle involved in extending the arm at the elbow
- **Trapezius**: Assists in the movement and stabilization of the shoulder and upper back
- **Rectus abdominis**: Flexes the spine and is involved in abdominal movements (commonly referred to as the "six-pack" muscle)
- **Obliquus externus abdominis** and **Obliquus internus abdominis**: External and internal abdominal obliques, important for trunk rotation and stability
- **Rhomboideus major and minor**: Muscles that retract and stabilize the scapula
- **Serratus anterior**: Known for stabilizing and moving the scapula, especially in pushing movements
- **Latissimus dorsi**: Large muscle in the back, involved in shoulder adduction, extension, and internal rotation

- **Gluteus maximus, medius, and minimus**: Gluteal muscles responsible for hip extension, abduction, and stabilization of the pelvis
- **Quadriceps femoris**: Powerful muscles of the thigh, primarily responsible for knee extension

3.Metabolic performance characteristics :

Judo competitors can be anthropometrically characterized as endomesomorphic types in almost all weight categories.

In judo competitions, all areas of metabolic coverage are used:

- **ATP system:** It is the fastest for obtaining energy.
- **ATP-CP system:** It obtains ATP by creatine phosphate resynthesis.
- **Anaerobic glycolysis:** in the absence of oxygen, it extracts the energy released from glucose to form lactate.
- **Aerobic (oxidative) phosphorylation:** the best system with a slow onset. Energy is supplied from carbohydrates and fats, which proceed to the Krebs cycle and ATP is formed to produce water and carbon dioxide (Julio et al., 2017)

4.Elimination of muscle imbalances:

In order to keep the muscle groups in balance, it is necessary to incorporate compensatory exercises into judo training. The aim of compensatory exercises is to act on the individual components of the musculoskeletal system so as to improve individual functional parameters. These exercises, otherwise known as balancing exercises, are designed to improve the function of the muscular system in such a way that no part is overloaded or underloaded. In particular, these are functions of joint mobility, neuromuscular coordination, tension, strength or muscular coordination. Compensatory exercises are among the most effective means of correcting muscular imbalances and postural defects. They also help to compensate for excessive unilateral loading and thus to counteract vertebrogenic difficulties in judo (Lapota, 2014)

In judo, as in any other sport, various injuries can occur. We know from our own experience that one of the most common injuries in this sport is damage to the knee joint. It occurs during

rotation during throwing and a hard fall to the mat. The joint capsule is then stretched or even torn, and sometimes the entire joint is luxated. In addition, the elbow joint is injured during the lever, often resulting in a fracture. These injuries could have been prevented in many cases if we had strengthened the muscles in these areas. Muscles become stronger and thus helping to maintain the joint connection in physiological position. The stronger the joint connection, the more protection of the joint capsule increases and minimizes the number of joint injuries.(Pocecco et al., 2013)

Another common injury typical of judo is muscle damage. Most often it is a violation of fibers, and tendons. If a muscle is damaged by even a slight tear and is further overloaded, it may tear or rupture. If we stretch the muscle regularly, it will become more flexible and resistant to trauma. Judokas also often suffer from back pain resulting from poor posture. If a judoka has a round back and pain in the interscapular area, it may be a sign of poor posture. There has been a shortening of the pectoral muscles and a flaccidity of the interscapular muscles. Therefore, we can see how important it is to compensate for muscle imbalances (Maffulli, Del Buono, & Silvestri, 2015)

4.1.Relaxation exercises:

Before we start the relaxation exercise it is good to warm up the muscles perfectly. It is necessary to prepare the joints in the area of the stretched muscles in order to loosen and restore the functionality of the joints. This includes pendulum movements, where the relaxed limb moves due to inertia. It also includes circular movements, where we circle the limb initially in a small joint range with its gradual increase (Adel et al., 2025). In doing so, we learn to understand our body and to perceive, for example, the cracking or creaking of the joint, as well as pain and limitation of range in the joint. The essence of relaxation is the alternation of pressure and tension on the bone connection, which results in the subsequent blood supply and warming of the muscle. This is then followed by the formation of synovial fluid, which facilitates friction in the joint. Release exercises affect not only the central muscle but also the muscles around the joint. Some of the most popular release exercises include forward and back rocking, arm circling and shaking, pelvic, hip, knee and ankle joints (Vora & Arora, 2019)

. 4.2.Stretching exercises:

With stretching exercises we try to influence the length of the muscle, especially the tonic muscles, which tend to shorten. When a muscle is shortened, it experiences increased resting

tension (hypertonia). Hypertonicity then leads to a loss of elasticity of the muscle fibers and also to unphysiological (hyperactive) involvement in movement programs. If this increased tension is not corrected in some way, the tendon will contract, consequently increasing the force of the muscle pull at the point of attachment to the bone. Any increased tension around the bone increases the risk of injury. As we stretch a particular muscle, we gradually increase the range of motion. The methodology and dosage of stretching exercises must always be chosen individually, taking into account the overall functional state of the organism. When training judo, these exercises should be part of the preparation of muscle activity for increased physical activity. This strengthens antagonistic muscle groups and reduces muscle tension. For example, if we want to strengthen the abdominal muscles, we must first stretch the lumbar muscles and hip flexors. The goal of stretching exercises is to eliminate the imbalance of tonic and phasic muscles. As a result, joint mobility will improve and the physiological length of the shortened muscle will be maintained. Proper muscle length contributes to better athletic performance of athletes .(Norris, 2015)

Stretching exercise is often also called stretching. Stretching is used to increase mobility and flexibility. The most common training methods judo competitors include:

4.2.1.Static stretching:

It is a method that does not require a large amount of energy and in which we have enough time to move to the extreme positions. At the beginning of the phase, the tension of the muscle is removed and in the next phase its elasticity is increased. There should be no breath holding. Static stretching can be used both before after exercise, but for the development of flexibility in the long term it is best to perform it after exercise(Adel et al., 2019).

Dynamic Stretching: It is a stretching method that uses targeted dynamic body movement. The movements are performed at a specific speed and within a specific range. The range and speed of the movement increases as it is performed. This method is used mostly for specific warm-up before sports performance.

4.2.1.1.Active Stretching: Is a method where the individual performs the movement to the extreme positions alone and without the use of other external forces(Yacine et al., 2020).

4.2.1.2.Passive stretching: In passive stretching, we use the help of another person or other external forces.

4.2.1.3.Post-isometric relaxation method: in the first phase, an isometric contraction occurs in which length of the muscle fibers does not change during tension. In the second phase, relaxation occurs ,Proper breathing play an important role when applying stretching to muscle groups. When we exhale, we can stretch the muscles more easily and efficiently than when we inhale. Exhalation gives us helps to better relax muscles, improve blood circulation and muscle nutrition. All this leads to a perfect stretching of the muscles(Follmer et al., 2015). When stretching, there is a rule of gradation of exercises from the easiest to the most difficult ones and from basic simple positions to the most difficult ones. Each exercise should initially be repeated at least 3 times and we should learn to feel and understand our muscle. If we learn this, our stretching will be perfect and will ensure better performance. Nowadays, stretching is one of the methods of physical education process that helps to balance the muscles by targeted stretching (Manescu, 2013)

. 4.3.Strengthening exercises:

Before starting a strengthening exercise it is always necessary to stretch the antagonistic muscle groups, i.e. the muscles with the opposite function (Costa, Herda, Herda, & Cramer, 2014). To eliminate muscle imbalances, slow, dynamically guided strengthening should be chosen. This means that the length of the muscle is changed, but not its tension. In the extreme position, we then add static strengthening, where, on the contrary, the muscle tension changes, but not its length. At the beginning of the weight training we include strengthening exercises that work with the weight of your own body(Belkadi, 2018). After about 10 seconds, we start to incorporate exercises with a higher level of difficulty. These exercises involve working against optimal resistance using exercise equipment such as overballs, dumbbells, rubber bands, etc. To be sufficiently effective, the exercises need to be repeated several times in succession (8 to 10 times). The strengthening always starts from the central parts towards the periphery. Breathing is also an important part of strengthening. When the load is overcome, we should exhale and when we relax, when we return to the basic position, we should breathe. The rule of thumb is to never hold your breath during exercise. This could cause other health complications(Boudehri, Belkadi, Dahoune, & Atallah, 2023). At the end of the strengthening exercise, we include strengthening of the abdominal muscles. The composition of the strengthening exercise is very individual and should take into account age, gender, previous movement experience and especially the specifics of the target groups. As mentioned above, we should never skip the different levels of difficulty. If we are not able to perform an exercise

of medium difficulty, we will not be able to perform an exercise of higher difficulty well and correctly. In this case, it is better to go back to the exercises with lower difficulty and after some time, when we manage to master these exercises without any problems, we can return to the more difficult ones again (Stastny, Lehnert, & Tufano, 2018)

The importance of strengthening exercises has a positive effect on several areas. As the muscle volume increases, so does the force the muscle is able to exert(Haff et al., 2008). By increasing the resting tone of the muscle, muscle imbalances in the are corrected. The longer and the more the more regularly the muscle is strengthened, the more its ability to work longer and more economically increases. In athletes, this exercise leads to increased endurance (Costa et al., 2014)

4.4.Breathing and relaxation exercises :

The aim of breathing exercises is to obtain the correct breathing stereotype, which to a considerable extent affects the correct posture, strengthens the (Steinmane & Fernate, 2024)hing muscles, improves the functioning of internal organs and relieves muscle and mental tension. Correct breathing habits contribute to better blood circulation and oxygenation of target tissues, prevention of chest deformities, hardening of the nasal mucosa and massage of internal organs. We have three types of breathing:

4.4.1.Abdominal: the diaphragm and abdominal muscles are most involved. It positively affects the massage of the abdominal organs and the lumbar spine.

4.4.2.Bone: When the movement of the lower ribs expands the chest forward, sideways and backward during inspiration. This is a signal to us that there is sufficient pulmonary ventilation(Buchheit & Laursen, 2013).

4.4.3.Clavicular: It is one of the least effective superficial breathing methods. It involves mainly the upper ribs and intercostal muscles.

The aim of relaxation exercises is to induce physical and mental tension through involuntary means, free movement activities and free resting means, where relaxation occurs mentally. Relaxation exercises are divided into 3 types:

- **Topical:** Acts on small specific small muscle groups.

- **Overall:** We relax the body as a whole, engaging a large of muscle groups.
- **Differentiated:** we act on muscles that are not part of the movement or position.(Steinmane & Fernate, 2024)

Chapter three

Functional movement

screen test

1.Measuring techniques:

There are a variety of quantitative and qualitative measurement techniques for assessing muscle strength. To perform a quantitative measurement, the use of an instrument such as a dynamometer is required. This makes the method more challenging. We base our work mainly on results that rely on the qualitative method. This includes, for example, the FMS test(Moran, Schneiders, Mason, & Sullivan, 2017).

1.1.FMS test :

The Functional Movement Screen (FMS) is a screening tool developed by Gray Cook and Dr. Lee Burton to assess fundamental movement patterns in individuals without current pain or musculoskeletal injury and identifying limitations or asymmetries in seven fundamental movement patterns that are key to functional movement quality. (Cook, Burton, & Hoogenboom, 2006), the developers of the FMS, emphasize that the purpose of the test is not to assess strength or fitness directly, but to evaluate the quality of movement, helping to predict injury risk and guide corrective exercises.

Although the FMS is largely subjective and based on observation, it is standardized and reliable enough to draw useful conclusions about an individual's movement capacity. To perform the FMS effectively, the following principles should be followed:

• Test should be performed using the standardized seven movement patterns (e.g., deep squat, hurdle step, inline lunge)

• Movements should be executed slowly and with control

• Scoring is done using the official 0–3 scale for each movement

• The test environment should be quiet and free of distractions

• Movements should be unassisted unless required (e.g., in clearing tests)

• Focus on symmetry and range of motion, not speed or strength

• Corrective strategies should follow based on test results

Testing should be conducted in a calm and warm environment to ensure optimal performance. For more accurate tracking, the FMS should be repeated periodically, and results should be recorded using the official FMS scoring sheet.(Dorrel, Long, Shaffer, & Myer, 2015; Simenko, 2019)

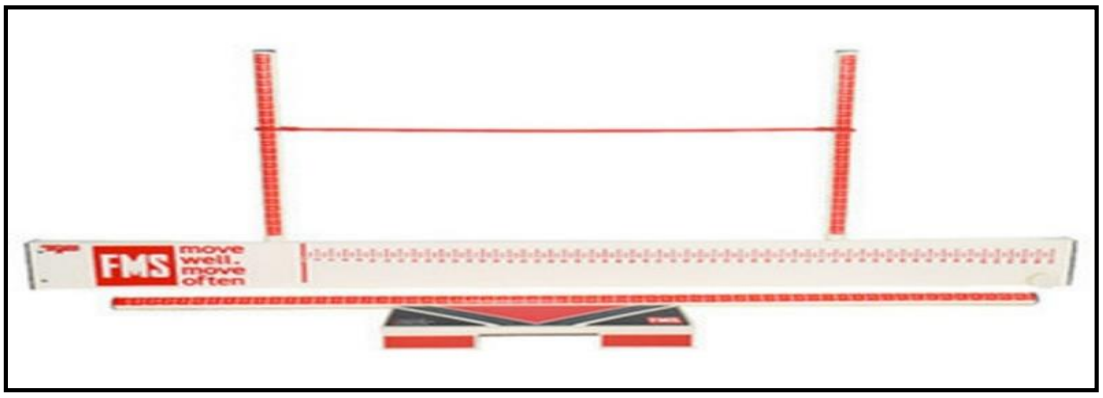


Figure 2: FMS test kit (The tool)

While the FMS is not designed to target specific muscles, each of its seven tests engages various muscle groups to evaluate mobility, stability, and neuromuscular control(Moran et al., 2017). Below is an overview of the seven FMS tests and the primary muscle groups involved:

1.1.1.Deep Squat :

Purpose: Assesses bilateral, symmetrical, and functional mobility of the hips, knees, and ankles.

