



INSTITUTO POLITÉCNICO
DE VIANA DO CASTELO

Joaquim Filipe de Freitas Ferreira

Development of a New Tool to Assess the Technique of Karate Athletes: Analyzing the
Influence of Age, Experience, Anthropometric Measurements, and Physical Fitness.

Master's degree in Sports Training

Dissertation under the supervision of

Ph.D. Filipe Manuel Batista Clemente,

Ph.D. Rui Miguel Fernandes Pereira da Silva

July 2023

Ferreira, Joaquim Filipe de Freitas

Development of a new instrument to evaluate karate athletes' technique: influence of age, experience, anthropometric measures, and physical fitness. Master dissertation supervisors Filipe Manuel Batista Clemente PhD, Rui Miguel Fernandes Pereira da Silva, Ph.D. – Master's Degree in Sports Training, Escola Superior de Desporto e Lazer, Instituto Politécnico de Viana do Castelo.

Keywords: karate, technical evaluation, Kumite, physical qualities.

“Wanting to win, being willing to lose if need be, and handling your victory and failure gracefully are what sport inculcates in a human being, and that is the essence of leadership.”

Sadhguru

DEDICATION

I dedicate this dissertation to the women in my life: my mother, my daughters Soraia and Inês, and my beloved wife, Helena. Because of you, I am inspired to strive for excellence every day. Your unwavering support and encouragement have been the driving force behind my achievements, and for that, I am eternally grateful.

ACKNOWLEDGMENTS

I would like to dedicate this to all the people who made the completion of my master's dissertation possible.

I want to thank my advisor, Filipe Clemente, for his guidance, professionalism, and constant support throughout the entire process of developing my research. His knowledge and experience were truly valuable to the success of this dissertation.

I would also like to express my gratitude to my co-advisor, Rui Silva, for his valuable advice and help in conducting my research and fieldwork.

I am grateful to the Portuguese Youth Karate Association (AJKP) for the opportunity to conduct my studies in this nationally renowned institution and for the support provided during my research.

I would like to thank all the teachers who inspired me to grow and all my classmates for the affection and friendship with which they welcomed me.

I would like to conclude these acknowledgments note by dedicating this work to my students, who have always inspired me to seek personal and collective development. The experience of teaching them and learning from their examples was an important incentive for me to step out of my comfort zone and challenge myself to grow as a teacher, martial artist, and researcher. I hope that this work can contribute to the advancement of knowledge in this area and inspire my students to follow their paths of development and learning.

Once again, I thank everyone who helped me on this journey and thank the School of Sports and Leisure at the Polytechnic Institute of Viana do Castelo for the opportunity to complete this work.

INDEX

CHAPTER I – GENERAL INTRODUCTION.....	16
GENERAL INTRODUCTION	17
PRESENTATION OF THE PROBLEM	17
1.2 PROBLEM DEFINITION	19
1.3 PERTINENCE OF THE STUDY.....	19
CHAPTER II - LITERATURE REVIEW.....	21
2.1 KARATE-DO HISTORY	22
2.2 TECHNICAL CHARACTERIZATION OF KARATE.....	23
2.3 KATA CHARACTERIZATION	23
2.3.1 CHARACTERIZATION OF PHYSIOLOGICAL EFFORT IN KATA	24
2.3.2 CHARACTERIZATION OF KUMITE	24
2.3.3 CHARACTERIZATION OF PHYSIOLOGICAL EFFORT IN KUMITE	25
2.3.4 CHARACTERIZATION OF THE PHYSICAL QUALITIES OF KARATEKAS	27
2.3.5 SOMATIC, FUNCTIONAL, AND BODY COMPOSITION DATA IN KUMITE	28
2.4. OBSERVATIONAL ANALYSIS IN SPORTS – ASSESSING TECHNIQUES	30
2.5. SYSTEMS FOR EVALUATING THE TECHNICAL QUALITIES OF KARATE.....	31
CHAPTER III – ORIGINAL PAPERS.....	33
PAPER 1	34
PAPER 2	79
CHAPTER IV – GENERAL DISCUSSION	103
GENERAL DISCUSSION	105
CHAPTER V – GENERAL CONCLUSION	112
REFERENCES	116
ATTACHEMENTS	128

INDEX OF FIGURES

Representation of the removable target.....	41
Biomechanics of Mawashi Geri.....	43
Critical points to be observed from the technical evaluation of the Mawashi Geri.....	44
Biomechanics of the Kizami Zuki.....	46
Critical points to note from the technical evaluation of Kizami Zuki.....	47
Gyaku Zuki biomechanics.....	48
Critical points to note from the technical evaluation in Gyaku Zuki.....	48
Biomechanics of the Ura Mawashi Geri.....	50
Biomechanics of the Mawashi Geri.....	51
Execution in reversed V.....	52
Biomechanics of Kizami Zuki.....	53
Pyramid Execution.....	54
Biomechanics of Gyaku Zuki.....	55

INDEX OF TABLES

Characterization of the Sample Evaluators.....	56
Sample Characterization of the Evaluated Individuals.....	57
Inter-observer evaluator results.....	58
Inter-observer evaluator results.....	59
Descriptive statistics (mean $\pm$ standard deviation) for the anthropometric and physical fitness variables organized by age groups.....	87
Descriptive statistics (mode [minimum; maximum]) for ordinal variables associated with technical tests.....	89
Mann-Whitney U (Z) values and p-values for comparison between pairs of age groups.....	90
Descriptive statistics (mode [minimum; maximum]) for ordinal variables associated with experience levels in the sport.....	91
Mann-Whitney U (Z) values and p-values in the comparison between pairs of experience levels	91
Correlation matrix (Rho) between the quality of execution of technical movements and anthropometric and physical fitness variables.....	92

ABSTRACT

*This master's dissertation in sports training presents two studies. They focus on evaluating and characterizing karate athletes. **Objectives:** The objective of the first study was to develop and establish the validity of a technical evaluation system in karate, while the objective of the second study was to compare the technical proficiency of karate athletes across different age groups and years of experience and to examine the relationship between technical proficiency, physical fitness, and anthropometric measures. **Methods:** The first study used three phases to establish the validity of the technical evaluation system in karate, including expert analysis and evaluation of the observation instrument, expert evaluation of athlete performance, and reliability testing of evaluators' observations. The evaluation system assessed four common techniques in kumite competitions at different levels of proficiency. The second study used an observational cross-sectional study design on a non-probabilistic convenience sample of 53 karate athletes, who were grouped according to age and years of experience. The participants were evaluated using anthropometry, physical fitness tests, and the System for the Technical Assessment of Kumite (STAK). **Results:** The first study found substantial to almost complete intra-rater reliability for expert and beginner athletes' evaluations, with ICC values ranging from 0.774 to 0.959. The STAK evaluation process was found to be a reliable method for assessing the success criteria of different techniques used in martial arts. However, novice athletes may require more specific and consistent evaluation criteria to improve their observation technique and refine their ability to interpret success variables in each motor action. The second study found statistically significant differences in physical fitness and technical proficiency among karate athletes of different age groups and years of experience. The technical observation instrument showed significant dependence relationships with experience, indicating the sensitivity of the instrument to differentiate the effect of experience on the quality of movement in karate athletes. **Conclusion:** Both studies contribute to the understanding of the technical evaluation and characterization of karate athletes. The first study establishes the validity and reliability of a technical evaluation system in karate, while the second study highlights the importance of experience in developing physical fitness and technical proficiency in karate athletes. Together, these studies provide insights into the factors that contribute to the success of karate athletes and offer a useful tool for evaluating their technical performance.*

RESUMO

Esta tese de mestrado em treino desportivo apresenta dois estudos que se concentram na avaliação e caracterização de atletas de karaté. **Objetivos:** O objetivo do primeiro estudo foi desenvolver e estabelecer a validade de um sistema de avaliação técnica no karaté, enquanto o objetivo do segundo estudo foi comparar a proficiência técnica de atletas de karaté em diferentes grupos etários e anos de experiência, e examinar a relação entre proficiência técnica, aptidão física e medidas antropométricas. **Métodos:** O primeiro estudo utilizou três fases para estabelecer a validade do sistema de avaliação técnica no karaté, incluindo análise e avaliação de especialistas do instrumento de observação, avaliação de especialistas do desempenho dos atletas e teste de confiabilidade das observações dos avaliadores. O sistema de avaliação avaliou quatro técnicas comuns em competições de kumite em diferentes níveis de proficiência. O segundo estudo utilizou um design observacional transversal em uma amostra de conveniência não probabilística de 53 atletas de karaté, que foram agrupados de acordo com a idade e anos de experiência. Os participantes foram avaliados através de antropometria, testes de aptidão física e do Sistema de Avaliação Técnica de Kumite (STAK). **Resultados:** O primeiro estudo encontrou uma confiabilidade intra-avaliador substancial a quase completa para avaliações de atletas iniciantes e especialistas, com valores de ICC variando de 0,774 a 0,959. O processo de avaliação SATK foi considerado um método confiável para avaliar os critérios de sucesso de diferentes técnicas usadas em artes marciais. No entanto, atletas novatos podem exigir critérios de avaliação mais específicos e consistentes para melhorar sua técnica de observação e refinar sua capacidade de interpretar as variáveis de sucesso em cada ação motora. O segundo estudo encontrou diferenças estatisticamente significativas na aptidão física e proficiência técnica entre atletas de karaté de diferentes grupos etários e anos de experiência. O instrumento de observação técnica mostrou relações de dependência significativas com a experiência, indicando a sensibilidade do instrumento para diferenciar o efeito da experiência na qualidade de movimento em atletas de karaté. **Conclusão:** Ambos os estudos contribuem para a compreensão da avaliação e caracterização técnica de atletas de karaté. O primeiro estudo estabelece a validade e confiabilidade de um sistema de avaliação técnica no karaté, enquanto o segundo estudo destaca a importância da experiência no desenvolvimento da aptidão física e proficiência técnica em atletas de karaté. Juntos, esses estudos fornecem insights sobre os fatores que contribuem para o sucesso dos atletas de karaté e oferecem uma ferramenta útil para avaliar seu desempenho técnico.

Keywords: karate, technical evaluation, Kumite, physical qualities

LIST OF ABBREVIATIONS

STAK – System for the Technical Assessment of Kumite

CMJ – Counter Movement Jump Test

SJ – Seat and Jump Test

BF – Biceps femoris

CHAPTER I – GENERAL INTRODUCTION

General Introduction

Presentation of the problem

Karate is a martial art developed in the Ryukyu Islands (Japan) through indigenous fighting methods and Chinese Kempo (Doria et al., 2009). Martial arts, defined as the combat arts that have developed—and continue to develop—in all geographies and cultural contexts around the world, are, in the popular and public imagination, intimately connected with spectacular flying kicks, violence, and superhuman powers (Di Placido, 2020). Karate is now considered one of the most widely practiced martial arts in the world, with over 10 million athletes and 100 million practitioners (Alesi et al., 2014). This martial art has developed into a highly organized sport, with national federations, intercontinental federations, and the World Karate Federation (WKF), which regulates its sports practice and represents Karate as an Olympic sport. These facts have given Karate a greater media dimension, resulting from its inclusion as a demonstration sport in the 2020 Tokyo Olympics. Karate athletes use almost all muscles during training and competition, but the two disciplines of the sport are Kumite and Kata, which differ significantly in terms of style and corresponding muscle use. Kata consists of a predetermined series of movements that are executed with explosive speed against imaginary opponents, while Kumite involves combat (Doria et al., 2009).

With the increase in visibility and notoriety of Karate, the need for greater scientific evidence has emerged, for Sports Karate to be developed to higher levels through science. Global competition in sports is constantly intensifying, and despite this greater demand, there is a lack of evidence-based guidelines for training and competition in Kumite discipline of Karate, to help coaches prescribe training programs specifically aimed at improving Kumite performance (Chaabène et al., 2012). There is already some scientific evidence characterizing the

physiological and biological effort of Kumite practitioners, (Chaabène et al., 2012; Gunawan, 2021; Herrera-Valenzuela et al., 2021; Pinto-Escalona et al., 2021), but not much evidence is available for the technical and tactical aspects of the discipline. It will be necessary, therefore, to characterize the technical and tactical aspects of the discipline itself, which are constantly evolving due to the constant changes in the Kumite rules and which are not yet described in the current literature, to promote high performance. These changes are important because to define a sport, its rules need to be defined, and the competition model is altered, making it desirable to formulate a new updated theoretical framework (Barrientos et al., 2021). From a neurophysiological perspective, the motor actions involved in sports karate are highly challenging and therefore require highly systematized motor skills to ensure that technical resources are immediately available without the need for deliberate and premeditated formulation of a motor pattern to perform a role during the action (Ojeda-Aravena et al., 2020).