Primary Muscles Involved:

- Quadriceps
- Gluteus Maximus
- Hamstrings
- Calves
- Core stabilizers
- Spinal erectors

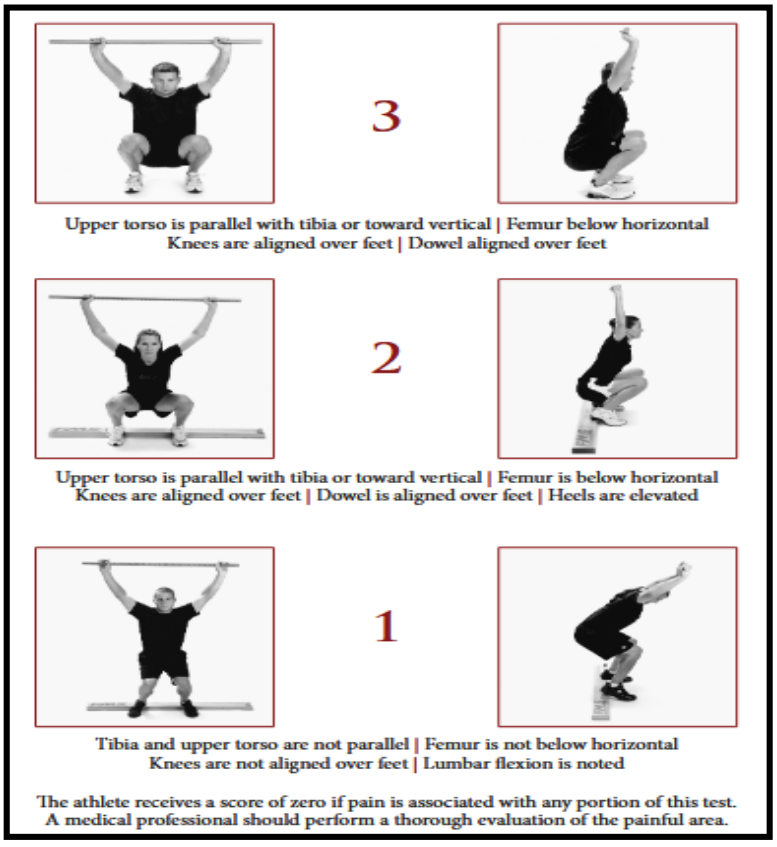


 Figure 3 : deep squat fms movment and the scooring

1.1.2.Hurdle Step :

Purpose: Evaluates stride mechanics and stability during stepping motion.

Primary Muscles Involved:

- Hip flexors (e.g., iliopsoas)
- Gluteus medius and maximus
- Quadriceps
- Hamstrings
- Core stabilizers

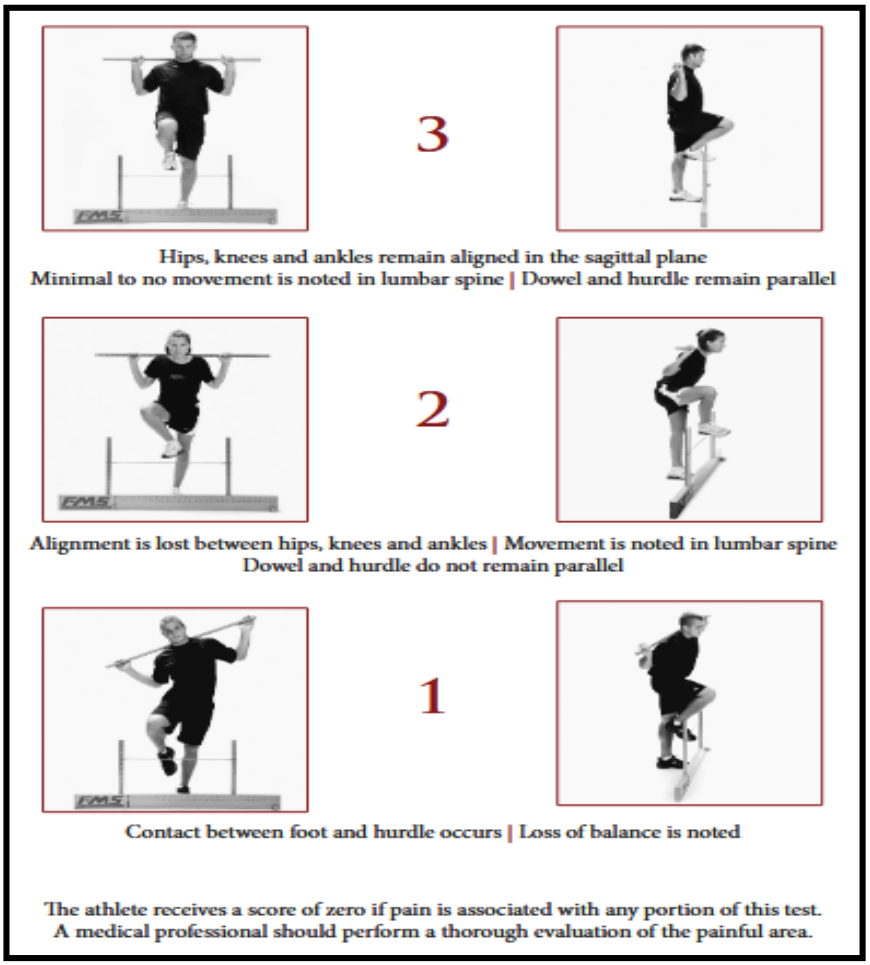


Figure 4: hurdle step fms movment and the scooring

1.1.3.In-Line Lunge :

Purpose: Assesses hip and ankle mobility and stability, quadriceps flexibility, and knee stability.

Primary Muscles Involved:

- Gluteus maximus
- Quadriceps
- Hamstrings
- Calves
- Core stabilizers

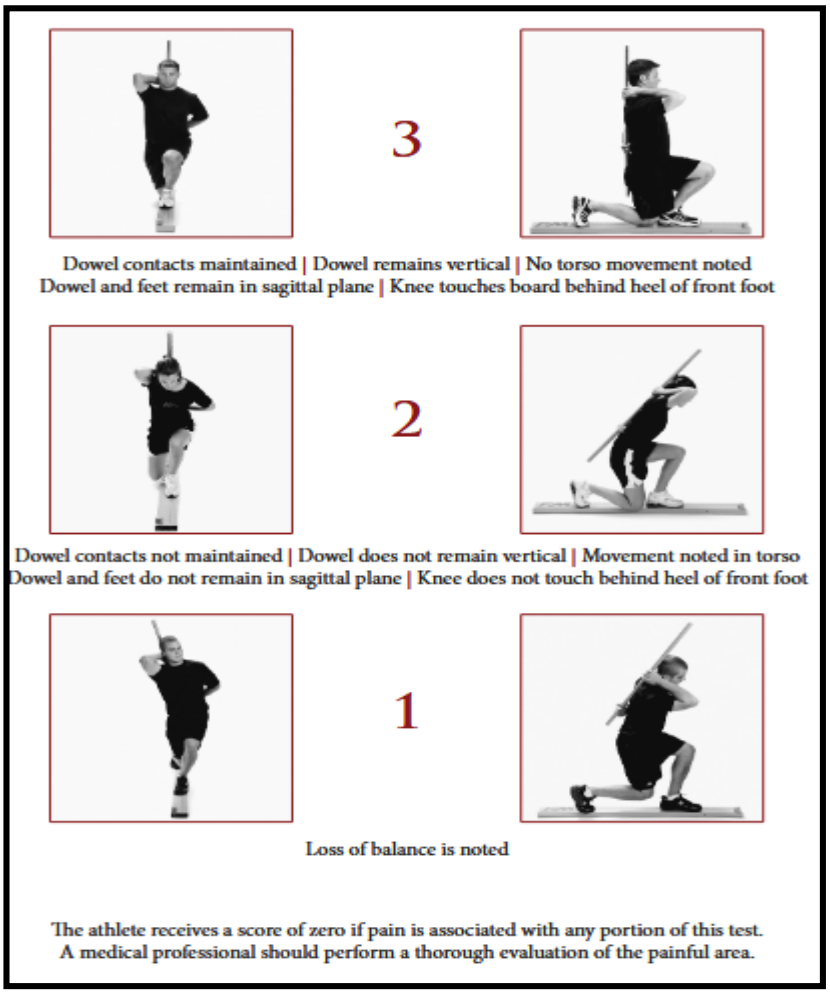


Figure 5 :in line lunge fms movment and the scooring

1.1.4.Shoulder Mobility :

Purpose: Evaluates bilateral shoulder range of motion, combining internal rotation with adduction and external rotation with abduction.

Primary Muscles Involved:

- Deltoids
- Latissimus dorsi
- Rotator cuff muscles
- (supraspinatus, infraspinatus, teres minor, subscapularis
- Pectoralis major and minor

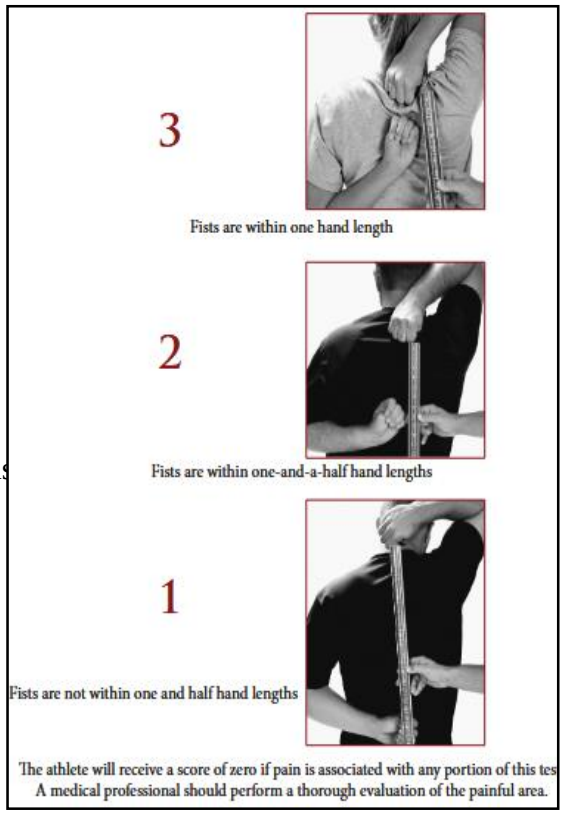


Figure 6 : shoulder mobilty fms movment and the scooring

1.1.5.Active Straight-Leg Raise :

Purpose: Assesses active hamstring and gastrocnemius flexibility while maintaining a stable pelvis and active extension of the opposite leg.

Primary Muscles Involved:

- Hamstrings
- Hip flexors
- Core stabilizers

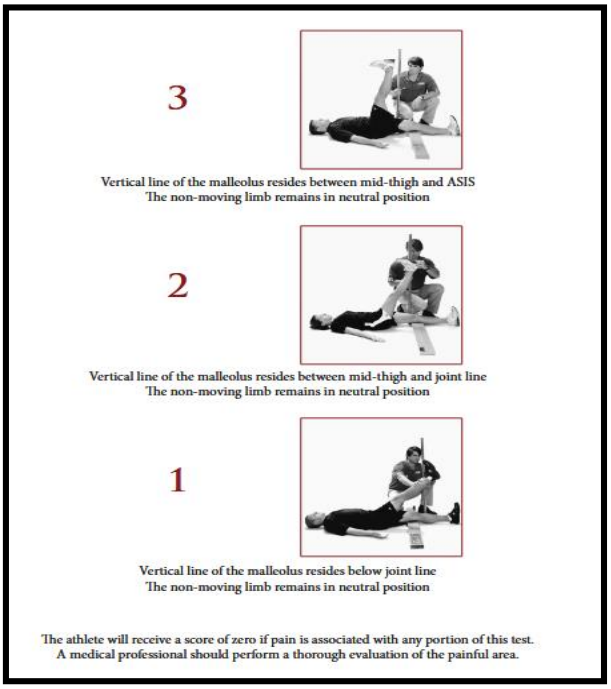


Figure 7 : active straight leg raise fms movment and the scooring

1.1.6.Trunk Stability Push-Up :

Purpose: Evaluates trunk stability in the sagittal plane while performing a symmetrical upper-body pushing movement.

Primary Muscles Involved:

- Pectoralis major
- Triceps brachii
- Anterior deltoids
- Core stabilizers
- Spinal erectors

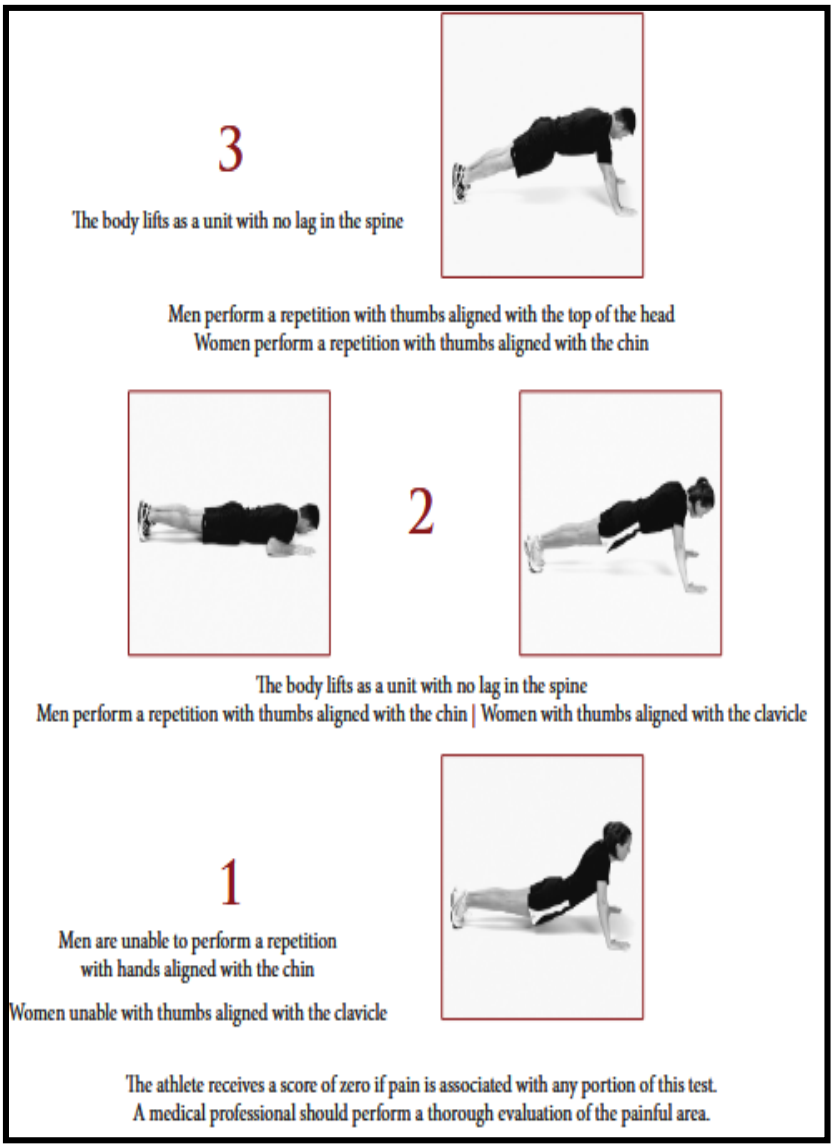


Figure 8 : trunck stability push up fms movment and the scooring

1.1.7.Rotary Stability :

Purpose: Assesses multi-plane trunk stability during a combined upper and lower extremity motion.