Studies have shown that technical skills are essential for success in karate. A study conducted by Chaabène et al. (2012) found that high-level karateka (karate practitioners) exhibited superior technical skills compared to lower-level karateka. This finding was based on a detailed analysis of the karateka's kinematic and kinetic patterns during a specific karate movement. Another study by Čavala et al. (2015), focused on the relationship between technical skills and performance in a different karate discipline, the Kata, which involves performing a series of predetermined movements. In addition to these specific findings, research has also shown that technical skills in karate are closely related to physical fitness and mental health. A study by Przybylski et al. (2021), found that karateka who were proficient in technical skills, such as kicking, punching, and blocking, also demonstrated superior levels of physical fitness, such as strength, speed, and endurance.

As technical actions are so determinant in competitive performance in karate disciplines, there is an urgent need to study the context of these actions about the influence of factors that may condition them, such as age, experience, physical fitness, and even anthropometric factors. However, to have measurable measures of analysis of these factors, the creation of a technical evaluation model and tool is necessary to concretely indicate to researchers at what technical level the observed athlete.

1.2 Problem definition

The problem at hand is the lack of evidence-based guidelines for training and competition in karate, particularly in the Kumite discipline. Despite the growing visibility and popularity of karate as a sport, there is a need for scientific research to help develop the sport to higher levels. While some research has been conducted on the physiological and biological aspects of kumite, there is a lack of evidence on the technical and tactical aspects of the discipline. Therefore, it is necessary to characterize these technical and tactical aspects to better understand how to improve kumite performance. This includes studying the context of technical actions about factors that may influence performance, such as age, experience, physical fitness, and anthropometric factors. Additionally, there is a need to create a technical evaluation model to measure these factors and determine the athlete's level of skill.

1.3 Pertinence of the Study

The evaluation of technique is an essential part of martial arts training, such as karate. Developing a new evaluation tool can provide a more precise and effective means of assessing the

technique of karate practitioners, which can lead to better training programs and the improvement of their skills.

Furthermore, the influence of age, experience, anthropometric measurements, and physical fitness are also important factors to consider in evaluating the technique of karate practitioners. Understanding how these factors can influence technique can help adapt training for athletes of different ages, experiences, and physical characteristics.

Finally, the studies contained in this dissertation can also contribute to the field of sports science by providing new insights into how to evaluate technique in martial arts and how factors such as age, experience, anthropometric measures, and physical fitness can influence athletic performance.

1.4. Objectives of the dissertation

Article 1

The purpose of the first article was to present the procedures used in developing and establishing the validity of a technical evaluation system in karate, as well as to highlight the advantages of this system for characterizing technical performance in athletes in the context of training and before kumite competitions.

Article 2

The second article had two purposes: (i) to compare differences in anthropometric measures, physical fitness, and technical gesture quality in karate among practitioners of different age groups and years of experience; (ii) to test the dependence relationship between the quality of execution of the technical gesture in karate and anthropometric and physical fitness measures.

CHAPTER II - LITERATURE REVIEW

2.1 Karate-Do History

Karate is an unarmed combat art that originated in Okinawa, the main island of the Ryukyu Islands. It became popular in the West after being learned and practiced by American soldiers stationed in Okinawa after World War II. The history of martial arts suggests that Karate has roots in the Shaolin temple in China, where Buddhist monk Bodhidharma taught his interpretation of Buddhist precepts. The fighters from the Shaolin temple spread their art to neighboring countries, including Okinawa, where it underwent adaptations to the local culture (Abel Figueiredo, 2006; Swennen, 2009).

The development of Karate in Okinawa took place between the 15th and 16th centuries, during the establishment of a new dynasty. King Sho Shin banned the use of swords and ordered the confiscation of weapons, leading to the emergence of combat schools. One of these schools, known as "the," was practiced by the nobility, while another called Ryuku kobudo was practiced by farmers and fishermen. The art of Karate was passed down secretly within families until its massification in Okinawa (Swennen, 2009).

In 1920, the Okinawa Shobukai was established, marking the first institutional organization of Karate. High in Funakoshi, the president of the organization, performed a demonstration in Tokyo, Japan, in 1922, which led to his decision to stay in Japan and promote Karate there. Karate's international diffusion was influenced by military personnel who learned the art in Japan and spread it to the United States and Europe after World War II. In the 1950s, Karate began to spread in Europe through France, with the arrival of Japanese masters such as Hiroo Mochizuki and Taiji Kase (Figueiredo, 2006).

Karate has undergone modifications to become an Olympic sport and has had a complex relationship with the Olympic Committee. The World Karate Federation (WKF) was formed in 1970 to oversee the international development of Karate. It was officially recognized by the International Olympic Committee in 1985, but the recognition was temporarily withdrawn until 1992. In 1999, the WKF received definitive recognition, and Karate was included as an experimental sport in the Tokyo 2020 Olympic Games. (World Karate Federation). Overall, Karate has a rich history that traces its origins back to Okinawa and the influence of Chinese martial arts. Its international spread and institutionalization have led to its recognition as a global sport, with aspirations of becoming an official Olympic sport.

2.2 Technical Characterization of Karate

Karate is a martial art that primarily focuses on striking techniques, employing punches, kicks, knee strikes, elbow strikes, and open-hand techniques like knife hands and spear hands. It also incorporates defensive maneuvers such as blocking, dodging, and parrying.

Practitioners of karate undergo training to enhance their speed, power, and precision in executing strikes, as well as to develop physical and mental endurance. Kata, a series of predetermined movements, holds great significance in karate training as it aids practitioners in refining their techniques and concentration.

Apart from physical training, karate places strong emphasis on cultivating discipline, respect, and humility in its practitioners. Competitions play a significant role in karate, with tournaments taking place at local, national, and international levels. Notably, karate made its debut as an experimental sport at the 2020 Olympic Games.

Karate is an activity that demands the mastery of various motor skills, including highly intricate techniques. Achieving proficiency in these techniques and effectively implementing them during a fight necessitates consistent and rigorous training, enabling practitioners to execute high-complexity actions in combat situations. The dynamics of combat and the frequency of movement are particularly emphasized, necessitating karateka to possess advanced motor and functional skills as well as speed and strength (Ravier et al., 2003a). Mastery of karate techniques is a long-term endeavor reliant on both fundamental motor skills and specific motor skills. Over time, these motor skills in karate, along with general and specific motor skills, become integrated into the practitioner's overall physical abilities (Chaahène et al., 2012).

2.3 Kata characterization

Kata, which means "form", incorporates techniques from various martial arts schools as athletes move in various directions in space. It is not considered a symbolic battle to be performed alone, but rather a battle against one or more invisible opponents. Different schools incorporate different numbers of kata techniques and refer to them by distinct names. The basic elements of proper kata technique include kime (a small isometric muscle contraction performed when a technique is completed), expressiveness, rhythm, strength, and athletic ability. During

competitions, athletes perform fixed kata styles (shitei) that have a different duration for each kata performed. The World Karate Federation (WKF) According to Francescato et al. (1995), the main objective of Karate has been to imprint the maximum amount of kinetic energy possible into a single body segment in the shortest possible period. According to Zehr & Sale (1993), kata consists of a complex series of organized, predetermined movements that incorporate both defensive and offensive techniques, using both upper and lower limbs, as well as rotations, turns, jumps, and displacements.

2.3.1 Characterization of physiological effort in Kata

Francescato et al. (1995) analyzed the total energy costs and sources of energy in eight 23-year-old male kata practitioners performing Pinan ni dan kata of the Wado style. They concluded that the metabolic power of these athletes was high and correlated with the duration of their activity. The main source of energy was the anaerobic alactic metabolism, producing 46–90% of the total energy (i.e., derived from the degradation of phosphagens) during competitions lasting 80 and 10 seconds, respectively. According to the same authors, the contribution of the aerobic system was from 10% to 41%, and that of the lactic system was up to 13%. These findings suggest that Kata requires a high level of anaerobic energy production, particularly during shorter-duration competitions.

2.3.2 Characterization of Kumite

Karate is one of the most popular combat sports worldwide, and Kumite represents one of the main types of practice and competition. Kumite consists of a combat that allows the use of punches (Tsuki), strikes (Uchi), and kicks (Geri) to the head (Jodan) and trunk (Chudan) of the opponent to score points. Kumite competitions are held on an 8x8-foot mat with a combat time of 3 minutes for adult men and women. Three main scores can be achieved in karate kumite: Ippon (three points), Waza-ari (two points), and Yuko (one point). Athletes can win earlier with a point difference of 8 or the expulsion of the other athlete for excess category 1 and 2 fouls. In case of a tie, the panel of judges determines the winner.

The Kumite combat game is characterized by a fictional fight simulating a real fight. Although competitions involve contact and symbolic techniques, they can be quite traumatic when not controlled. Athletes must demonstrate the potential force of their movements and execute them as if they were real, using control to interrupt movements to avoid causing harm to the opponent.

2.3.3 Characterization of physiological effort in Kumite

Kumite is characterized by high-intensity activity, including explosive and intermittent actions lasting between 0.3 and 2.1 seconds (time: pause 19:8s; 1:2) Beneke et al. (2004), which requires great technical and tactical skill (Pereira et al., 2014). High cardiorespiratory fitness, including oxidative dominance through the ATP-PC pathway and, to a lesser extent, the glycolytic system Beneke et al. (2004), is necessary to deal with the metabolic demand during combat and recovery (Chaabène et al., 2012).

It has been reported that high-intensity intermittent sports mainly depend on anaerobic energy sources, with determinant actions being a function of explosive movement (Glaister, 2005). Some of the early studies conducted to characterize the effort in Kumite, such as that of Arazi and Izadi (2017), defined the Kumite event as being of high intensity, and consequently, its predominant energy source would come from the anaerobic system. Thus, the decisive actions of karatekas depend mainly on anaerobic energy pathways (Francescato et al., 1995; Beneke et al., 2004).

However, more recent studies indicate that the metabolic profile of this test is predominantly aerobic, with some supplementation from the phosphate system (anaerobic alkaline). Due to the intermittent nature of karate kumite, aerobic metabolism (77.8 5.8%) plays an important role during combat, followed by anaerobic lactic metabolism (16.0 4.6%) and lactic anaerobic metabolism (6.2 2.4%). Beneke et al. (2004) and Chaabène et al. (2015) also point out that kumite is a high-intensity discipline that requires a high level of anaerobic endurance. The study also addresses the aerobic system, mentioning that the heart rate of Kumite athletes exceeded 90% of the maximum heart rate during 65% of the total combat time.

Castelo (1987) observed that, on average, the player is in action (objective technical-tactical execution, offensive or defensive, observable) for only 15 seconds of the combat's total time, divided between actions that last more than 0.50 seconds (80%) and Beneke et al. (2004) recorded 16,3 high-intensity attacks per combat, with each attack lasting 1 to 3 seconds, for a total of 3,4 high-intensity attacks per minute. Castelo (1987) observed that, on average, the player is in action (objective technical-tactical execution, offensive or defensive, observable) for only 15 seconds of the useful time of the combat, divided into actions not exceeding 0.50 seconds (80%) and actions between 0.50 and 1.50 seconds (20%). Beneke et al. (2004) recorded 16.3 high-intensity actions per combat, lasting 1 to 3 seconds each, culminating in a result of 3.4 high-intensity actions per minute. The same study observed that refereeing decisions provoked an activity-to-interval ratio of almost two to one, coming from 18 seconds of activity for 9 seconds of break.

An athlete's performance can also be measured by their level of cardiorespiratory endurance. Cardiorespiratory endurance involves the ability to sustain prolonged exercise involving the cardiovascular and respiratory systems. The body's demand for oxygen during strenuous activity depends on the efficiency and ability of these systems to work together. Maximum oxygen consumption (VO_{2max}) is considered a determinant factor of the cardiorespiratory level of any athlete. VO_2 max is widely used by researchers to indicate the level of functional cardiovascular capacity. It is defined as the greatest amount of oxygen an individual can use during increasing-intensity exercise, according to the American College of Sports Medicine (2006).

There is currently a validated evaluation system for the aerobic system of karate practitioners, namely the KSAT (Nunan, 2006). In a research article written by Chaabene et al. (2015) for the aerobic system of karate practitioners, namely the KSAT (Nunan, 2006). In a research article written by Chaabene et al. (2015) the aim was to determine the relationship between KSAT performance time to exhaustion (TE) and continuous laboratory test aerobic performance parameters and establish the correlation between KSAT performance and intermittent endurance parameters measured through YoYoIRTL1. The results showed that vVO_{2max} was significantly correlated with KSAT TE, while VO_{2max} was not. However, there was a significant relationship between KSAT TE performance and YoYoIRTL1. The KSAT is a specific sports field

test designed to assess the aerobic performance of karate practitioners. The test provided good absolute and relative reliability and successfully discriminates karate athletes by competitive level. The results of this study may be of interest to karate coaches, trainers, and practitioners, as the KSAT represents the only specific aerobic field test for karate available in the scientific literature. Considering that test reliability and discriminant ability are two important aspects, this test can be used to monitor karate training programs, especially those targeting the improvement of karate athletes' aerobic fitness.

2.3.4 Characterization of the physical qualities of Karatekas

The search for supremacy in a combat through high-intensity motor actions (offensive and defensive) reflects the importance of components such as speed and explosive strength in the Kumite game. Speed is expressed in both offensive and defensive actions, in attempts to surprise the opponent or react to an action produced by them. Furthermore, its positive variation is an intrinsic factor for the effective transmission of impact force (Figueiredo & Dias, 2002).

As we have seen, "impact is not explicitly sought in institutionalized competition, but as its inherent biomechanical consequence, depending on high quantities of movement, speed becomes an explicit criterion for scoring and a mechanically important physical quality (vigorous application). Moreover, it is tactically important to reach the opponent by making their defense reactions difficult, which further praises this quality" (Figueiredo & Dias, 2002, p. 13). According to Chaahène et al. (2012), joint mobility and agility are fundamental for the physical preparation of a karateka, thus determining that they are two intrinsic physical abilities for the karateka. Flexibility is also one of the very important characteristics to be developed in karateka. In a study comparing the level of joint flexibility between karate practitioners and control subjects that assessed knee flexion and extension, hip flexion and extension, medial hip rotation, lateral hip rotation, dorsiflexion, plantar flexion, and inversion and eversion of the foot, Probst et al. (2012) found that karatekas had greater flexibility only in the flexion of the right and left hip compared to the control group, regardless of the upper or lower body of the athlete (Chaahène et al., (2012),

Physical qualities are also crucial in distinguishing the competitive level of athletes. Candeias et al. (2018) conducted a systematic review of published studies to identify factors that distinguish karate athletes with better competitive performance, and the results revealed that there are distinctive factors between elite and non-elite athletes. The distinctive factors were as follows: a predominantly ecto-mesomorphic somatotype; higher levels of aerobic capacity; a lower concentration of lactate in the blood; and higher levels of maximum strength and muscle power. Meanwhile, Drid (2017) compared muscle strength between hamstrings and quadriceps in male Karate athletes of different ages and concluded that the isokinetic parameters of the lower and upper limbs were significantly higher in senior athletes than in juniors, and juniors were higher than cadets in comparison.

Considering that performance in Karate depends on technical and physical factors, there is, by inference, an attempt to analyze the dependence relationships between these dimensions. Karate may depend on technical and physical factors, there is, by inference, an attempt to analyze the dependence relationships between these dimensions. A study by Rakita et al. (2018) determined the relationship between morphological characteristics and specific motor skills of junior karate athletes and concluded that there is a relationship between morphological characteristics and specific motor skills of junior karate athletes, namely the variables of body height, lean mass, and total body water. Despite these examples, the study of relationships is scarce and should be expanded in different contexts.

Regarding strength, the article by Chaahène et al. (2012) analyzes the specific needs of karate in Kumite. The study mentions that karate athletes exhibit high levels of energy production in the upper and lower limbs, suggesting high muscle strength. Additionally, the study highlights the importance of explosive strength for performance in Kumite. Another article by the same author

2.3.5 Somatic, functional, and body composition data in Kumite

In sports where competition is divided by weight categories, reading anthropometric data becomes one of the essential components of achieving sporting success. Superficially, weight is the result of the combination of fat mass (FM) and fat-free mass (FFM), and the weight category

in which the player is placed should be the one that best represents the correct proportion between both of these components and other factors, such as height and segment length.

Malina (1982) suggested that sex and sport are the factors that most influence fat variation. Endurance runners have lower fat values than swimmers, while women consistently have higher fat values than men (Giampietro et al., 2003). Giampietro et al. (2003) consider that an increase in weight due to the accumulation of a higher percentage of fat mass (%FM) may result in a decrease in athlete performance. Thus, it is important to differentiate and evaluate the values of two fundamental body components: (i) FM and (ii) FFM (Giampietro et al., 2003).

In a study by Giampietro et al. (2003) that evaluated 35 male subjects divided into two distinct groups (group 1: high-level professionals and group 2: amateurs), it was found that, in general, group 1 subjects are taller (1.80 ± 0.07 m) than group 2 subjects (1.75 ± 0.07 m). It was also concluded that, on average, the limb-height ratio was higher in group 1, with 86% of the subjects being classified as having long segments, while only 57% of the group 2 subjects were qualified in the same way. Although no statistically significant differences were observed between the other body composition parameters and indices, the authors state that a leaner physique can affect performance positively, and it is expected that subjects of low and medium height with long extremities will achieve the best sports results.

The obtained somatotype values indicate that high-level athletes are situated in the mesomorphy-ectomorphy zone, reflecting the greater development of their vertical constitution compared to amateurs, who are situated in the middle zone of mesomorphy. The %FM was low in both groups studied, although it was found that professional players achieve better results (Jackson-Pollock Protocol: $8.1 \pm 2.4\%$ and Sloan-Weier Protocol: $9.8 \pm 1.6\%$) than amateur players (Jackson-Pollock Protocol: $8.9 \pm 3.3\%$ and Sloan-Weier Protocol: $11.2 \pm 3.7\%$).

In a study conducted with Taekwondo athletes during the Sydney Olympic Games (Kazemi et al., 2006), it was recorded that the average height (1.83 ± 0.08 m) of the male winning players was higher than the average (1.79 ± 0.08) of their category. In this regard, the authors state that these data corroborate one of Taekwondo coaches' long-held beliefs: taller players in each weight category may be more successful due to their greater reach, slimmer bodies, and larger levers, which help them cover long distances while expending less energy. It was also found that, in the heaviest categories, in both sexes, the average weight of the winners was lower than the category

average. Except the winner in the +80 kg category, the average weight of male winners (73.4 12.1 kg) is higher.

In the article by Koropanovski et al. (2011), a study was conducted with 31 elite male karate competitors divided into two groups: kumite and kata. The researchers tested the hypothesis that these two groups of competitors would have different anthropometric and physical performance profiles due to distinct selection of movement techniques and kinematic and kinetic patterns. The tests applied included anthropometric measurements (height, weight, and body mass index) and physical performance tests such as flexibility, speed, explosive power, agility, and aerobic endurance.

The results showed that kumite competitors had a larger body size in terms of height and weight, as well as greater acceleration and explosive power, while differences in body composition were not significant. On the other hand, kata competitors had slightly greater flexibility, but this difference did not reach statistical significance. The authors interpret these results in terms of the distinct differences in movement techniques and suggest that explosive power may be more important for kumite, while a smaller stature and greater flexibility (particularly of the lower limbs) may be important for the low postures of kata competitors.

2.4. Observational analysis in sports – assessing techniques

The use of technical observation systems in the field of sports biomechanics, as mentioned by Anguera et al. (2010), has been widely recognized as an important practice for analyzing and improving athletes' performance. In this regard, it is crucial to review the conceptual framework and the analysis of technique as part of performance analysis, as highlighted by Bartlett, (1999) and Hay & Gavin Reid, (1982).

In the context of sports technique, it is important to clearly define the concept of technique and its relationship to performance. As pointed out by Bober, (1981) technique can be defined as "a way of doing something," while Chambers, (1972) defines technique as "a specific sequence of movements." These definitions have been widely used in the literature, but their lack of clarity can lead to misconceptions. It is necessary to establish criteria for evaluating technique, recognizing

that better performance does not always indicate better technique, as noted by Hay and Reid (1982) and Bartlett (1999).

In technique analysis, it is common to use qualitative and quantitative methods. Qualitative analysis, as mentioned by Cooper and Glassow (Cooper, 1976), involves the observation and subjective judgment of athletes' movements. For this analysis, observation aids such as phase analysis, temporal analysis, and critical feature analysis are used. On the other hand, quantitative analysis relies on the collection of biomechanical data, including linear and angular displacement variables, as reported by several studies, (Cooper and Glassow, (1976), Anguera (2010), Hay and Reid (1982), and Bartlett (1999).

However, it is necessary to develop a solid conceptual framework that establishes the theoretical foundations for technique analysis. This lack of distinction between technique and performance, as mentioned by Bartlett (1999), limits the effectiveness and practical application of technique analysis in sports biomechanics and performance analysis.

Observational methodology, as discussed by Anguera, (2010), plays a crucial role in technique analysis and the study of human behavior. It allows for the systematic recording of athletes' observable behavior using appropriate instruments and parameters. Furthermore, the flexibility of observational methodology, as emphasized by Angera, (2003), allows for varying the extent to which a particular behavior is considered as a whole or focuses on discrete aspects of it.

In the field of sports biomechanics, it is essential to explore new methods and technologies that can enhance technique analysis. The use of artificial neural networks, as mentioned in the previous text, and other methods based on modeling and computer simulation have the potential to provide a comprehensive understanding of the technique as a whole.

Technical observation, through appropriate observational systems and methodologies, plays an important role in assessing athletes' technical progress, enabling the measurement of advancements and setbacks, and enhancing the potential for technical growth among athletes.

2.5. Systems for Evaluating the technical qualities of Karate.

The quality of motor actions is crucial in Karate, so developing methods to determine the quality of movements is also a necessity for the scientific community to collaborate with coaches and teams who want to improve their training systems. Chiu & Shiang. (1999) conducted experiments similar to real competition situations to determine several important factors of punch techniques in karate competition using the GDL (gesture descriptive language) method. This type of information can be extremely valuable in characterizing each subject's technique and in developing training programs as well as competitive strategies. For researchers or coaches, it is essential to work with a motor test that has the highest reliability index. It is one of the guarantees that their results will be valuable and well-constructed.

Human motion capture is commonly used in various fields, including sports, to analyze, understand, and synthesize kinematic and kinetic data. Specialized computer vision and marker-based optical motion capture techniques constitute the gold standard for precise and robust human capture. With this highly accurate system, Szczesna et al. (2021) conducted a study comparing techniques such as Gyaku Zuki (reverse punch), Mawashi Geri (roundhouse kick), Mae Geri (front kick), and Ushiro Mawashi Geri (spinning back kick) among practitioners of various levels of expertise, analyzing joint angles and amplitudes used for each evaluated technique.

At the young ages, there is a current concern to combat early specialization in children, and with this aim, Styriak et al. (2020) conducted research to establish the absolute and relative reliability of a new karate discipline for formation karate, which was designed to evaluate the motor skills of young athletes. The reliability results showed that all karate agility courses for younger karateka presented very good relative and absolute reliability between test and retest. This would mean that not only is the test reproducible for performance measurement, but it also consistently highlights motor skill progress. Other organizations may follow this model of technical evaluation for their practitioners, with an increase in complexity and degree of difficulty at later ages.