Primary Muscles Involved:

- Obliques
- Transverse abdominis
- Gluteus medius and maximus
- Shoulder stabilizers

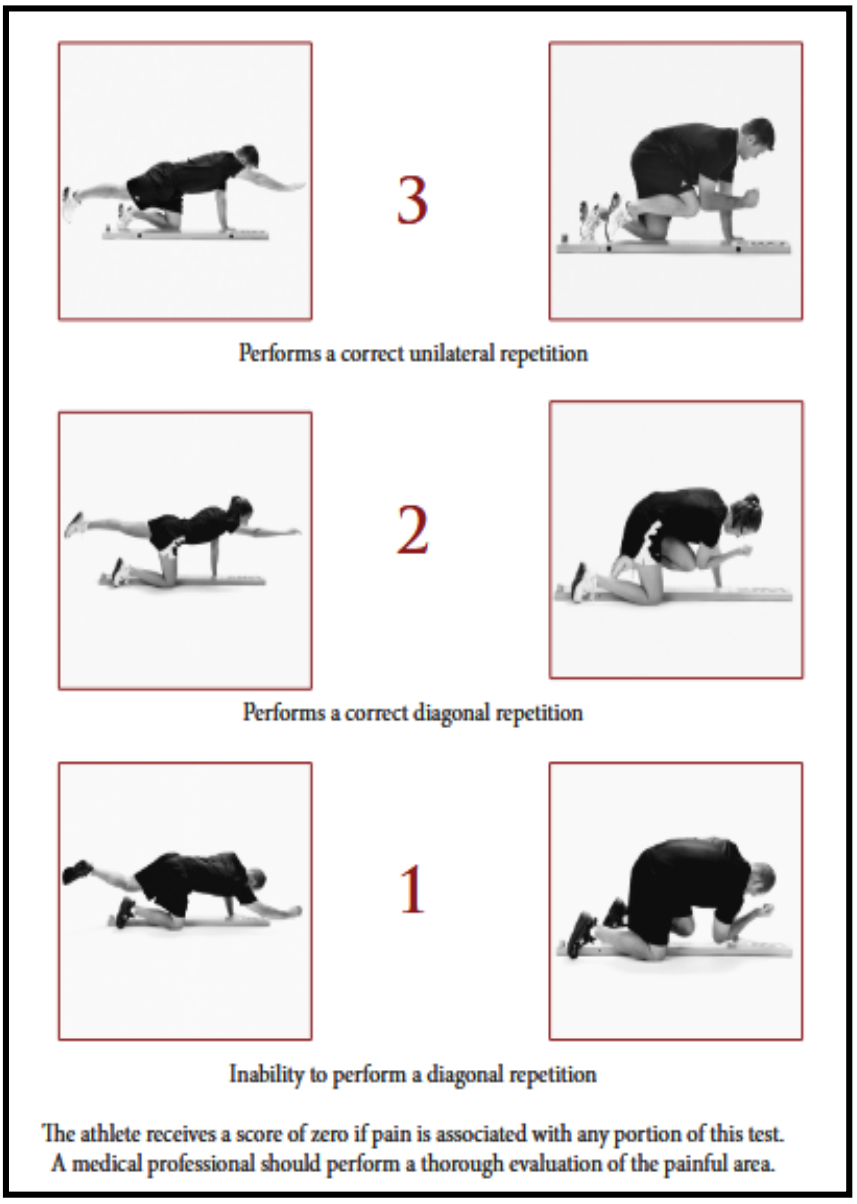


Figure 9 : rotary stability FM's movement and the scooring

1.Shortened and flaccid Muscle Testing :

Based on the scientific research conducted by (Lopata & Brodáni, 2014) and (Ceylan & and Balci, 2022), who adapted (García-Ramos et al., 2018) muscle testing methods to suit the purposes of physical education in judo athletes, a structured framework was established to identify muscular imbalances in this athletic population.

(Lopata & Brodáni, 2014) conducted a study on both male and female judokas; however, in our research, we focused exclusively on the results concerning male athletes. The study was carried out in November 2024 at the judo training hall in Mostaganem judo gym.

The research sample included fifteen male judo athletes. The study aimed to identify the muscle groups most prone to shortening, as well as those most neglected or weakened. The selection of these muscle groups was based on the work of (Belkadi, Alia, & Mohammed, 2020).

For the purpose of evaluation, muscle testing methods based on Janda's approach were applied, with modifications suitable for the specific demands of judo practice. The study focused on eight postural muscles considered most susceptible to shortening in judokas, which are:

- **Trapezius muscle, upper part**
- **Pectoralis major muscle**
- **Tensor fascia lata muscle**
- **Quadratus lumborum muscle**
- **Hip adductor muscles**
- **Knee flexor muscles**
- **Rectus femoris muscle**
- **Triceps surae muscle**

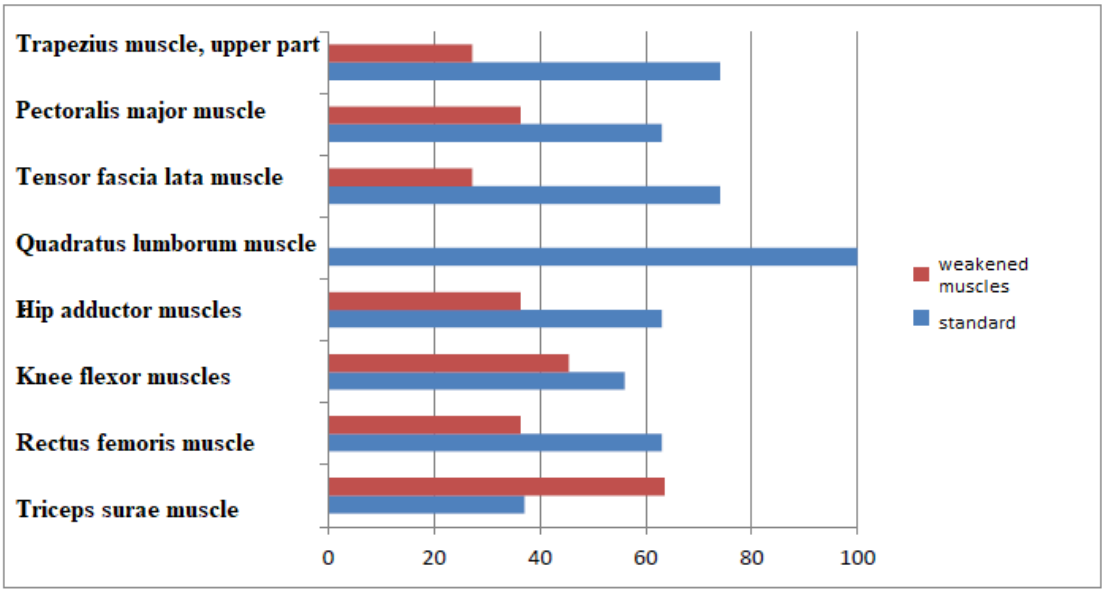


Figure 10 : most weakened muscles in judoka

As with the testing of shortened muscles, the testing of flaccid muscles was based on the work of Balaskova (2014), who tested five muscles with the greatest tendency to flaccidity. Again, she conducted a research investigation with eleven male judoka. She summarized the results of the research in a clear graph

- **lower blade fixators**
- **hip abductors**
- **abdominal muscles**
- **deep neck flexors**
- **hip extensors**

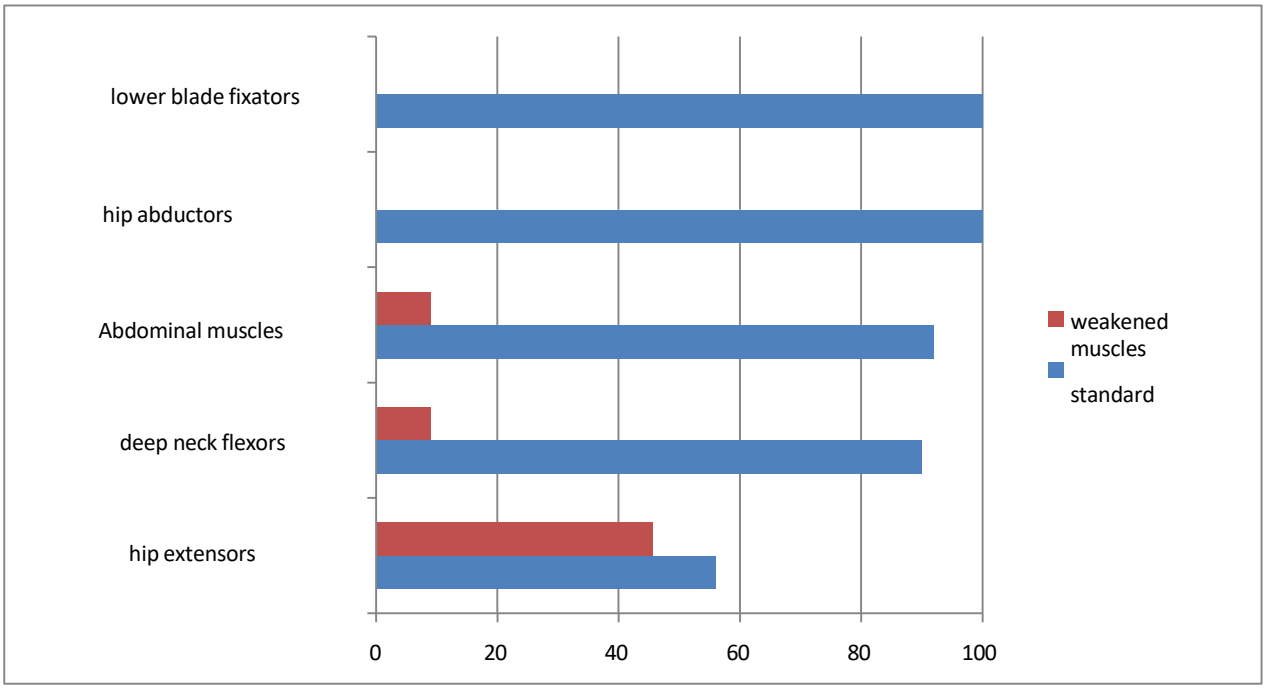


Figure 11 : most flaccid muscles in judoka

2.Training unit:

The basic cycle of sports training includes a training unit. For each training unit there are only recommendations, not dogmas that a coach must follow. It is true that in most sports disciplines, training units have a fixed structure, but they tend to be influenced by various factors(Funk, Haugtvedt, & Howard, 2000). Each training session has to adapt to the current demands, but of cores this depends on the training period we are in, or whether we are coming off an injury, or have had a competition weekend, or are on the contrary before a competition. The coach is in charge of these matters during the preparation period and consults individually with the athletes. The basic organizational unit in the training process is the training unit. We call it basic because there are other types of training, e.g. supplementary exercises, carried out on the basis of individual tasks (strengthening, morning exercises, individual elimination of deficiencies, etc. The training unit is generally divided into an introductory, main and final part (Belkadi et al., 2015)

2.1.Introductory part of the training:

This introductory part, sometimes also called the preparatory part, is situated at the beginning of the training. Its main function is to prepare the body for the main and most important part of

the workout. Judo training always begins with a bow and greeting. This part of the training also has several phases that are intertwined(Belkadi et al., 2020).

2.1.1.Warm-up: contains 3 parts:

2.1.1.1.Warm-up: Warm-up and blood circulation throughout the body, the essence of which is the activation of the cardiovascular and respiratory systems. In most cases, we choose various sports games, e.g. chase, chasing, etc., as a means of warming up the body.

2.1.1.2Stretching: All major muscle groups. We include here mostly stretching exercises and their alternatives. These exercises prepare the entire motor system (muscles, joints, tendons) for the load and are a good way to prevent damage.

The purpose of which is to harmonize and synchronize the entire body of the athlete. It is necessary to work not only the body but also the spirit of the athlete into balance (Perič, Dovalil, 2010).

2.1.2.Preparation for movement activity:

Its role is to provide favourable conditions and prerequisites for the composition of the entire training unit, i.e. to prepare the organism and the athlete's psyche for the training load and the achievement of the main goals. The athlete is initially familiarized with the tasks, must understand the nature of performance, the process of loading, demands, and focus on the decisive moments. The initial exercises begin to prepare the musculoskeletal system, respiratory system, cardiovascular system, relax and stretch muscles, joints and tendons, the intensity gradually increases (increase blood circulation, blood supply to muscles, increase pulmonary ventilation). During the movement activity, which will be covered in the main part of the training unit, the cooperation and interplay of all systems in the organism must be ensured. The duration of the preparatory phase should be on average 30 minutes. It is not possible to set an exact time because the tasks in the preparatory phase are very diverse and change according to the external conditions (Choutka, Dovalil, 1987).