CHAPTER III – ***ORIGINAL PAPERS***

PAPER 1

Ferreira, J. F., Silva, R., Badicu, G., & Clemente, F. M. Development, validation, and reliability of a new instrument of observation and technical evaluation in karate athletes. (Submitted in Heliyon journal).

Development, validation, and Reliability of a new instrument of Observation and technical evaluation in karate athletes: *Experimental Approach*

Joaquim Filipe Ferreira¹, Rui Miguel Silva^{1,2}, Georgia Badicu³, Filipe Manuel Clemente^{1,2,4}

¹School of Sports and Leisure, Polytechnic Institute of Viana do Castelo, Rua Escola Industrial e Comercial de Nun'Álvares, 4900-347 Viana do Castelo, Portugal

²Research Center in Sports Performance, Recreation, Innovation and Technology – SPRINT, 4900-347 Viana do Castelo, Portugal

³Transilvania University of Brasov

⁴Institute of Telecommunications, Delegation of Covilhã, 1049-001 Lisbon, Portugal

Resumo

O objetivo deste artigo é apresentar os procedimentos utilizados no desenvolvimento e estabelecimento da validade de um sistema de avaliação técnica em karaté, bem como destacar as vantagens desse sistema para a caracterização da performance técnica em atletas no contexto do treino e antes das competições de kumité. Esses procedimentos consideraram as cinco perspectivas da noção de validade que valorizam os pontos críticos observados em cada fase da técnica. Dessa forma, o processo de validação concentrou-se em três pontos: i) análise e avaliação por especialistas em relação aos conteúdos do instrumento de observação; ii) análise e avaliação de avaliadores especialistas em relação à performance dos atletas em cada uma das técnicas escolhidas; e iii) fiabilidade das observações dos avaliadores. O sistema de avaliação técnica em karaté avalia as técnicas Mawashi geri, Ura Mawashi geri, Kizami Zuki e Gyaku Zuki, descritas na literatura como as técnicas mais comuns em competições de kumite, e foram ajustadas para diferentes níveis de proficiência. Os resultados indicam fiabilidade intra-avaliador substancial a quase completa tanto para avaliações de atletas especialistas quanto iniciantes, com valores de ICC variando de 0,774 a 0,959. Esses valores sugerem que a avaliação realizada em momentos diferentes não causou interferência significativa na avaliação e que a estimativa desse acordo está dentro de um intervalo de confiança de 95%. No geral, os resultados de fiabilidade inter-observador e intra-avaliador sugerem que o processo de avaliação STAK é um método fiável para avaliar os critérios de sucesso de diferentes técnicas utilizadas em artes marciais. No entanto, os resultados também indicam que atletas iniciantes podem exigir critérios de avaliação mais

específicos e consistentes para melhorar sua técnica de observação e refinar sua capacidade de interpretar as variáveis de sucesso em cada ação motora.

Palavras-chave: karaté desportivo, avaliação técnica, kumité, desportos de combate

Abstract

The purpose of this article is to present the procedures used in the development and establishment of the validity of a technical evaluation system in karate, as well as to highlight the advantages of this system for the characterization of the technical preform in athletes in the context of training and before kumite competitions. These procedures considered the five perspectives of the notion of validity that value the critical points observed in each phase of the technique. In this way, the validation process focused on three points: i) analysis and evaluation by experts about the contents of the observation instrument; ii) analysis and evaluation of expert evaluators in relation to the athletes' performance in each of the chosen techniques; and iii) reliability of the evaluators' observations. The technical evaluation system in karate evaluates the Mawashi geri, Ura Mawashi geri, Kizami Zuki, and Gyaku Zuki techniques, which are described in the literature as the most common techniques in kumite competitions and were adjusted to different levels of proficiency. The results indicate substantial to almost complete intra-rater reliability for both expert and beginner athletes' evaluations, with ICC values ranging from 0.774 to 0.959. These values suggest that the evaluation conducted at different times did not cause significant interference in the assessment and that the estimate of this agreement is within a 95% confidence interval. Overall, the inter-observer and intra-rater reliability results suggest that the STAK evaluation process is a reliable method for assessing the success criteria of different techniques used in martial arts. However, the results also indicate that novice athletes may require more specific and consistent evaluation criteria to improve their observation technique and refine their ability to interpret success variables in each motor action.

Keywords: sports karate, technical evaluation, kumite, validation.

INTRODUCTION

With the increased visibility and notoriety of the sport Karate, the need for greater scientific evidence began to emerge, so that Sport Karate is developed to higher levels through science. Global competition in sports is constantly intensifying. Despite this increased demand, there is a lack of evidence-based guidelines for karate training and competition in the discipline of kumite and kata to help coaches prescribe training programs specifically targeted to improve kumite performance (Chaabène et al., 2012b).

Karate presents Kata and Kumite as fundamental elements in the performance and demonstration of skill. These are currently the two competitive disciplines that make up the competition system of Karate.

Kata is a discipline that involves large displacements of mass with load provided by keeping the center of gravity lower. The execution of techniques with great speed and explosion forces the athletes to develop a great capacity for dynamic and positional balance. Kata consists of a predetermined series of movements that are executed with explosive speed against imaginary opponents (Doria et al., 2009).

Kumite is characterized by high-intensity activity, including explosive and intermittent actions lasting between 0.3 and 2.1 seconds (time: pause 19:8s; 1:2) (Doria et al., 2009), which requires great technical and tactical skill (Ojeda-Aravena et al., 2020). High cardiorespiratory fitness, including oxidative predominance by the ATP-PC pathway and to a lesser extent by the glycolytic system Doria et al., (2009) is necessary to cope with the metabolic demand during combat and recovery (Chaabène, Hachana, Franchini, Mkaouer, & Chamari, 2012). As we saw in the paragraph above, there is some scientific evidence on the characterization of the physiological and biological effort of Kumite practitioners, but there is not much evidence for the technical aspects of the sport.

An observational study Sastre et al. (2021) where they analyzed the technical and tactical performance in the initiation of kumite of 37 athletes in 40 combats performed. They were able to characterize the offensive technical action performed either with the fist or with the leg, the laterality related to the guard that supports the action and the segment with which it is performed,

the area of the body to which the technique is directed, and the efficiency obtained, which can make a difference in the longitudinal programming of formative karate. Also, a study Ribas et al. (2020a) identifying the main techniques used by medalists of a championship of Brazilian style, observed eleven fights involving thirteen athletes in the category - 65kg, showing that the attack more performed and with better rates of achievement of point in this weight category, was the Mawashi Geri followed by Gyakuzuki.

An observational study was conducted where elite karate athletes were observed in a competitive context. The results show that elite karate competitors are more likely to use blows with upper limb than the lower, with more incidence to jodan (upper torso) than to level chudan (trunk or back middle zone), also observed that the jodan blows were more successful than the chudan (Ibáñez et al., 2018). Despite the existence of technical observation instruments in the competitive context, there is no instrument capable of characterizing the athlete from a technical point of view in the context of their individual development (unlike the physiological and physical aspects) (Hachaj et al., 2014; Nunan, 2006; Tabben et al., 2014).

Karate is a sport in which the technique is observed in competition context as a way to assess points to athletes, the absence of instruments that allow the identification of the technical level of practitioners, does not allow coaches to estimate whether they will be prepared to compete or not (Chiu & Shiang., 1999). An instrument that allows the identification of the technical level will be of enormous relevance for the coaches, who will work according to the results of each athlete, meeting the individual gaps of each competitor (Božanić & Bešlija, 2010).

Technical evaluation systems are tools used to evaluate the technical performance of individuals. They can be used in several areas, such as sports, martial arts, among others. Technical evaluation systems usually include evaluation criteria, measurement methods, scoring processes, and other tools to ensure the objectivity and accuracy of the evaluation (Borba Francisco, 2013). Some examples of technical evaluation systems include rating systems for fighters in martial arts, performance evaluation systems in sports. The sport technique is nothing more than the "ideal image" of a sequence of movements that allow obtaining, in a rational and mainly economic way, the resolution of a motor problem (Rodrigues & Louro., 2016).

The goal of technical evaluation systems is to provide an objective and reliable assessment of performance in order to identify strengths and weaknesses, and to help make decisions about

training and development. For the competitor to be successful in sports, the quality of motor actions is determinant, so developing methods that determine the quality of movements is also a need for the scientific community in order to collaborate with coaches and teams who want to improve their training systems (De Quel et al., 2020). A study (Chiu & Shiang., 1999) conducted experiments similar to real competition situations to determine several important factors of punching techniques in karate competition through the GDL (gesture descriptive language) method. However, there is no observable battery of tests in the literature that allows to classify the entirety of the technical actions and to frame the coaches about the state of development of the athletes in different phases of their evolution.

Thus, this study had as objectives: (i) develop an observation system of technical skills in karate adjusted to different levels; (ii) proceed to the evaluation by experts of this observational system; (iii) test the intra- and inter-observers' reliability during the use of the observation system of technical skills in karate. In the second study, the objective is to characterize and evaluate the physical qualities of karate athletes at different levels and test their relations with the new Technical Evaluation System in Kumite.

METHODS

Experimental Approach

This study followed an expert validation design and intra- and interobserver reliability test. The study protocol was reviewed and approved by the Ethics Committee for Social, Life and Health Sciences of the Polytechnic Institute of Viana do Castelo (Code: 32/2022).

Materials and Procedures

The procedures adopted to develop and validate the STAK were based on the known literature Wainer et al. (1988) According to the five perspectives described, the calculation methods used and the detailed description of the behaviors to be assessed by the observation instrument to be built. The validation of the system was performed following the following procedures: (i) Content validity: Select the determinants of success of each of the techniques, to be observed by experts of the Karate modality, verification and contribution of all experts to elaborate a last document with all the corrections and in agreement with all. (ii) Validity of

construct: analysis and evaluation of coaches in relation to the performance analysis and evaluation of experts who have enough experience in this function. (iii) Reliability of observations: in order to verify the consistency / temporal stability of the observations of evaluators, with the purpose of verifying the understanding they have in relation to the variables used in the observation instrument, the intra and inter evaluators correlations will be evaluated.

The STAK was developed to provide coaches and athletes with a means to assess and quantify an athlete's technique, the test also makes it possible to train technique while performing. Predicting whether an athlete is technically ready to participate in a kumite competition will now be easier, as karate technique is subject to technical evaluation criteria by the referees, so having a test that assesses that these skills are at the maximum level facilitates the work of coaches and athletes. Performing the techniques at maximum intensity causes imbalances in recovery that can compromise the efficiency and performance of the athlete. Also, the maximum intensity and speed makes hand-eye coordination and foot-eye coordination more demanding, endowing athletes with the necessary skills for institutionalized competition in which the control of techniques is mandatory. The technical system adopted for beginners or children is designed to be a progression to the higher level, creating at that level the acquisition of skills necessary to aim for higher levels of proficiency.

Development of the Kumite technical evaluation system: validation

A new assessment was devised after pilot testing and consultation with karate practitioners, coaches, and sports scientists: karate-specific STAK (System for the Technical Assessment of Kumite) test. The STAK design was based on a thorough analysis of karate competition in the scientific literature to develop a field test that replicated the technical demands of real competition. Two levels were designed, one for children or beginner athletes and one for advanced competitive athletes. The developed instrument was sent to three experts external to the project who validated it and helped to improve some semantic aspects. The expert coaches meet the following conditions: (i) coaches holding a karate level II coaching license or more; (ii) have more than five years of experience as a coach; and (iii) have a higher education degree in sport science and/or physical education.

After analysis and assessment of the instrument by each of the external evaluators, the proponent group integrated the suggestions for improvement, designing a refined instrument that received a final favorable opinion from all the evaluators.

Test description

The test will be performed using a removable target, with a punctured sponge ball that will serve as a target and will perform the 4 technical tests, 3 at head height and 1 at abdomen height (Figure 1).

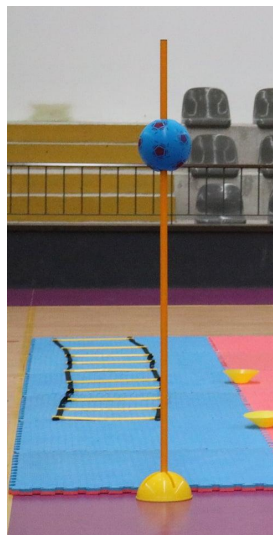


Figure 1. Representation of the removable target.