2.2.Main part of the training :

The main phase of the training is devoted mainly to strength exercises, learning new techniques, improving them and using them in specific situations. Another element of this part of the training is undoubtedly training speed and endurance in judo competitors. Then all these learned techniques are practiced in a practice match (randori). Judo is divided into three basic circuits that are interrelated in competition and training:

- **safe fall**
- **postural movements, which are further divided into four subgroups**
- **holding, choking and wrestling techniques**

The rules of judo change every four years to adapt to current needs. Judo is a sport that is always changing and developing new and modified techniques. In judo, competitors are pitted against each other according to weight categories so that they do not have to fight against a significantly lighter or heavier opponent. A judoka wins if he or she achieves a greater point gain during the match by holding, throwing, grappling, choking, or offending the opponent (Schafer, 2007).

Usually, the main part of the training is divided into monothematic (one-sided loading) and multithematic (multiple movement activities). The multithematic part has its own sequence of movement activities:

2.2.3.Coordination-intensive exercises: these exercises require a high level of concentration and central nervous system activity. The intervals of these exercises become shorter, increasing the intensity of concentration and sustaining attention. In practice, these are acrobatic and gymnastic exercises leading to the training of new techniques and judo moves (Perič, Dovalil, 2010).

2.2.4.Speed exercises: speed is one of the judoka's abilities to perform certain movement actions and solve movement problems in the shortest possible time. As a movement activity, speed is of great importance in judo. It is a direct component of the technique of holds, the individual elements of judo technique, and is one of the most important factors in the effectiveness of holds in a match. In training practice we usually distinguish two types of speed. The first type is cyclic (sprinting) speed and the other type is acyclic (changing. In modern

grappling sports, which judo undoubtedly is, speed is also an indispensable tactical element already in conjunction with basic technical skills such as grip and movement on the wrestling floor. In order to achieve maximum speed, judo technique must be mastered in perfect spatial and temporal coordination and all distracting counter movements must be eliminated. It must be remembered that in order to practice speed, athletes must be provided with appropriate external conditions. A firm and flexible wrestling ground with a smooth surface becomes the basis. If the surface is uneven, movement may slow down and even injure the athlete. Other external factors include the ambient temperature. It is known that a cold environment is not suitable for speed training even after a thorough warm-up (Srdinko, Vachun, 1984).

2.2.5.Strength exercises: they are ranked third in the main part of the workout. Strength exercises include strength training exercises, special strength equipment such as weight training with dumbbells or weight training with own weight (Peric, Dovalil, 2010).

2.2.6.Endurance exercises: they are usually placed at the end of the main part. These are the ability of a person to resist fatigue during prolonged physical activity. It is necessary for a judoka to pay close attention to endurance when training. These exercises tend to be very unpleasant because of their unpleasant sensations of exhaustion of the muscles and the central nervous system. Often these strength exercises include, for example, circuit training. In heavyweight judokas (over 95 kg), overloading of the joints and tendons of the lower limbs can occur in endurance training when frequently included in running training. For such athletes, it is then advisable to include e.g. , cross-country skiing, etc. among endurance exercises (Srdinko and Vachun, 1984).

2.3.Final part of the training :

In this part, the transition from high training load is ensured gradually towards calming down and return of body functions to normal state. This part represents the beginning of the recovery phase of the training. Its proper organization contributes to the acceleration of the regeneration process. At the end, the athlete should have a good feeling of accomplished tasks, should have a feeling of relaxation and should be able to evaluate the contribution of the training to his further sports growth. Such feelings are the building blocks for further motivation and self-confidence and lead to the strengthening of the athlete's personality (Choutka, Dovalil, 1987).

We can divide it into two units:

Dynamic part: this part includes low-intensity exercises aimed at speeding up recovery after the workout and starting to break down the waste substances produced during the load. It is good to include here e.g. trotting etc.

Static part: this is one of the most important parts of the training. It includes both stretching the muscles that have been predominantly involved in the training and the muscles that tend to shorten in judo. Training is often focused unilaterally and therefore compensatory exercises should be performed before significant muscle imbalances and postural defects occur. Even static exercises contribute to the overall calming of the body, which has a positive effect on recovery.

The most important personality of the training is undoubtedly the coach, who determines the composition and speed of the training unit. The trainer can look at the training not only from the point of view of

their parts, but also from a social point of view. Sometimes they try to make training more varied for their charges, for example in a group or collective form (Perič, Dovalil, 2010).

Second part:

Practical part of research

1.Research Methodology:

This study adopted the experimental method, as it is the most appropriate approach for the nature of the topic, which investigates the effect of compensatory exercises on correcting muscular imbalances in judo athletes. A training program was designed, incorporating a set of exercises (including breathing, strengthening, and stretching). This program was then implemented in the field on the sample subjects in order to observe its practical impact on their muscular balance.

The Functional Movement Screen (FMS) is a widely used assessment tool to identify movement limitations and asymmetries in athletes. These limitations can potentially increase the risk of injury and affect sports performance. This study aims to analyze the impact of an intervention (training program) on the FMS scores of 15 judo athletes by comparing their performances before and after the intervention.

The main objective is to determine whether significant improvements in functional movement patterns can be observed following the intervention period, thereby providing evidence of the effectiveness of the implemented program.

2.Research Population :

The research population consists of judo athletes in the senior and junior categories. This group was selected due to their engagement in high levels of competitive training, which makes them particularly susceptible to muscular imbalances resulting from the repetitive and unilateral execution of techniques and movements. Therefore, this population represented an ideal environment for applying the experimental program developed in this study.

2.1.Participants

Fifteen judo athletes (A1 to A15) participated in this study. Their FMS scores were recorded twice: once before the intervention (Pre-Tests) and once after the intervention (Post-Tests).

2.2.FMS Tests

The Functional Movement Screen (FMS) consists of seven fundamental movement tests, each scored on a scale from **0 to 3** , where:

0 = Pain during the movement

1 = Inability to perform the movement

2 = Performance with compensation

3 = Perfect execution

The included tests are:

- **Deep Squat**
- **Hurdle Step**
- **In-Line Lunge**
- **Shoulder Mobility**
- **Active Straight-Leg Raise**
- **Trunk Stability Push-Up**
- **Rotary Stability**

A **total FMS score** is calculated by summing up the scores of all seven tests, with a **maximum possible score of 21** .

3.Variables of the Study:

3.1.Independent Variable:

The proposed training program, which includes a set of compensatory exercises (breathing, stretching, strengthening, and relaxation), designed and implemented by the researcher for the study sample.

3.2.Dependent Variable:

Muscular imbalance in judo athletes, which was evaluated through the specific test applied in the research.

3.3.Controlled Variables:

Chronological age of the participants

Level of athletic experience (all participants are elite judokas)

Number of training sessions per week

Training environment (same facility and equipment)

4.Scope of the Study :

4.1.Temporal Scope:

The study was conducted over a period of five months, which included sample selection and testing, program design, implementation, and monitoring of the athletes' performance.

4.2.Spatial Scope:

The training program was implemented at the judo clubs of *Association of ABTAL* and *Judo Club Mostaganem*, both of which are equipped with the necessary facilities and equipment.

4.3.Human Scope:

The study involved 15 elite judo athletes from the senior and junior categories. These athletes represent the top level in the sport and are particularly prone to muscular imbalances due to the intensive nature of judo movements and training.

5.Research Instruments:

In this study, the following instruments were used to collect data and assess the athletes' condition:

5.1.Previous Research on Neglected and Weak Muscles:

A scientific study was utilised to measure the presence of neglected and weak muscles in judokas, based on validated scientific protocols(Moran et al., 2017).

5.2.Functional Movement Screening (FMS) Test:

The FMS test was employed to evaluate movement quality and patterns, and to identify weaknesses and imbalances in muscular and functional symmetry(Cook, Burton, Hoogenboom, & Voight, 2014).

5.3.Compensatory Exercise Program:

A specifically designed program including breathing, stretching, and strengthening exercises was implemented in the field with the selected sample to address muscular imbalances(Chorba, Chorba, Bouillon, Overmyer, & Landis, 2010).

5.4.Observation and Field Notes:

Players' performance was monitored throughout the implementation of the program, with notes recorded regarding the quality of execution and the athletes' adherence to the prescribed exercises.

5.5.Statistical Methods:

Statistical analysis was conducted to compare the pre-test and post-test results of the athletes participating in the compensatory training program, aiming to evaluate the program's effectiveness in improving muscular balance and motor performance. The paired sample t-test was used to identify statistically significant differences between the test results before and after the program implementation. Means and standard deviations were calculated for each studied variable. A significance level (α) of 0.05 was adopted as the threshold to determine whether the differences between pre- and post-program results reflect a true effect of the training program(Adel et al., 2019).

5.6.Pilot Study:

Before initiating the experimental training program, a preliminary pilot study was conducted. This involved administering a pre-test using the Functional Movement Screening (FMS) on the research sample. The objectives of this pilot study were to:

Assess the general motor condition of each judoka by evaluating fundamental movement patterns using the FMS test.

Identify muscular imbalances and dysfunctions in terms of strength, balance, and joint stability.

Ensure that athletes fully understood the test procedures and instructions.

Examine the suitability of the field conditions for implementation (time, location, equipment, space availability, etc.).

Establish a baseline for future comparison in the event of post-intervention testing.

This pilot study enabled me to better tailor the compensatory program and adjust the intensity and specificity of the exercises to align with the actual physical condition of the athletes.

The results of the pre-test were as follows:

5.6.Scientific Foundations of the Tests Used :

In this study, I relied on the Functional Movement Screen (FMS), a tool developed by (Cook et al., 2014). Lee Burton, which is globally recognized for assessing the quality of fundamental movement patterns in athletes.

This test is grounded in several precise scientific principles, including:

Qualitative assessment of fundamental movement patterns, rather than mere muscular strength. This enables the detection of muscular and motor imbalances, even in the absence of pain or visible injury.

Use of seven standardised screening tests that encompass various aspects of functional movement. These include: deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up, and rotary stability.

A unified scoring system (0 to 3), which ensures objectivity and clarity in tracking athlete performance and monitoring progress over time.

Strong correlation between FMS scores and injury risk. Studies have shown that lower FMS scores are associated with an increased likelihood of injury due to poor motor control or muscular imbalance.

Ease of administration in sports environments, without the need for advanced equipment, making it ideal for on-field athlete assessment.

Based on these principles, FMS was used as a reliable scientific tool to evaluate the motor condition of the research sample before implementing the compensatory training program(Garrison, Westrick, Johnson, & Benenson, 2015)

6.Main Experiment:

After completing the pilot study and conducting the pre-test using the Functional Movement Screen (FMS), I proceeded to implement the main experiment, which involved applying the compensatory training program I specifically designed to address muscle imbalances in judo athletes from the senior and junior categories(Chorba et al., 2010).

The main experiment lasted for eight weeks, during which the program was integrated into the training sessions of the sample group. Initially, the program was applied three times per week, then reduced to twice weekly in the later phase to consolidate the results and maintain gradual improvement.

The compensatory training program was as follows:

Breathing and relaxation exercises at the beginning of each session to prepare the core muscles and enhance the respiratory-motor system.

Strengthening exercises targeting the weak and flaccid muscle groups.

Stretching exercises aimed at restoring the natural length of shortened and tight muscles.

Throughout this phase, I closely monitored the exercise execution, corrected techniques when necessary, and recorded observations related to muscular response and motor development among the athletes.

6.1.Detailed Compensatory Exercises Program :

Below are the exercises included in the compensatory training program, each with descriptions, sets, repetitions, and images illustrating proper technique

6.1.1.Exercises:

6.1.1.1Breathing exercises :

<u>Exercise 1:</u> Diaphragmatic Breathing in Crook Lying :

Position: Lie on your back with knees bent, feet flat on the floor. Place one hand on your chest and the other on your abdomen(Chorba et al., 2010).

Execution:

- Inhale deeply through the nose, directing the breath into the abdomen so that the hand on your stomach rises while the hand on your chest remains still.
- Exhale slowly through the mouth, allowing the abdomen to fall.
- Maintain a neutral spine throughout the exercise.

Repetitions: 10–15 breaths.

Figure 12 : Exercise 1: Diaphragmatic Breathing in Crook Lying

Exercise 2: Crocodile Breathing (Prone Diaphragmatic Breathing)

Position: Lying face down (prone), forehead resting on hands, legs extended

Execution:

- Inhale slowly through the nose, expanding the abdomen and lower ribs into the floor (feel the belly push gently against the ground).
- Exhale fully through the mouth, drawing the belly in and engaging the deep core muscles.
- Keep shoulders relaxed and neck neutral throughout.
- Reps: 2 sets × 10 full breaths

Figure 13 : Exercise 2: Crocodile Breathing (Prone Diaphragmatic Breathing)

Exercise 3: Sting arm up breathing

Basic position: Sit to squat.

Execution of the exercise: Inhale: Raise your arms up ; exhale : your arms down

Reps :12 breaths in and out

Figure 14 Exercise 3 : Sting arm up breathing (exhale)

Figure 15 : Exercise 3 : Sting arm up breathing(inhale)

6.1.1.2.Strengthening exercises :

Exercise 1: Bodyweight Squat:

Purpose: Improves lower body strength, hip mobility, and squat pattern, which is crucial for judo takedowns and stances.

Execution:

- Stand with feet shoulder-width apart.
- Keep your chest up, engage your core, and lower your hips back as if sitting in a chair.
- Go as low as your mobility allows, keeping your knees aligned with your toes.
- Push through your heels to return to standing.
- Repetitions: 3 sets of 15 reps.trengthening exercises :

Repetitions: 3 sets of 15 reps.

Figure 16 : Exercise 1: Bodyweight Squat (upart)

Figure 17: <u>Exercise 1:</u> Bodywight Squat (down part)

Exercise 2: Reverse Lunge

Purpose: Develops lower body strength, balance, and coordination, especially for movement in multiple directions like in judo.

Execution:

- Stand with feet hip-width apart.
- Step back with one leg, lowering the back knee toward the ground while keeping the front knee over the ankle.
- Push through the front heel to return to standing.
- Alternate legs with each rep.

Repetitions: 3 sets of 15 reps per leg.

Figure 18: Exercise 2: Reverse Lunge (up part)

Figure 19 : Exercise 2: Reverse Lunge (down part)

Exercise 3: Plank to Push-Up :

Purpose: Builds core strength, stability, and upper body strength, critical for controlling and stabilizing during judo techniques.

Execution:

- Start in a forearm plank position, with your elbows under your shoulders.
- Push up onto your hands one arm at a time, coming into a push-up position.
- Lower back down to your forearms one arm at a time to return to the plank position.
- Keep your core tight throughout the movement to avoid sagging.

Repetitions: 3 sets of 10 reps.

Figure 20 : Exercise 3: Plank to Push-Up (plank part)

Figure 21: Exercise 3: Plank to Push-Up (moving up)

Figure 22 : Exercise 3: Plank to Push-Up (push up part)

Exercise 4 : Glute Bridge

Purpose: Strengthens the glutes, hamstrings, and lower back muscles, improving hip stability, which is essential for judo mat work.

Execution:

- Lie on your back with knees bent and feet flat on the floor, hip-width apart.
- Engage your core and press through your heels to lift your hips towards the ceiling.
- Squeeze your glutes at the top of the movement and hold for a second.
- Lower back down with control and repeat.

Repetitions: 3 sets of 15 reps.

Figure 23 : Exercise 4 : Glute Bridge (up part)

Figure 24: Exercise 4 : Glute Bridge (down part)

Exercise 5 : Front neck bridge :

Purpose: Strengthens Muscles of the lumbar spine, neck and lower torso, abdominal muscles

Execution: Slowly move the head forward and backward

<u>Modifications:</u> To make the exercise easier, you can use your hand to support

Repetitions : 3 sets of 10 reps

Figure 25 : Exercise 5 : Front neck bridge

Figure 26 Exercise 5 : Front neck bridge (help with your hands)

Exercise 6 : Hollow Body Hold :

Purpose: Strengthens Abdominal muscles, buttock muscles.

Execution of the exercise: Inhale -lifting the legs off the mat to a height of about 10 cm

Exhale and inhale - alternate while holding Exhale - relax and feet on the mat

Repetitions :3sets of 15 seconds

Figure 27:exercise 6 : Hollow Body Hold

Exercise 7 : Donkey Kick :

Purpose: Strengthens Extensor of the hip joint, muscles of the lower limbs, abdominal muscles

Execution of the exercise: Inhale: bring the leg up Exhale:

back to the basic position

Repetitions : 2 sets of 15 repetitions on both sides.

Figure 28: Exercise 7 : Donkey Kick (negative part)

Figure 29: Exercise 7 : Donkey Kick (positive part)

6.1.1.3.Stretching exercises :

Exercise 1: Hip Flexor Stretch (Lunge Stretch) :

Purpose: Helps open up the hips, improve hip flexor mobility, and prevent tightness, which is essential for judo movements.

Execution:

- Start in a lunge position with one foot forward and the back knee on the ground.
- Push your hips forward gently, feeling the stretch in the hip flexors of the back leg.
- Switch sides and repeat.

Repetitions : 15s repetitions on both sides

Figure 30. : Exercise 1: Hip Flexor Stretch (Lunge Stretch) (negative part)

Figure 31: Exercise 1: Hip Flexor Stretch (Lunge Stretch) (pushing part)

Exercise 2: Standing Hamstring Stretch :

Purpose: Targets the hamstrings, improving flexibility in the posterior chain, which is key for judo stances and mobility.

Execution:

- Stand with feet hip-width apart and take a small step forward with one leg.
- Hinge at the hips and lean forward, reaching for the toes of the extended leg while keeping the back straight.
- Repeat on the other leg.

Repetitions : 15 s repetitions on both sides

Figure 32 : Exercise 2: Standing Hamstring Stretch

Exercise 3: Thoracic Spine Rotation Stretch

Purpose: Improves rotational mobility in the thoracic spine, important for judo movements such as throws and sweeps.

Execution:

- Start on all fours in a tabletop position, with hands under shoulders and knees under hips.
- Place your right hand behind your head and rotate your chest open towards the right.
- Return to the starting position and repeat on the other side.

Repetitions : 15s repetitions on both sides

Figure 33 : Exercise 3: Thoracic Spine Rotation Stretch

Exercise 4: Child's Pose (Balasana) :

Purpose: A relaxing stretch that targets the lower back, hips, and shoulders, promoting overall flexibility and relaxation for judoka.

Execution:

- Start on all fours, then push your hips back toward your heels, reaching your arms forward on the floor.
- Keep your forehead on the ground and breathe deeply into your back.

Repetitions : 2x15s repetitions .

Figure 34 : Exercise 1: Child's Pose (Balasana)

Third part:

Presentation and Discussion of Results

1.Results :

The descriptive statistics show an increase in average scores for all individual FMS tests and for the total FMS score after the intervention. The standard deviation also decreased for most tests, suggesting greater homogeneity in performance among athletes following the intervention.

1.2.Post Tests :

Athlete	**Deep Squat**	**Hurdle Step**	**In-Line Lunge**	**Shoulder Mobility**	**Active SLR**	**Push-Up**	**Rotary Stability**	**Total FMS**
A1	**2**	**1**	**1**	**2**	**2**	**2**	**1**	**11**
A2	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**15**
A3	**2**	**2**	**1**	**1**	**2**	**2**	**2**	**12**
A4	**1**	**1**	**1**	**1**	**2**	**1**	**1**	**8**
A5	**3**	**2**	**3**	**3**	**2**	**2**	**3**	**18**
A6	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**14**
A7	**2**	**1**	**2**	**2**	**1**	**1**	**2**	**11**
A8	**2**	**2**	**1**	**2**	**1**	**2**	**1**	**11**
A9	**3**	**3**	**3**	**2**	**3**	**3**	**3**	**20**
A10	**1**	**1**	**2**	**2**	**2**	**1**	**1**	**10**
A11	**2**	**2**	**1**	**2**	**1**	**2**	**2**	**12**
A12	**2**	**2**	**2**	**2**	**2**	**1**	**2**	**13**
A13	**3**	**2**	**2**	**3**	**3**	**2**	**2**	**17**
A14	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**21**
A15	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**7**

Table 01 :Post FMS test results

1.3.Pre tests :

Athlete	Deep Squat	Hurdle Step	In-Line Lunge	Shoulder Mobility	Active SLR	Push-Up	Rotary Stability	Total FMS
A1	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**15**
A2	**3**	**3**	**2**	**2**	**2**	**3**	**3**	**18**
A3	**3**	**2**	**2**	**2**	**2**	**3**	**2**	**16**
A4	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**14**
A5	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**21**
A6	**3**	**3**	**3**	**3**	**3**	**2**	**3**	**20**
A7	**3**	**2**	**2**	**3**	**2**	**2**	**2**	**16**
A8	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**14**
A9	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**21**
A10	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**14**
A11	**3**	**3**	**2**	**3**	**2**	**2**	**2**	**17**
A12	**2**	**3**	**2**	**2**	**3**	**2**	**2**	**16**
A13	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**21**
A14	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**21**
A15	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**14**

Table 02 :Pre FMS test results

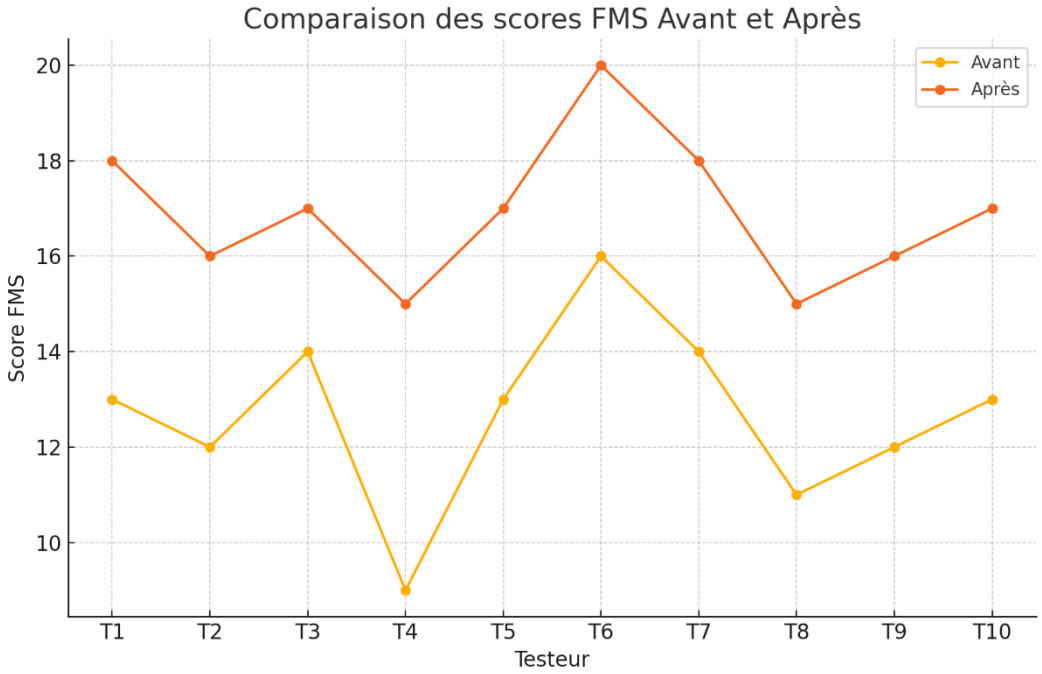


Figure 35 : Comparaison des scores FMS Avant et Aprés

Athlete	Total FMS_Before	Total FMS_After	Difference
A1	11	15	4
A2	15	18	3
A3	12	16	4
A4	8	14	6
A5	18	21	3
A6	14	20	6
A7	11	16	5
A8	11	14	3
A9	20	21	1
A10	10	14	4
A11	12	17	5
A12	13	16	3
A13	17	21	4
A14	21	21	0
A15	7	14	7

Table 03 :Pre and post and difference in FMS test results

	Moyenne	Médiane	Écart-type	Minimum	Maximum
Avant	13,33333	12	4,151879	7	21
Après	17,2	16	2,88345	14	21