The hand-eye coordination and foot-eye coordination control is one of the technical prerequisites to be evaluated because the Kumite technique in competition must always be controlled. Thus, any blow executed with excessive contact is automatically annulled, having to restart the test again.

the practitioner must start the test in Kamae and away from the target in the preparation distance, that is, in a distance that makes possible to reach the target only with a displacement in Yori ashi in full extension of the lower and/or upper limb in the final phase. It will also be important to ensure that in the recovery phase the action travels the same distance.

Place the targets at the height of the defender's head. In the Gyaku Tsuki Chudan, place the targets in the middle zone (trunk) of the subject.

All techniques must conform to these 4 criteria for qualitative technical evaluation of WKF Kumite events:

- Good form

A technique is said to have good form when its characteristics give it probable effectiveness within the conceptual parameters of traditional karate;

Connection to the ground, keep the center of gravity in dynamic balance between the technique and the connection with the ground. Postural maintenance, all techniques must observe a correct posture, which resembles the natural anatomical position. Core activation, the techniques are performed with a transfer of energy through the active core, and the correct activation allows maintaining the dynamic balance during the execution and impact phase. In simultaneity, the technique must be executed with the simultaneous arrival of the body mass in the technique at the final phase of the posture used to maximize energy delivery. Compression expansion, the body must observe during any technique a phase of energy compression and expansion depending on the technique used may change the order, but one should always alternate with the other. Tamé, characterizes the ability to move (without moving) without showing the intention to attack the opponent in the first phase of execution (Ferreira et al., 2011).

- Vigorous Application

It defines the power and speed of a technique, as well as the clear will for it to succeed.

- Martial Attitude (zanshin)

Martial attitude (Zanshin) is the criteria most often missed when evaluating a technique. It is the state of maintaining motivation in which the athlete remains fully focused, keeping a close eye on the possibility of the opponent countering. In other words, during the execution of the technique the performer keeps his gaze on the target and, after the technique has been executed, keeps his gaze vigilant.

- Correct distance

This refers to the moment when the technique is completed and touches, or almost touches, the target. Techniques with an execution distance between a skin touch and a distance of 5 centimeters from the target area show adequate control. However, jodan techniques that come within 5 centimeters of the target and that the opponent does not attempt to block or avoid are punishable, provided that they meet the other criteria.

1st Technical Evaluation Level I - 6 Mawashi geri jodan (Observation and Success Criteria)

Figure 2 presents the elements associated with the Mawashi Geri gesture. Next, we present, by points, the success criteria.

- Foot with light touch (skin touch) on the target or up to 5 centimeters away.
- *Kamae*
- Always run with the back foot (switch)
- Raise the knee,
- Rotate in block with the support between 135 and 180
- Foot in extension at the end of the technique, knee extended and oriented horizontally, look at the target.
- *Hiki ashi* (technique recovery/heel to gluteal), support the foot next to the other and exchange the guard.

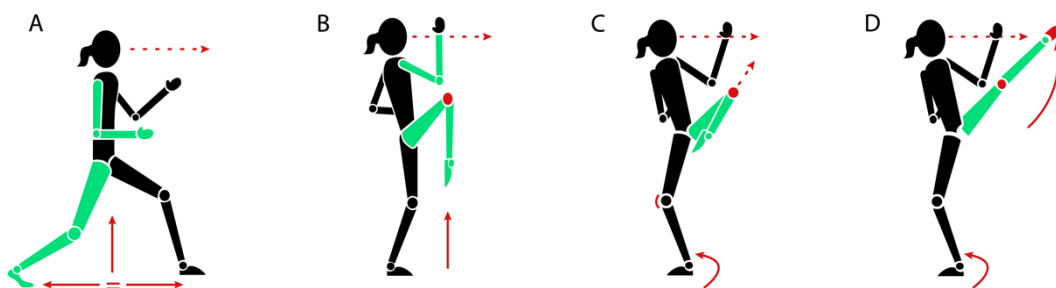


Figure 2: Biomechanics of Mawashi Geri





Figure 3. critical points to be observed from the technical evaluation of the Mawashi Geri.

Qualitative evaluation

3) Excellent (can perform with all success criteria)

2) Medium (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard).

1) Bad (fails in any of these aspects, does not lateralize the torso during the execution phase, does not orient the action horizontally when finishing, and does not change the guard)

2nd Technical Evaluation Level I - 6 Jodan Kizami Tsuki (Observation and Success Criteria):

1nd Preparation: Start from the position of Kamae (guard)

2nd The execution phase: Complete extension of the front upper limb, simultaneously with the entrance of the lower limb to the front, moving the center of mass to the control distance between 0.1 and 10 cm from the target, support directed to the front.

3nd Recovery Phase: Do Gyaku Kamae, slightly remove the anterior lower limb with the foot at 20° internal degrees, remove in a straight line the upper limb that performed the strike and return in line the back support rotate the anterior third to allow the total rotation of the hip.

Swap midway through the exercise (6 repetitions).

3rd Recovery Phase: Performs Gyaku Kamae, slightly withdraws the anterior lower limb with the foot at 20° internal degrees, withdraws the upper limb that performed the blow in a straight line and executes it again in line, the back support rotates in the anterior third to allow the full hip rotation.

.

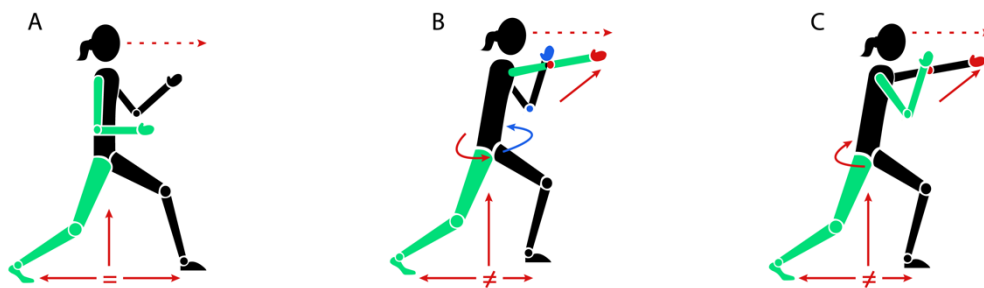


Figure 4: Biomechanics of the Kizami Zuki.



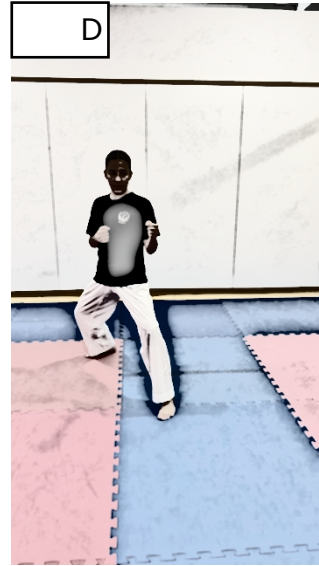


Figure 5. Critical points to note from the technical evaluation of Kizami Zuki.

Qualitative evaluation

3) Excellent (can perform with all success criteria).

2) Medium (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard in place).

1) Bad (fails in any of these aspects, does not lateralize the torso in the recovery phase, does not move the center of mass in the technique, and does not exchange the guard correctly).

3rd Level I Technical Evaluation - Chudan Gyakuzuki (Observation and Success Criteria)

1st In the preparation phase the torso should be positioned between 10° and 20° , the supports slightly apart and bent, and the CG (Chudan Gyakuzuki) slightly lower.

2nd In the execution phase, an external rotation of the torso between 90° and 135° should be performed. Rapid, direct, and linear extension of the upper body to the target, there must be a controlled impact at the final moment of the action, the opposite upper body must rise slightly, protecting the opposite zone. The center of mass should remain lower and closer to the support of the front hand. Coordinate the movement of the upper limb extension, the rotation of the torso and hip, the displacement and flexion of the front upper limb, simultaneously.

3rd In the recovery phase, the torso should return to a position close to 10° to 20° . Perform a fast approach to anterior support.

Change in the middle of the exercise (6 repetitions).

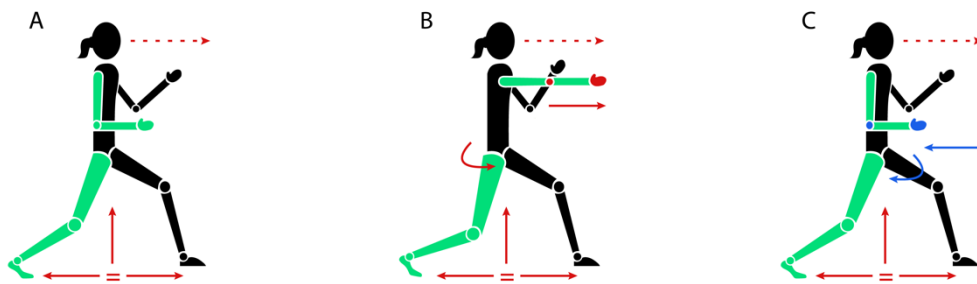


Figure 6: Gyaku Zuki biomechanics

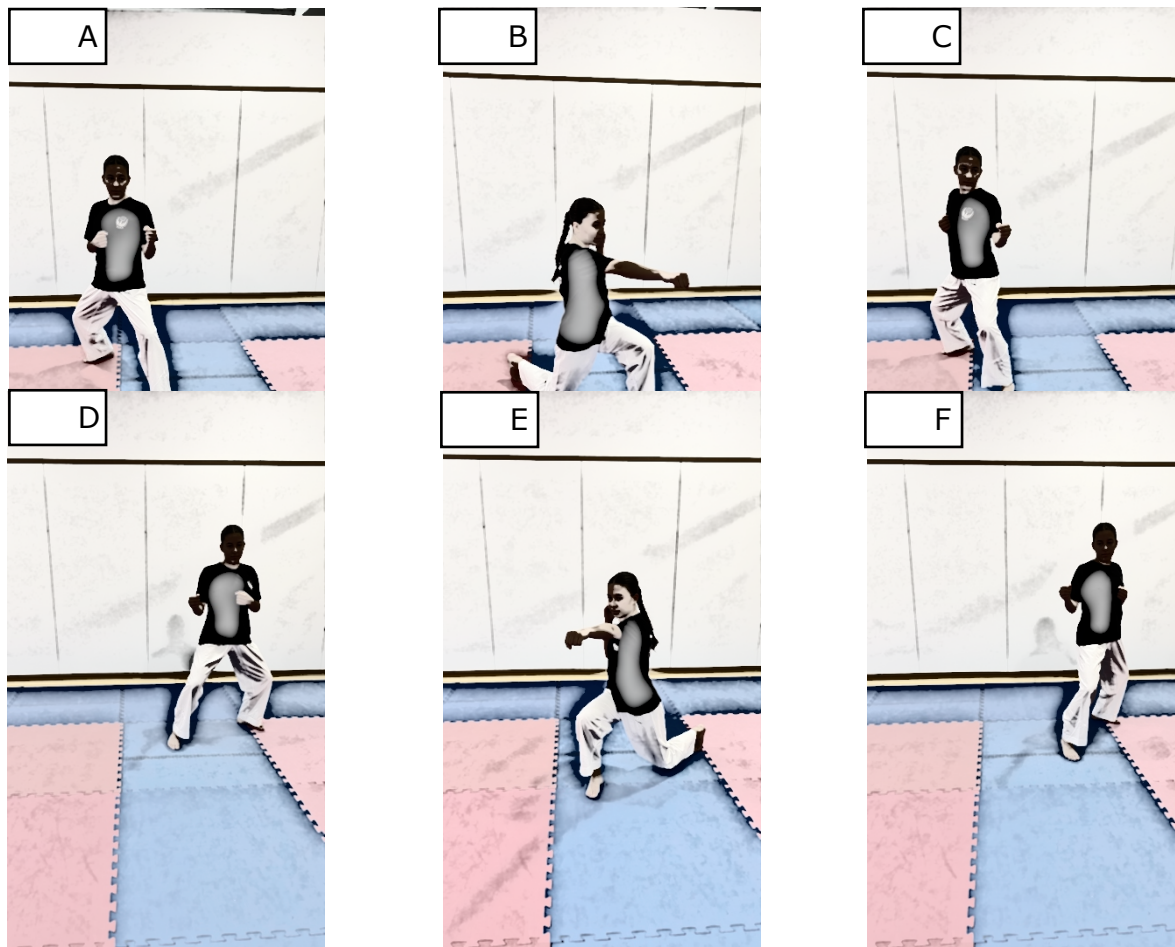


Figure 7. Critical points to note from the technical evaluation in Gyaku Zuki.