Table 04 : Descriptive Statistics of FMS Scores Before and After the Program

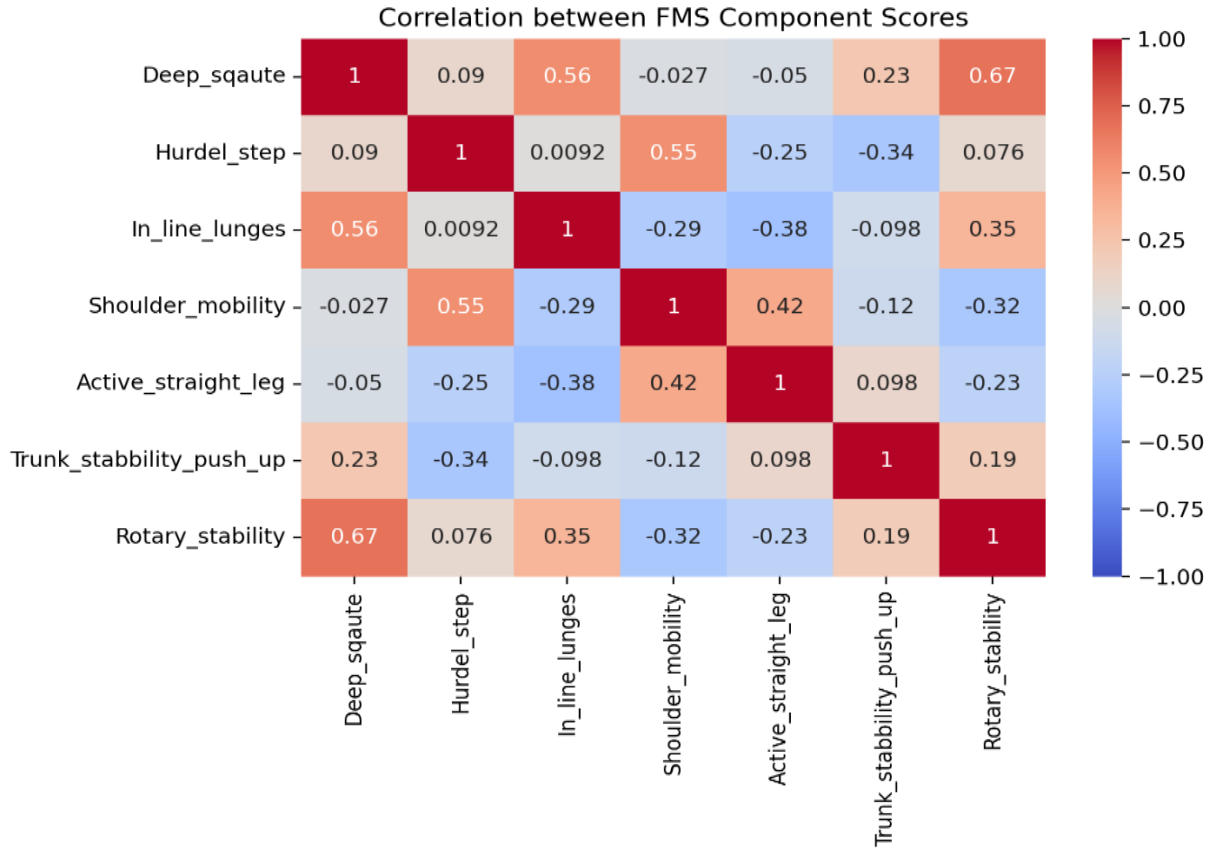


Figure 36: Correlation between FMS Component Scores

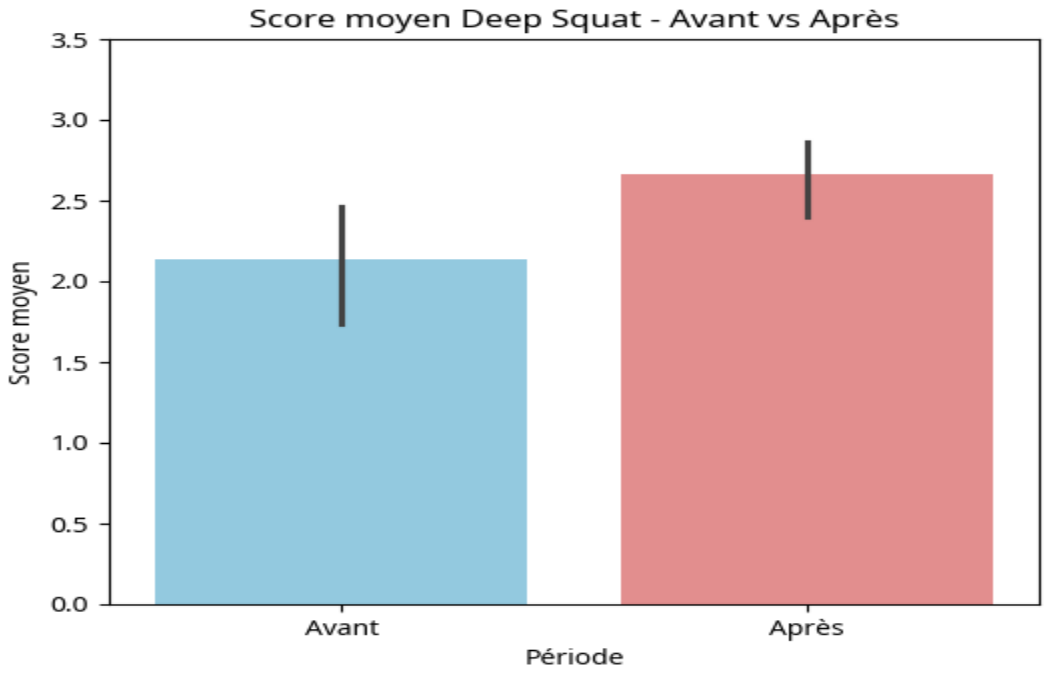


Figure 37 :Score moyen Deep Squat – Avant vs Apres

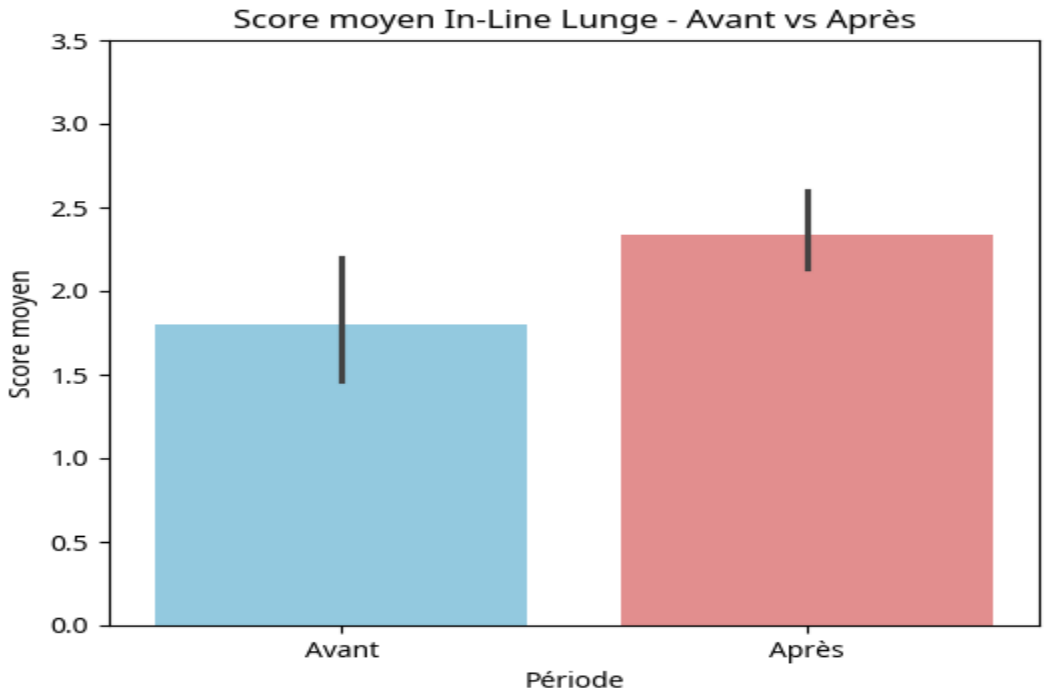


Figure 38 : Score moyen In Line Lunge Avant vs Apres

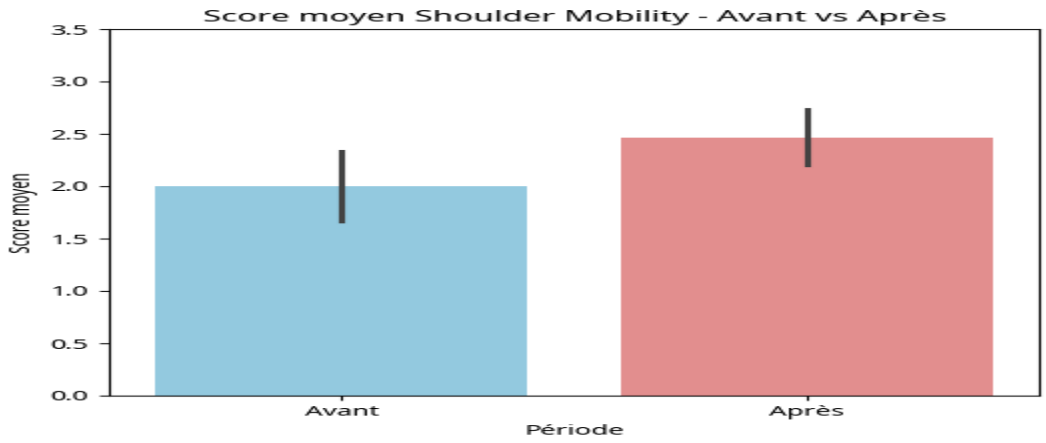


Figure 39 : Score Moyen Shoulder Mobility Avant vs Apres

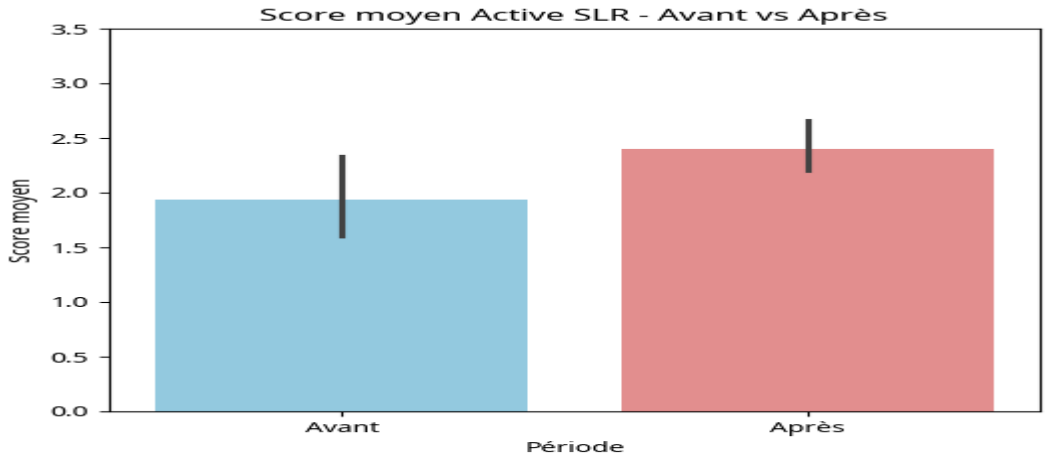


Figure 40 :Score Moyen Active SLR avant et apres

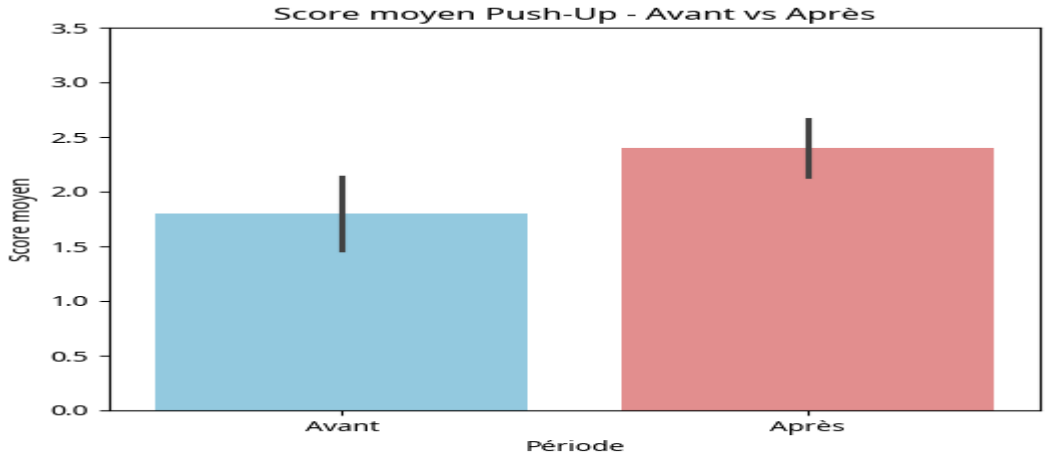


Figure 41 :Score moyen Push Up Avant vs Apres

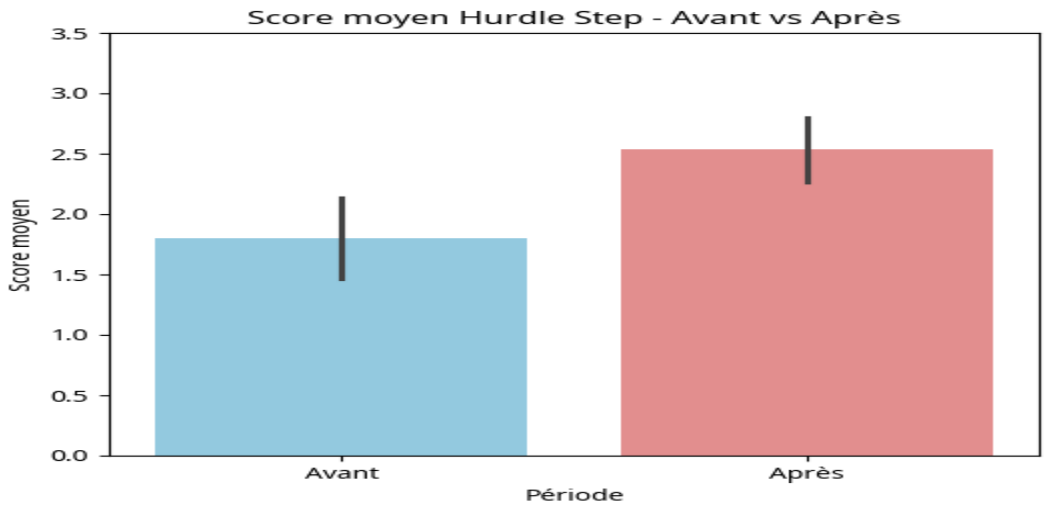


Figure 42 : Score moyen Hurdle Step Avant vs Apres

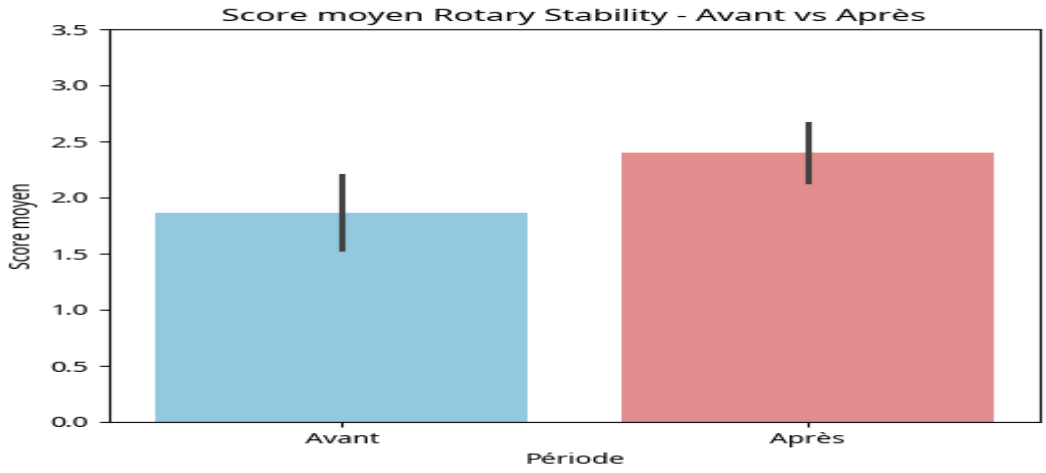


Figure 43 : Score moyen Rotary stabiliry Avant vs apres

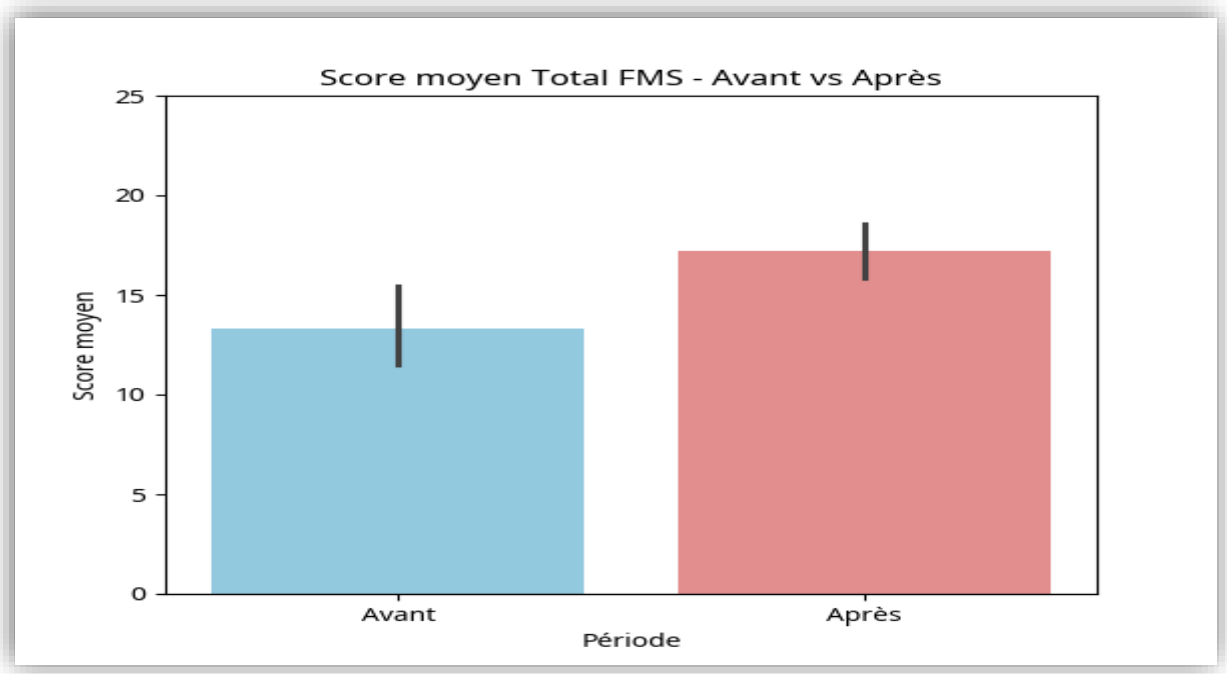


Figure 44: Score moyen Total FMS – avant vs apres

2.Discussions:

In the demanding world of competitive judo, where physical prowess, technical skill, and mental resilience converge, maintaining optimal musculoskeletal health is essential for both performance and longevity in the sport. Judo athletes are subjected to repetitive, high-intensity movements that often result in muscular imbalances, asymmetries, and functional limitations. These imbalances not only hinder athletic performance but also increase the risk of injury, particularly in key areas such as the lower back, shoulders, knees, and hips.