Qualitative evaluation

- 3) **Excellent** (can perform with all success criteria)
- 2) **Medium** (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard in place).
- 1) **Bad** (fails in any of these aspects, does not lateralize the torso in the recovery phase, does not move the center of mass in the technique, and does not exchange the guard correctly)

4th Technical Evaluation Level I - 6 Ura Mawashi Geri (Observation and Success Criteria)

1st Preparation phase of the base guard.

2nd In the execution phase, the upper limb should be lifted from behind to the midline of the trunk using body compression, then quickly rotated in anterior rotation of the torso, expanding the leg by external circular extension of the upper limb, and placing the foot in extension. The body segments must always be completely aligned in the previous phases (lower limb support, hip joint, trunk, and lower limb in elevation aligned).

3rd In the recovery phase, you should return to the guard position by changing the supports and guard to execute again.

6 repetitions

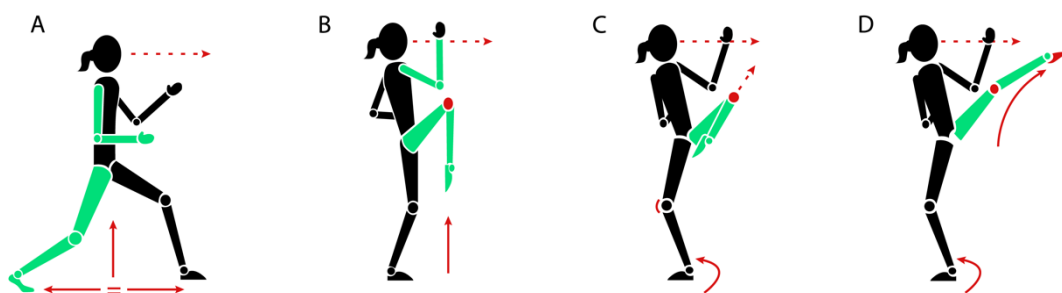


Figure 8. Biomechanics of the Ura Mawashi Geri.

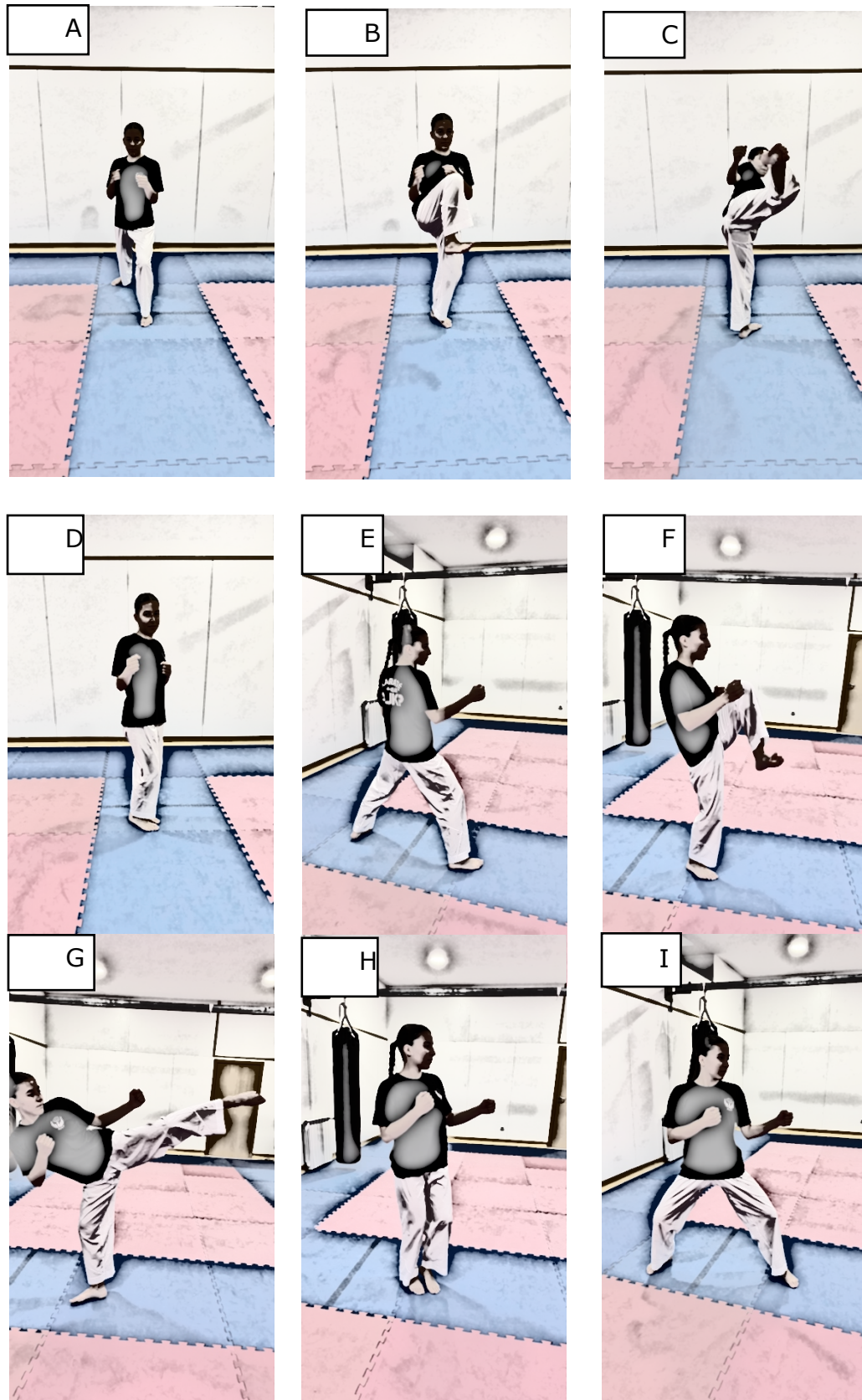


Figure 7. Critical points to note from the technical evaluation in Gyaku Zuki.

Qualitative evaluation

3) Excellent (can perform with all success criteria)

2) Medium (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard in place).

1) Bad (fails in any of these aspects, does not lateralize the torso in the recovery phase, does not move the center of mass in the technique, and does not exchange the guard correctly)

1st Technical Evaluation Level II - 10 Jodan Nidan Mawashi Geri (Observation and Success Criteria)

1st Preparation phase of the base guard.

2nd In the execution phase, you must perform an elevation of the knee in flexion to the shoulder of the same side. Block rotation of the support between 135 to 180°, foot in extension at the moment of the end of the technique, knee stretched and oriented horizontally, look at the target. Without touching the target until 10 centimeters, does Hikiashi (technique recovery/heel to buttocks) and performs the second action.

3rd In the recovery phase, takes the lower limb that performed next to the support and exchanges with this one returning to the guard position to perform again.

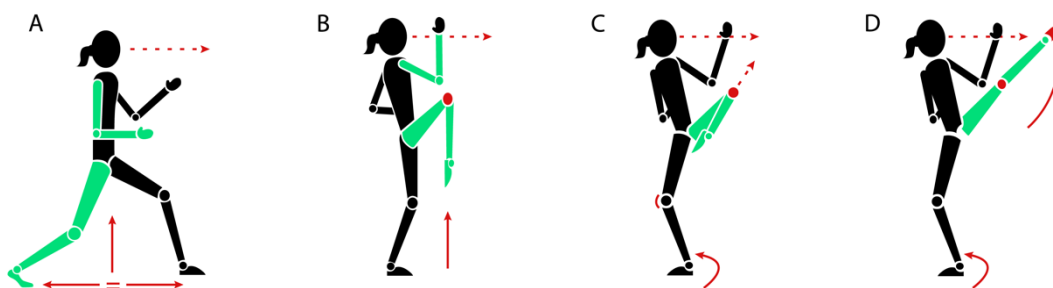


Figure 8. Biomechanics of the Mawashi Geri.

Qualitative evaluation

3) Excellent (can perform with all success criteria).

2) Medium (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard in place).

1) Bad (fails in any of these aspects, does not lateralize the torso in the recovery phase, does not move the center of mass in the technique, and does not exchange the guard correctly).

2nd Technical Evaluation Level II - 10 Jodan Kizami Tsuki (Observation and Success Criteria)

1st Preparation, lateralizing to 45° degrees with Migi Kamae (right guard to the front)

2nd Execution Phase with complete extension of the front upper limb, simultaneously with the entrance of the anterior lower limb forward, moving the center of mass to the control distance between 0 and 10 cm from the target, support directed to the front.

3rd Recovery Phase, perform the posterior hayumiashi leaving at 45° to the guard, and one more short posterior Yori ashi of preparation, in Hidari Kamae (left guard in front).

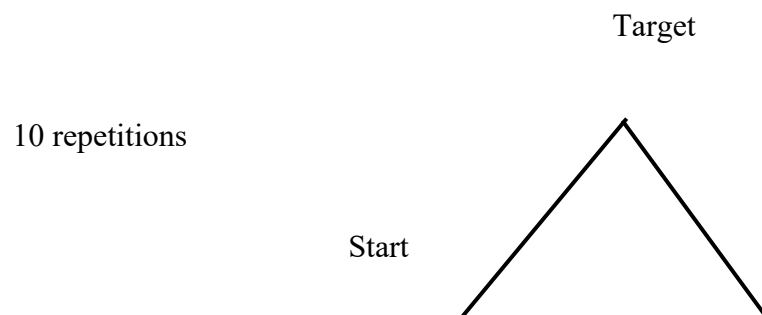


Figure 9. Execution in reversed V

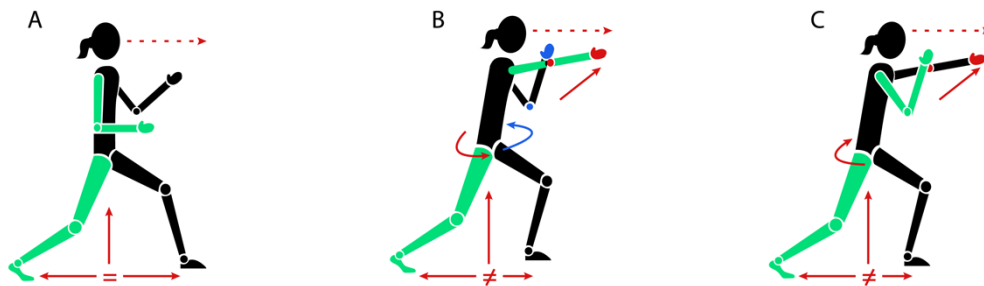


Figure 10. Biomechanics of Kizami Zuki.

Qualitative evaluation

- 3) **Excellent** (can perform with all success criteria)
- 2) **Medium** (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard in place).
- 1) **Bad** (fails in any of these aspects, does not lateralize the torso in the recovery phase, does not move the center of mass in the technique, and does not exchange the guard correctly)

3rd Technical Evaluation Level II - 10 Ura Mawashi Geri (Observation and Success Criteria)

1st Preparation phase of the base guard.

2nd In the execution phase, the upper limb should be raised from behind to the midline of the torso using body compression, then quick execution in anterior rotation of the torso, expanding the leg by external circular extension of the raised upper limb and placing the foot in extension. The body segments must always be completely aligned in the previous phases (support ICM, hip, trunk, and elevated ICM aligned).

3rd In the recovery phase, you should return to the guard position by switching supports and guarding to execute again.