To address these concerns, this study focuses on the implementation and evaluation of a structured compensatory exercise program aimed at correcting muscle imbalances and enhancing functional movement quality in elite judo athletes(Adel et al., 2019; Yacine et al., 2020). The Functional Movement Screen (FMS) was employed as a standardized assessment tool to identify baseline movement deficiencies and track progress following an 8-week intervention. FMS is widely recognized for its ability to detect dysfunctional movement patterns that may predispose athletes to injury, making it an ideal instrument for guiding corrective strategies(Garrison et al., 2015).

The research involved 15 elite judo athletes , who underwent pre- and post-intervention FMS assessments to evaluate the effectiveness of the compensatory training program. This program consisted of a combination of breathing exercises, stretching routines, strengthening drills, and neuromuscular relaxation techniques , specifically tailored to address common muscle imbalances observed in judo practitioners (Abdelouaheb, Zenati, Sifi, Belkadi, & Hrabach, 2025; Belkadi et al., 2020). Key areas targeted included:

Overactive (tight) muscles: pectoralis major/minor , hip flexors , upper trapezius , and hamstrings .

Underactive (weak) muscles: gluteus maximus/medius , core stabilizers , lower trapezius , and deep neck flexors .

Statistical analysis was conducted using Python-based tools including Pandas for data manipulation , SciPy for statistical testing , and Seaborn/Matplotlib for visualization . A paired t-test was applied to compare pre- and post-intervention FMS scores, while descriptive statistics and graphical representations were used to interpret individual and group-level changes.

This introduction sets the stage for understanding how integrating compensatory exercises into regular training can significantly enhance movement efficiency, reduce injury risk, and ultimately improve athletic performance in judo. The findings presented in the following sections provide empirical evidence supporting the efficacy of this approach and offer practical insights for coaches and athletes seeking to optimize long-term development and well-being.

Through this scientific research, the following conclusions were drawn:

2.1.Clear Muscle Imbalances in Judo Athletes:

The results of the pre-test using the Functional Movement Screen (FMS) showed that many judo athletes suffer from weakness in some muscles (flaccid muscles) and shortening in others, which negatively affects their motor efficiency and increases the likelihood of injury(Moran et al., 2017; Adel et al., 2025).

2.2.Effectiveness of the Compensatory Program in Improving Muscle Balance: Implementing the compensatory program, which included breathing, stretching, and strengthening exercises, contributed to improving movement quality and muscle balance, positively reflected in the post-test results.

Possibility of Integrating Compensatory Exercises into Regular Training Sessions: The program demonstrated the feasibility of effectively incorporating compensatory exercises into regular training sessions without disrupting technical and tactical training flow, while enhancing overall performance.

Significant Improvement in Motor Performance after 8 Weeks:

After eight weeks of applying the program, improvements were observed in basic movement patterns, as well as increased muscular and joint stability among the athletes.

Importance of Close Monitoring and Correct Technique in Exercise Performance: Achieving positive results was linked to athletes' commitment to performing exercises correctly, along with coach intervention to correct errors and guide execution.

Importance of Breathing Exercises in Activating Core Muscles: Breathing exercises at the beginning of each session contributed to improved muscular coordination and respiratory-motor function, positively impacting overall performance.

Absence of Compensatory Exercises in Traditional Training Programs is a Deficiency:

Despite their significant benefits, compensatory exercises are still largely missing from most training programs, leading to a prevalence of muscle and joint injuries in judo(Benbernou, Bennama, Belkadi, Boukchiche, & Koutchouk, 2022).

Potential to Enhance Program Results by Incorporating Complementary Sports:

The impact of compensatory exercises can be enhanced by including complementary sports such as swimming and calisthenics, which have a positive effect on improving muscle balance and strengthening the body comprehensively (Asli, Belkadi, Bennama, & Djourdem, 2025).

3.Recommendations for Practice :

Based on our findings, we recommend incorporating a series of compensatory exercises into the training program. Considering that this program targets judo athletes undergoing intensive training at a frequency of no less than five sessions per week, we suggest initially including the proposed exercises at least three times per week. We advise maintaining this system for no less than five months to partially correct muscle imbalances. After this period, the frequency should

be gradually stabilized to twice per week. This will help ensure muscular balance in judo athletes.

At the beginning of each training session, we recommend incorporating breathing exercises to activate the trunk muscles. Additionally, we suggest performing the strengthening and stretching exercises after the training session, once fatigue has set in, in order to prevent injuries and improve the effectiveness of the exercises

4.Conclusion :

It is unfortunate that compensatory exercises have not yet secured a stable place within the training units of judo athletes, despite their crucial role in reducing frequent muscular and joint injuries. Implementing such exercises effectively contributes to strengthening weak and flaccid muscles, correcting muscular imbalances, and ultimately enhancing the athlete's health and athletic performance.

Among the proposed recommendations to enhance the effectiveness of training programs is the inclusion of complementary sports alongside traditional judo training, such as swimming and calisthenics. Swimming supports muscle development without overloading the joints, while calisthenics—based on bodyweight exercises—enhances neuromuscular coordination, flexibility, and functional strength, making it an ideal solution for correcting muscular imbalances.

The coach remains the central figure in planning and executing the training content, bearing the responsibility of selecting suitable exercises and integrating them into the training units(Benhammou, Clemente, Mourot, & Belkadi, 2025). Therefore, it is vital for coaches to be familiar with the full range of compensatory exercises and to recognize their positive impact on both athlete health and performance levels.

In the theoretical section of this thesis, we addressed the basics, history, and key characteristics of judo as a combat sport. We also clarified the concept of a training unit and how its structure should be tailored according to the nature of each sport. The practical section focused on explaining and understanding the concept of muscular imbalance in judo—its causes, anatomical basis, and consequences.

After analysing field data, we identified the muscle groups most susceptible to imbalance in judo athletes. Based on these findings, we developed a set of compensatory exercises—including strengthening, stretching, and relaxation exercises—primarily using bodyweight. These exercises aim to either correct or mitigate muscular imbalances.

From my own practical experience, I acknowledge that many coaches strive to integrate such exercises into their programs. However, the pressure to achieve competitive results often limits the time available for stretching and relaxation. Therefore, raising awareness about the importance of compensatory exercises and ensuring they have a dedicated place in training sessions will undoubtedly improve both the health and athletic performance of judo practitioners.

References:

Abdelouaheb, A., Zenati, Y., Sifi, B., Belkadi, A., & Hrabach, B. (2025). Comparative assessment of cardiorespiratory function and physical fitness in students with chronic respiratory diseases versus healthy students. *Scientific Journal of Sport and Performance*, *4*(3), 414–425. https://doi.org/10.55860/PWAH5831

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

Adel, B., Asli, H., Cherara, L., Benhammou, S., Djemal, M., & Sebbane, M. (2025). INVESTIGATING THE RELATIONSHIP BETWEEN CARDIAC AUTONOMIC MODULATION AND RESTING HEART RATE IN YOUTH ACROSS PHYSICAL ACTIVITY LEVELS. *Physical Education and Sport Through The Centuries*, *12*(1), 17–31.

Andreato, L. V., Julio, U. F., Gonçalves Panissa, V. L., Del Conti Esteves, J. V., Hardt, F., Franzói de Moraes, S. M., … Franchini, E. (2015). Brazilian Jiu-Jitsu Simulated Competition Part II: Physical Performance, Time-Motion, Technical-Tactical Analyses, and Perceptual Responses. *Journal of Strength and Conditioning Research*, *29*(7), 2015–2025. https://doi.org/10.1519/JSC.0000000000000819

Araujo, P. R. M. de, & Neto, J. M. (2017). BENEFÍCIOS DO JUDÔ NA EDUCAÇÃO FÍSICA E SUA REGULAMENTAÇÃO. *Revista UNI-RN*, 43–43.

Asli, H., Belkadi, A., Bennama, N., & Djourdem, B. (2025). Assessing Nutritional Balance and Its Influence on Physical Activity and Performance Among University Sports Students. *Studia Universitatis Babeş-Bolyai Educatio Artis Gymnasticae*, 63–79. (STUDIA UBB EDUCATIO ARTIS GYMN., 70 (LXX), No. 1, March 2025, pp. 63-79). https://doi.org/10.24193/subbeag.70(1).06

Belkadi, A. (2018). *Etude comparative de deux protocoles de récupération en immersion en eau froide (continu et fractionné) après un entraînement intense (cas du hand-ball).*

Belkadi, A., Alia, C., & Mohammed, Z. (2020). Algerian Judo Competition Modality and its Impacts on Upper and Lower Limbs Strength Perseverance and Limitations. *Orthopedics and Sports Medicine: Open Access Journal*, *3*(4), 293–299.

Belkadi, A., Othman, B., Mohamed, S., M, B. H., Gleyse, J., Adel, B., … Gleyse, J. (2015). Contribution to the Identification of the Professional Skills Profile of Coaches in the Algerian Sport Judo System. *International Journal of Sports Science*, *5*(4), 145–150.

Benbernou, O., Bennama, F., Belkadi, A., Boukchiche, S., & Koutchouk, S. M. (2022). Analysis of the Professional Competency Indicators of University Physical Trainer Students. *Acta Facultatis Educationis Physicae Universitatis Comenianae*, *62*(1), 53–71.

Benhammou, S., Clemente, F. M., Mourot, L., & Belkadi, A. (2025). Physiological and Biomechanical Responses Induced by a Continuous Test and an Intermittent Test in Middle-Distance Runners. *International Journal of Sports Physiology and Performance*, *1*(aop), 1–6. https://doi.org/10.1123/ijspp.2024-0350

Bohannon, R. W., Peolsson, A., Massy-Westropp, N., Desrosiers, J., & Bear-Lehman, J. (2006). Reference values for adult grip strength measured with a Jamar dynamometer: A descriptive meta-analysis. *Physiotherapy*, *92*(1), 11–15. https://doi.org/10.1016/j.physio.2005.05.003

Boudehri, M. E. amine, Belkadi, A., Dahoune, O., & Atallah, A. (2023). The effects of circuit exercise training strategy on health-related physical fitness level and biomarkers in elderly people with cardiovascular diseases. *Quality in Sport*, *11*(1), 16–31. https://doi.org/10.12775/QS.2023.11.01.002

Buchheit, M., & Laursen, P. B. (2013). High-intensity interval training, solutions to the programming puzzle: Part I: cardiopulmonary emphasis. *Sports Medicine (Auckland, N.Z.)*, *43*(5), 313–338. https://doi.org/10.1007/s40279-013-0029-x

Butcher, A. (2002). *Judo: The Essential Guide to Mastering the Art* (First Edition). Lyons Pr.

Callan, M., & Bradić, S. (2018). Historical development of judo. In *The Science of Judo*. Routledge.

Ceylan, B., & and Balci, Ş. S. (2022). Comparison of physiological and perceptual load between uke and tori after intermittent osaekomi-waza exercise in judo. *International Journal of*

Performance Analysis in Sport, *22*(4), 505–515. https://doi.org/10.1080/24748668.2022.2084593

Chandy, R., Keith ,Katherine L., & and Feldman, S. R. (2022). Side effect jiu-jitsu. *Journal of Dermatological Treatment*, *33*(8), 2151863. https://doi.org/10.1080/09546634.2022.2151863

Cherara, L., Belkadi, A., Mesaliti, L., & Beboucha, W. (2022). Characteristics of Handgrip (Kumi-Kata) Profile of Georgian Elite Judo Athletes. *GYMNASIUM*, *23*(1), 54–66.

Chorba, R. S., Chorba, D. J., Bouillon, L. E., Overmyer, C. A., & Landis, J. A. (2010). Use of a functional movement screening tool to determine injury risk in female collegiate athletes. *North American Journal of Sports Physical Therapy: NAJSPT*, *5*(2), 47–54.

Cook, G., Burton, L., & Hoogenboom, B. (2006). Pre-participation screening: The use of fundamental movements as an assessment of function - part 2. *North American Journal of Sports Physical Therapy: NAJSPT*, *1*(3), 132–139.

Cook, G., Burton, L., Hoogenboom, B. J., & Voight, M. (2014). FUNCTIONAL MOVEMENT SCREENING: THE USE OF FUNDAMENTAL MOVEMENTS AS AN ASSESSMENT OF FUNCTION-PART 2. *International Journal of Sports Physical Therapy*, *9*(4), 549–563.