Qualitative evaluation

- 3) **Excellent** (can perform with all success criteria)
- 2) **Medium** (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard in place).
- 1) **Bad** (fails in any of these aspects, does not lateralize the torso in the recovery phase, does not move the center of mass in the technique, and does not exchange the guard correctly)

4th Technical Evaluation Level II - 10 Chudan Gyakuzuki (Observation and Success Criteria)

1rd In the preparation phase the torso should be positioned between 10° and 20°, the supports slightly apart and bent and the CG slightly lower with Hidari Kamae at 25° degrees from the front.

2rd In the execution phase, an external rotation of the trunk between 90° and 135° must be performed. Quick, direct, and linear extension of the upper limb to the target, there must be a controlled impact in the final moment of the Action, the opposite upper limb must rise slightly protecting the opposite zone. The center of mass must remain lower and closer to the front upper limb support. Coordinate the movement of the upper limb extension, the rotation of the trunk and hip join, the displacement and flexion of the lower limb forward, simultaneously.

3rd In the recovery phase the torso must return to an initial position, perform a lateral displacement in Yoko Yori ashi (lateral displacement) with the previous support, to prepare a new action in Migi Kamae.

Pyramid Execution

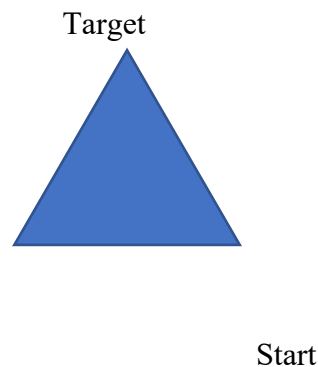


Figure11. Pyramid Execution.

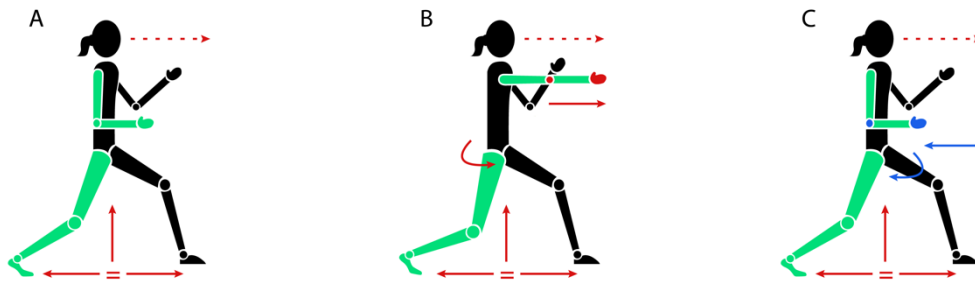


Figure 10. Biomechanics of Gyaku Zuki.

Qualitative evaluation

- 3) **Excellent** (can perform with all success criteria).
- 2) **Medium** (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard in place).
- 1) **Bad** (fails in any of these aspects, does not lateralize the torso in the recovery phase, does not move the center of mass in the technique, and does not exchange the guard correctly).

Expert Analysis - validation

The STAK content was evaluated by a panel of four experts. To meet these requirements, the experts should have worked in technical committees in the basic categories and in professional teams. Additionally, they should have a minimum level II coaching degree, and at least half should have an academic degree in the area of sports with a focus on karate. By meeting these criteria, the panel was composed of a master and a graduate in Sports Science, and all had already belonged to technical teams that coached teams in national competitions, and some in the national teams and training departments of FNKP (National Karate Federation of Portugal).

The expert coaches were asked to observe the pertinence of the variables that make up the assessment instrument, considering the determinants of success for all the techniques that make up the STAK, as well as the practical assessment system of each intervened level.

All the contents that raised semantic doubts were reformulated and presented again to the experts via e-mail, until a consensus was reached that that evaluation was the best suited for this test. Only after the analysis of the aspects mentioned in the previous paragraph and the unanimous approval were the technical and evaluation variables incorporated into the system.

Development of Kumite's technical evaluation system: reliability process

In this case, six coaches were selected by convenience (Table 1) that met some requirements for the function: (i) Be a black belt in karate sport with >18 years old. (ii) Have practical experience as an evaluator. (iii) Have actively participated in kumite competitions as a coach or athlete. All the evaluators chosen met all the criteria, including the added value of all of them belonging to the group of evaluators of the training competitions of the Associação Juvenil de karate Portugal that makes 5 annual competitions since 2014 and 3 of them also as judges of the National Karate Federation Portugal. All the evaluators are karate black belts, aged between >21 and <40 years old.

The coaches were asked to evaluate the techniques taking into account the critical components described in the STAK, through video recorded previously in a class context, 10 students were recorded (Table 2) for the basic level and another 10 students for the expert level, after the recordings the videos were placed in Google Drive, the evaluators were asked to make their first evaluation and to put the notes in an Excel sheet built for that purpose and sent via e-mail. All the first evaluations were duly collected and after three weeks they were asked to watch the same videos for a second evaluation by the same trainers, the three-week interval was respected to minimize familiarity problems with the task.

Table 1. Characterization of the Sample Evaluators

	N	Min	Max	Average	SD
Age (years)	6	24	40	32	8
Practice Time	6	19	26	22,5	3,5
Evaluator practice	6	2	8	5	3
Gender	6	2	4	3	1

Tabela 2. Sample Characterization of the Evaluated Individuals.

	N	Min	Max	Average	SD
Age (years)	20	10	22	16	6
Practice Time	20	3	15	9	6
Level	20	10	10	10	0
Gender	20	10	10	10	0

RESULTS

Resents the inter-observer reliability values. The inter-rater results demonstrated substantial to nearly complete ICC values when evaluating expert athletes. Such indicators suggest that the evaluators were consistent in the success criteria and judged very similarly conferring credibility to the STAK evaluation process. However, the results showed a lower correlation in the evaluations of novices compared to experts, possibly revealing that when technique is not yet sufficiently refined it can lead to a lower ability to interpret the success variables in each motor action.

The analysis used a two-way mixed statistical method to assess the absolute agreement between ratings or measurements from different observers or methods, and the estimate of this agreement is within a 95% confidence interval.

Table 3. Inter-observer evaluator results

	Inter- observer ICC	Min	Max	Inter- observer ICC	Min	Max
	Valor 1	Valor 1	Valor 1	Valor 2	Valor 2	Valor 2
Experts						
Mawashi Geri	0,899	0,760	0,971	0,828	0,600	0,950
Ura-mawashi Geri	0,769	0,474	0,931	0,843	0,622	0,954
Kizami zuki	0,894	0,745	0,969	0,895	0,738	0,970
Gyaku zuki	0,871	0,690	0,962	0,834	0,607	0,951
Beginners						
Mawashi Geri	0,536	0,130	0,840	0,262	-0,073	0,679
Ura-mawashi Geri	0,647	0,258	0,888	0,535	0,131	0,839
Kizami zuki	0,606	0,194	0,874	0,640	0,248	0,887
Gyaku zuki	0,781	0,484	0,935	0,653	0,263	0,892

Two-way mixed statistical method < Absolute agreement < 95%CI

According to the results presented in Table 4, the Intra-rater agreement was substantial to almost complete, regardless of the level of the athletes evaluated. This suggests that the evaluation done at different times did not cause a significant interference in the evaluation and that the estimate of this agreement is within a 95% confidence interval.

Table 4. Inter-observer evaluator results

	Average 1	Average 2 (20 days after)	Inter-observer ICC	Min	Max
Experts					
Mawashi Geri	2,48	2,47	0,905	0,842	0,943
Ura-mawashi Geri	2,62	2,57	0,897	0,829	0,939
Kizami Zuki	2,50	2,50	0,931	0,885	0,959
Gyakuzuki	2,57	2,58	0,865	0,774	0,919
Beginners					
Mawashi Geri	1,93	1,80	0,868	0,769	0,923
Ura-mawashi Geri	1,82	1,85	0,861	0,768	0,917
Kizami Zuki	1,97	1,88	0,877	0,794	0,926
Gyakuzuki	2,13	2,08	0,865	0,775	0,919

Two-way mixed statistical method < Absolute agreement < 95%CI

DISCUSSION

This study aimed to develop, validate, and test the reliability of an instrument to observe the technical skills of karate fighters. For this purpose, and from a model of content and construct validation, we proceeded to the processes of evaluation by experts who followed the logic of analyzing the purpose of this study was to explain the procedures used in the development and establishment of the validity of a system of technical assessment in karate through the observation of the technical skills most used in competition, Mawashi geri, Ura Mawashi geri, Kizami Zuki and , Gyaku Zuki (Chaabène., 2012) that were and adjusted to different levels of proficiency, creating a working tool for coaches, who by using STAK are able to gauge the technical competence of their athletes.

STAK construct validation

The techniques chosen to develop in STAK were those that according to the literature are the most used in kumite competitions. although the kumite tests in karate competitions, may vary depending on the style, the sports federation, and the rules of the specific competition. However, we follow those that are most commonly used in World Karate Federation competition which is the one recognized by the Olympic committee. The techniques chosen were the Mawashi Geri, Ura Mawashi Geri, Gyaku Zuki Chudan and the Kizami Zuki.

A study was made (Alinaghipour et al., 2020) to determine the most scored techniques and their frequencies in the final kumite competitions of the 2016 Karate world championship, having been observed a total of 70 points in 10 fights with 18 different participants verified that the frequencies of the techniques scored by winners in percentage was the Mawashi Geri the Ura Mawashi Geri and the with the Gyaku Zuki 100%, whereas the Kizami Zuki with 69.5%, however the most performed and scored technique by all participants was the Kizami Zuki. Also, another study (7) identified the most used techniques by medalists and defeated athletes during the 2017 Brazilian Shotokan Karate Championship, the results show that the most frequent attack during the fights was "Mawashi geri", 26.3 ± 1.5 times, followed by "Gyaku zuki" with 19.5 ± 2.0 times ($p < 0.01$).

The choice of these techniques for the SATK was also, due to the fact that they are techniques widely studied in the literature, giving confidence that with this work the acquisition of technical skills will benefit the athletes and teams that apply it in the training context.

Gyaku Zuki is a punching technique in karate, also known as an opposite punch. Gyaku means "inverted" or "opposite" and Zuki means "punch". In Gyaku Zuki, the arm that is behind is brought forward in a straight line, while the arm that was in front is pulled back toward the body to form a reverse position from the starting position. The fist of the hand which is in front is rotated so that the palm is down, while the fist of the hand which is behind is rotated so that the palm is up. Gyaku Zuki is a powerful and versatile punch that can be used to strike different areas of the opponent's body, such as the face, chest, or abdomen (Ferreira et al., 2011). It is a very common technique in karate competitions. A study De Lisboa et al. (2016) on 9 junior male athletes, who obtained a podium place in the National Karate Championships (in individual kumite) and who were in a selection process for the 2006 European Karate Championships. They observed that the

athletes are able to perform the Gyaku Zuki with higher speeds and power when they are in motion in front of the targets than in a static position. The muscular action of the lower limbs, trunk rotation, and upper limbs is optimized with typical combat movement, translating into higher hand speed. Upper limb acceleration is influenced by the dynamism of the mass movement.

Mawashi Geri is a circular kicking technique used in karate and other martial arts. Mawashi means "circulatory" or "spinning" and Geri means "kick." The Mawashi Geri is a kick that involves a rotation of the hip, where the leg is raised laterally and then is extended forward in a circular arc. The goal is to hit the target with the bottom of the foot, usually at the opponent's head, ribs, or legs. It is a powerful and dynamic technique that requires good flexibility and balance from the practitioner (Ferreira et al., 2011). Mawashi Geri is a common technique in competitions and is taught in many styles of karate, as well as other martial arts such as taekwondo and kickboxing. A review article by Hariri & Sadegh. (2018) analyzing the kinetics and biomechanics of Mawashi Geri Jodan (high) in articles from 2000 to 2018. The results of the research showed that the quadriceps muscles, especially the rectus femoris muscle, played an important role in the performance effectiveness of the technique. By keeping the knee up while rotating the body, the technique will be performed faster due to the greater distance from the opponent.