Costa, P. B., Herda, T. J., Herda, A. A., & Cramer, J. T. (2014). Effects of dynamic stretching on strength, muscle imbalance, and muscle activation. *Medicine and Science in Sports and Exercise*, *46*(3), 586–593. https://doi.org/10.1249/MSS.0000000000000138

Dorrel, B. S., Long, T., Shaffer, S., & Myer, G. D. (2015). Evaluation of the Functional Movement Screen as an Injury Prediction Tool Among Active Adult Populations. *Sports Health*, *7*(6), 532–537. https://doi.org/10.1177/1941738115607445

Follmer, B., Dellagrana, R. A., Franchini, E., & Diefenthaeler, F. (2015). Relationship of kimono grip strength tests with isokinetic parameters in jiu-jitsu athletes. *Brazilian Journal of Kinanthropometry and Human Performance*, *17*(5), 575–582. (Fifteen male JJ athletes). https://doi.org/10.5007/1980-0037.2015v17n5p575

Funk, D., Haugtvedt, C., & Howard, D. (2000). Contemporary Attitude Theory in Sport: Theoretical Considerations and Implications. *Sport Management Review*, *3*, 125–144. https://doi.org/10.1016/S1441-3523(00)70082-9

García-Ramos, A., Pérez-Castilla, A., Macias, F. J. V., Latorre-Román, P. Á., Párraga, J. A., & García-Pinillos, F. (2018). Differences in the one-repetition maximum and load-velocity profile between the flat and arched bench press in competitive powerlifters. *Sports Biomechanics*, *0*(0), 1–13. https://doi.org/10.1080/14763141.2018.1544662

Garrison, M., Westrick, R., Johnson, M. R., & Benenson, J. (2015). ASSOCIATION BETWEEN THE FUNCTIONAL MOVEMENT SCREEN AND INJURY DEVELOPMENT IN COLLEGE ATHLETES. *International Journal of Sports Physical Therapy*, *10*(1), 21–28.

Haff, G. G., Jackson, J. R., Kawamori, N., Carlock, J. M., Hartman, M. J., Kilgore, J. L., … Stone, M. H. (2008). Force-time curve characteristics and hormonal alterations during an eleven-week training period in elite women weightlifters. *The Journal of Strength & Conditioning Research*, *22*(2), 433–446.

Julio, U. F., Panissa, V. L. G., Esteves, J. V., Cury, R. L., Agostinho, M. F., & Franchini, E. (2017). Energy-System Contributions to Simulated Judo Matches. *International Journal of Sports Physiology and Performance*, *12*(5), 676–683. https://doi.org/10.1123/ijspp.2015-0750

Kano, J. (2013). *Kodokan Judo: The Essential Guide to Judo by Its Founder Jigoro Kano*. Kodansha USA.

Lapota, P. (2014). The Impact of Compensation Exercises on the Muscle Imbalance at 15-Year-Old Students. *Prace Naukowe Akademii Im. Jana Długosza w Częstochowie Kultura Fizyczna*, *13*(1), 151–159.

Lopata, P., & Brodáni, J. (2014). The impact of compensation excercises on muscle imbalance and movement performance. *Studia Kinanthropologica*, *15*, 195–201. https://doi.org/10.32725/sk.2014.058

Maffulli, N., Del Buono, A., & Silvestri, E. (2015). Muscle Injuries: Pathophysiology and New Classification Models. In E. Silvestri, A. Muda, & D. Orlandi (Eds.), *Ultrasound Anatomy of Lower Limb Muscles: A Practical Guide* (pp. 33–38). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-09480-9_6

Malliaropoulos, N., Callan, M., & Pluim, B. (2013). Judo, the gentle way. *British Journal of Sports Medicine*, *47*(18), 1137–1137. https://doi.org/10.1136/bjsports-2013-093161

Manescu, C. O. (2013). Inclusion Of Stretching And Flexibility Movements In Fitness And Bodybuilding Training. *Marathon*, *5*(1), 62–75.

Moran, R. W., Schneiders, A. G., Mason, J., & Sullivan, S. J. (2017). Do Functional Movement Screen (FMS) composite scores predict subsequent injury? A systematic review with meta-analysis. *British Journal of Sports Medicine*, *51*(23), 1661–1669. https://doi.org/10.1136/bjsports-2016-096938

Norris, C. M. (2015). *The Complete Guide to Stretching: 4th edition* (4th edition). London: Bloomsbury Sport.

Pocecco, E., Ruedl, G., Stankovic, N., Sterkowicz, S., Del Vecchio, F. B., Gutiérrez-García, C., … Burtscher, M. (2013). Injuries in judo: A systematic literature review including suggestions for prevention. *British Journal of Sports Medicine*, *47*(18), 1139–1143. https://doi.org/10.1136/bjsports-2013-092886

Sacripanti, A. (2012, June 7). *A Biomechanical Reassessment of the Scientific Foundations of Jigoro Kano's Kodokan Judo*. arXiv. https://doi.org/10.48550/arXiv.1206.1135

Sakaue, Y., & Thompson, L. (2020). The rise of modern sport and the Olympic Movement in Japan. In *The Routledge Handbook of Sport in Asia*. Routledge.

Sato, S. (2013). The sportification of judo: Global convergence and evolution. *Journal of Global History*, *8*(2), 299–317.

Simenko, J. (2019). The benefits of Functional Movement Screen in judo. *Revista de Artes Marciales Asiáticas (RAMA)*, *14*(2s). https://doi.org/10.18002/rama.v14i2s.5988

Stastny, P., Lehnert, M., & Tufano, J. J. (2018). Muscle Imbalances: Testing and Training Functional Eccentric Hamstring Strength in Athletic Populations. *Journal of Visualized Experiments : JoVE*, (135), 57508. https://doi.org/10.3791/57508

Steinmane, V., & Fernate, A. (2024). AIM AND MEANING OF BREATHING EXERCISES: INTERDISCIPLINARY LITERATURE REVIEW. *SOCIETY. INTEGRATION. EDUCATION. Proceedings of the International Scientific Conference*, *2*, 742–752. https://doi.org/10.17770/sie2024vol2.7876

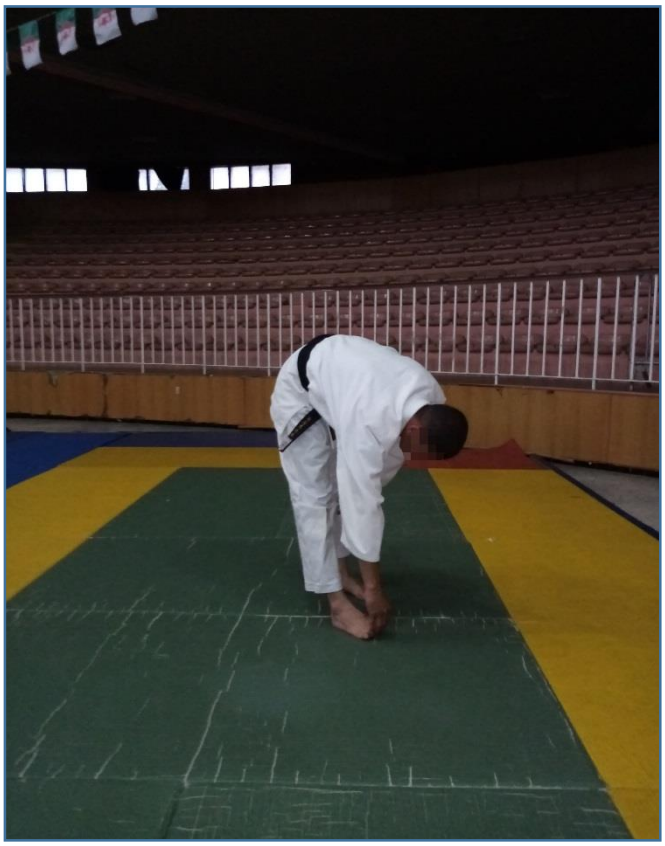
Sterkowicz-Przybycień, K. L., & Fukuda, D. H. (2014). Establishing normative data for the special judo fitness test in female athletes using systematic review and meta-analysis. *Journal of Strength and Conditioning Research*, *28*(12), 3585–3593. https://doi.org/10.1519/JSC.0000000000000561

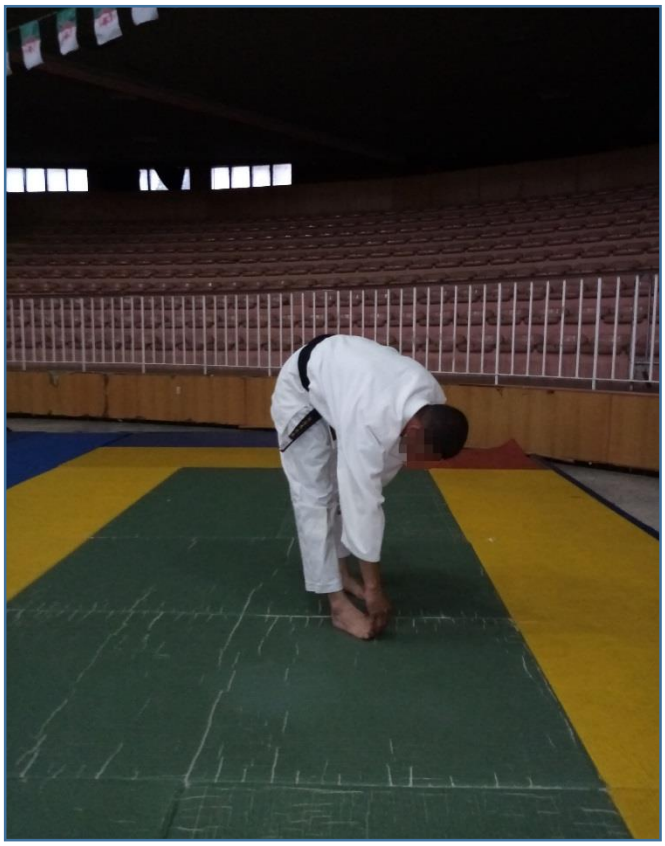
Vora, M., & Arora, M. (2019). An Analysis of the Evidence Base Relating to the Role of Warm-Up and Stretching in Reduction of Injury Risk in Athletes. *Orthopedics and Sports Medicine: Open Access Journal*, *2*(4), 1–3.

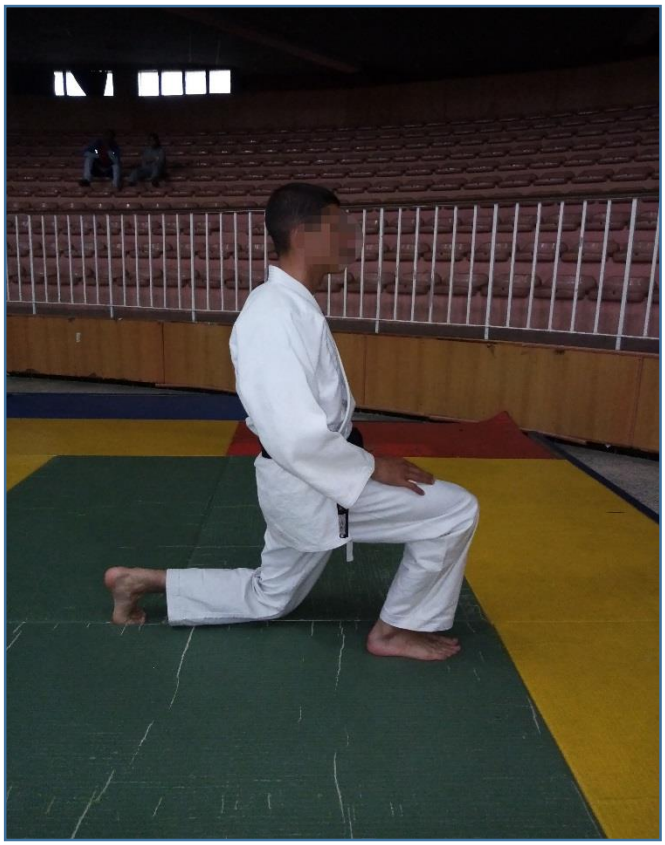
Warner, D. (2024). *Skill Acquisition for Judo: Principles into Practice* (1st edition). Routledge.

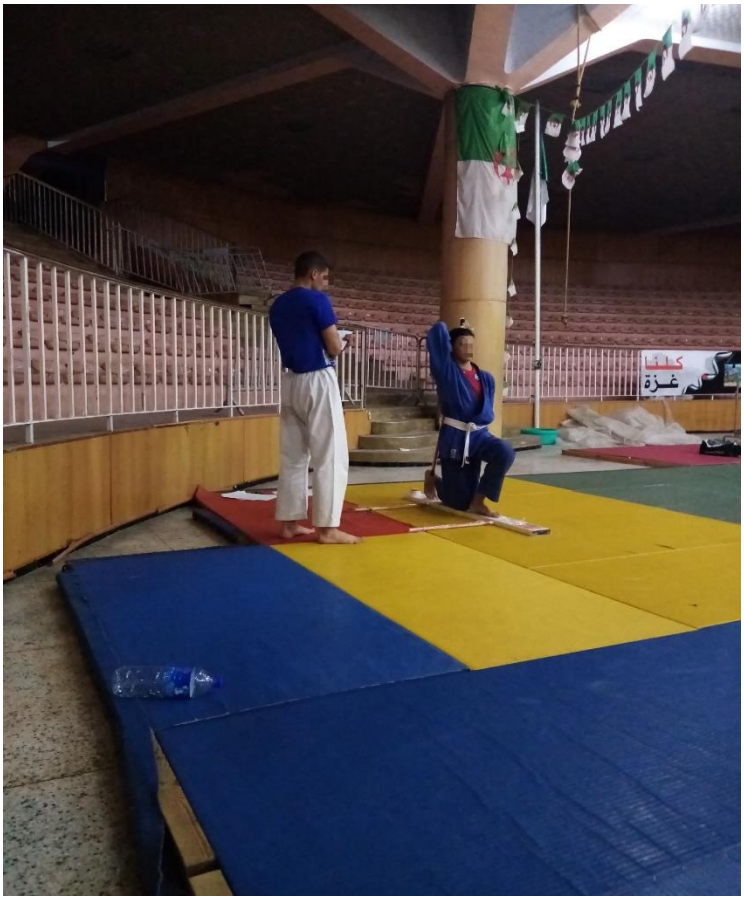
Yacine, Z., Othmane, B., Adel, B., Mohamed, S., Aabdelkader, B., & Lalia, C. (2020). Functional movement screening as a predictor of injury in highly trained female's martial arts athletes. *Polish Hyperbaric Research*, *71*(2), 67–74.

Annex








كلنا
غزة


كلنا
غزة