Ura Mawashi Geri is a variation of Mawashi Geri, the word Ura means "reverse" or "inside", so Ura Mawashi Geri is translated as "reverse circular kick". In Ura Mawashi Geri the leg is raised toward the body while the knee bends upward, then the leg is extended forward and rotates in a circular arc to kick the target, (Ferreira et al., 2011). The Ura Mawashi Geri is a more advanced and complex strike that requires more skill, strength, and flexibility to be executed correctly. It is an increasingly common technique in karate competitions. A biomechanical analysis by Rangel, (2011) of the Ura Mawashi Geri technique with 5 athletes concludes that the most determinant variables of success in the execution of the technique are the displacement of the back foot and the angles of the knees of both the attacking and supporting leg, as well as the displacement of the center of gravity of the body and the time of execution of the technique.

Kizami Zuki is a punching technique used in karate and other martial arts. Kizami means "initial attack" and Zuki means "punch". Kizami Zuki is a fast and accurate punch in which the arm is extended straight toward the target, with the fist facing down. The technique involves a quick extension of the arm and a quick shortening of the fist, which is used to impact the target

(Ferreira et al., 2011). A study by Rakita et al. (2018) assessed the influence of morphological characteristics on specific motor skills of junior karate athletes and found that muscle mass had a statistically significant effect for success in performing Kizami Zuki.

By choosing techniques that are well studied in the literature, our desire is that it will be possible through STAK to build a solid foundation for the development of efficient training programs that are suited to the technical needs of athletes. In addition, choosing well-established techniques can help ensure the safety of athletes by minimizing the risk of training-related injuries or health problems. However, it is important to remember that each athlete is unique and may respond differently to STAK's technical benchmarks.

STAK Reliability

The act of evaluating consists of substantiating, knowing, clarifying, negotiating, and legitimating the information collected, (Mendes et al., 2012) The sport technique is nothing more than an "ideal image" of a sequence of movements that allow to obtain, in a rational and mainly economic way, it is important to consider the deviations between the ideal or standard technique and the individual athlete's response (Rodrigues & Louro, 2016). Considering the relevance of the observation of motor behavior and technical skill, the present study sought to offer a new instrument that enables coaches to monitor the state of proficiency of karateka. However, as an observational instrument, it lacks confirmation about the possibility of offering inter-observer and intra-observer reliability and accuracy. Regarding the testing of the proposed instrument in relation to its reliability, we used a procedure of compacting results intra- and inter-observers, evaluating the same events with a time interval of two weeks.

It was found that in the first evaluation of the expert athletes the technique with the highest convergence was the Mawashi Geri with 0.899, in the second evaluation it was the Kizami Zuki with 0.895. A two-way mixed statistical method was used for the analysis to evaluate the absolute agreement between the ratings or measurements of different observers, and the estimate of this agreement is within a 95% confidence interval, indicating that STAK is an effective technique evaluation system that can predict sporting success as far as technique is concerned. In addition to the careful methodological description of the process of subject and rater selection, data collection, and the analytical techniques employed, the results of agreement investigations were expressed by

agreement percentage data (total and subgroup), as well as the estimators, with their 95% confidence intervals and statistical significance. Only in this way is it possible to interpret under what circumstances the variables diverge. The interpretation of the magnitude of the concordance estimators (kappa or ICC) is conventionalized as: 0 (absence), 0-0.19 (poor), 0.20-0.39 (weak), 0.40-0.59 (moderate), 0.60-0.79 (substantial), and ≥ 0.80 (almost complete) (Lee, et al. 2012 & Sim & Wright, 2005) In novice athletes in the first and second assessment the technique with the highest inter-rater convergence was Gyaku Zuki with a lower mean than in the experts 0.781 for the first and 0.653 for the second.

The technical execution always encompasses a tactical thought in Karate Rosa & Gonçalves, (2007) because without it the action would not have a purpose, one of the reasons why the observation of novices obtained less convergence, may be the lack of tactical intention in the actions, because the practitioners concerned are still in sports training, and thus transfer less intentionality in each technique. The age of the participants and the fact that they are still quite immature in the technique may leave more to the individual interpretation of each observer. The importance of the pre-observation phase, as an element that promotes a better adaptation of the observation to its purpose. In fact, the author divides this phase into two essential conditions: i) concerning the observer and; ii) concerning the situation, (Mendes et al., 2012) In fact, the situation, here, may have been determinant, since the observers evaluated the novices' techniques together with the experts' techniques through previously recorded videos, this factor may have created mental patterns that later adapted to each observer's convictions conditioning their evaluation.

The sport initiation to karate has traditionally been characterized by learning the kata and the basic technique directed to them (kihon), being the teaching of kumite (combat) postponed to later stages, (Sastre et al., 2021). However, in recent years we have seen an increase in the practice of kumite by the training levels, which have not yet completed the stages of growth to sustain good technical levels. In fact, if the work is well developed by the coach, there should be little specialization in these training ages, the teaching learning process should be suitable for a more playful and general methodology. A study (Daniel et al., 2010) in acrobatic gymnastics revealed that practice and specialization begin at an early age in both genders. Justifying that early specialization occurs due to the very nature of the sport, the age of participation in official events,

and the preparation time required for gymnasts to be able to compete. Our sample comes from an organization (AJKP), where the training ages are respected, and where the development of motor and social skills are the main objective at these ages, and hence the technique is more difficult to interpret according to the benchmarks for observers.

In the intra-rater agreement results, the technique with greater convergence in the results was the Kizami Zuki, the average evaluation remained consistent from the first evaluation to the second with little difference from one to the other. When the variables of interest are quantitative and there is estimation by two raters (interobserver), two instruments, or the variables are estimated at different times (test-retest), the ICC is commonly used for complete agreement. The assessment technique used in a study by Conrad et al. (2015) showed a high Intra rater agreement, thus suggesting that the technique is reliable and can be safely used in future assessments. The little difference between evaluations also indicates that the technique is consistent and produces stable results, which is desirable for any technical evaluation system.

The reliability demonstrated in the study allows this evaluation system to be used by coaches and karate teams around the world not only to determine the technical level of their most experienced practitioners but also to train the technical skills of younger and less experienced athletes, the way the test was structured allows a methodological progression (Rosa & Gonçalves J., 2007) from simple to complex structuring the practical learning through the execution of the techniques described in the STAK. In addition to this test the coach can, and should, place another factor that can further increase the requirement and the technical and physical improvement of the practitioner, can in each observation give the execution time, trying to lower this time or comparing them with more experienced athletes (Doria et al., 2009).

The results showed a lower success rate in the evaluations of the less experienced compared to the experts and may reveal that when the technique is not yet sufficiently refined it can lead to a lower capacity and subjectivity of interpretation of the success variables in each motor action. Urge the creation of a technical test only for beginners and for age groups below 13 years.

CONCLUSIONS

This study developed, tested, and validated the reliability of an instrument of observation of technical skills of karate fighters in 20 practitioners with ages between 10 and 22 years. For this purpose, and from a model of content and construct validation, we proceeded to the evaluation processes by 6 experts who followed the logic of analyzing the technical skills of karate players. The purpose of this study was to explain the procedures used in the development and establishment of the validity of a system of technical evaluation in karate through the observation of the technical skills most used in competition, Mawashi geri, Ura Mawashi geri, Kizami Zuki and, Gyaku Zuki. The technical difficulty was adjusted to different levels of proficiency, creating a working tool for coaches, who when using STAK will be able to assess the technical competence of their athletes as a form of evaluation, but also of preparation.

Institutional Review Board Statement

The study was conducted according to the guidelines of the Declaration of Helsinki, and the protocol was approved by the Ethics Committee for Social, Life and Health Sciences of the Polytechnic Institute of Viana do Castelo (Code: 32/2022). Ethics and Scientific Committee of the School of Sport and Leisure of the Polytechnic Institute of Viana do Castelo.

References

- Abd El-Kader, A. M. (2010). Efficacy of Static and Dynamic Distance Perception on Kumite Performance in Karate. *World Journal of Sport Sciences*, 3, 205–209.
- Alesi, M., Bianco, A., Padulo, J., Vella, F. P., Petrucci, M., Paoli, A., Palma, A., & Pepi, A. (2014). Motor and cognitive development: the role of karate. *Muscles, Ligaments and Tendons Journal*, 4(2), 114–120.
- <http://www.ncbi.nlm.nih.gov/pubmed/25332920>

- Alinaghipour, M., Zareian, E., & Ardakani, Z. P. (2020). The scoring techniques in the final competitions of the Karate World Championships 2016. *Annals of Applied Sport Science*, 8(2), 1–7. <https://doi.org/10.29252/aassjournal.760>
- Alves, L., & Figueiredo V. (2019). *Influência da educação física no desenvolvimento motor da criança na educação infantil: Uma breve revisão bibliográfica*.
- Angera M, Moreno Rosset, & Carmen. (2003). *Evaluación psicológica : concepto, proceso y aplicación en las áreas del desarrollo y de la inteligencia*. Sanz y Torres.
- Anguera, M. T. (2010). Posibilidades y relevancia de la observación sistemática por el profesional de la Psicología. *Papeles Del Psicólogo*, 31(1), 122–130.
<http://www.cop.es/papeles>
- Arazi, H., & Izadi, M. (2017). Physical and physiological profile of Iranian world-class karate athletes. *Biomedical Human Kinetics*, 9(1), 115–123.
<https://doi.org/10.1515/bhk-2017-0017>
- Balsalobre-Fernández, C., Glaister, M., & Lockey, R. A. (2015). The validity and reliability of an iPhone app for measuring vertical jump performance. *Journal of Sports Sciences*, 33(15), 1574–1579.
<https://doi.org/10.1080/02640414.2014.996184>
- Bartlett, R. (1999). *Sports Biomechanics: Reducing Injury and Improving Performance*. E & FN Spon, an imprint of Routledge.

- Bober, T. (1981). Biomechanical aspects of sports techniques. *In Biomechanics VII-A*, 501–550.
- Borba Francisco. (2013). *Teste de Avaliação da Performance da Luta* [Thesis]. Universidade Técnica de Lisboa.
- Božanić, A., & Bešlija, T. (2010). *Relations between fundamental motor skills and specific karate technique in 57 year old beginners*.
<https://www.researchgate.net/publication/228692235>
- Branco, M., Vences Brito, A. M., Seabra, A. P., Mercê, C., Rodrigues-Ferreira, M. A., Milheiro, V., & Catela, D. (2019). Exploratory study on maturation and competition level in young karate practitioners. *Revista de Artes Marciales Asiáticas*, 14(1), 1–8. <https://doi.org/10.18002/rama.v14i1.5762>
- Candeias Pedro, Martins, P. J., & Correia Candeias, P. M. (2018). *Fatores que Distinguem os Karatecas com Melhor Desempenho Competitivo*. Universidade de Lisboa Faculdade de Motricidade Humana.
- Čavala, M. , J. J. , & Č. M. (2015). The influence of the specific motoric abilities and knowledges on the karate kata performance in young karate players. *Acta Kinesiologica*, 9(2), 18–22.
- Chaabe, H., Ne, Chamari, and K., Youne, ' , Hachana, Se. F., 3, & Mkaouer, B. (2016). Physical and Physiological Profile of Elite Iranian Karate Athletes. *International Journal of Applied Exercise Physiology*, 5(4).

- Chaabène, H., Hachana, Y., Franchini, E., Mkaouer, B., & Chamari, K. (2012). Physical and physiological profile of elite karate athletes. In *Sports Medicine* (Vol. 42, Issue 10, pp. 829–843). <https://doi.org/10.2165/11633050-000000000-00000>
- Chaabène, H., Hachana, Y., Franchini, E., Mkaouer, B., Montassar, M., & Chamari, K. (2012). Reliability and Construct Validity of the Karate-Specific Aerobic Test. *Journal of Strength and Conditioning Research*, 26(12), 3454–3460. <https://doi.org/10.1519/JSC.0b013e31824eddda>
- Chaahène}^{\wedge}, H., Hachana}^{\wedge}, Y., Franchini^{\wedge}, E., Mkaouer^{\wedge}, B., & Chamarf, T. (2012). *Physical and Physiological Profile of Elite Karate Athletes*.
- Chambers. (1972). Chambers 20th Century Dictionary. *Edinburgh*.
- Chiu, H.-T., & Shiang, T.-Y. (1999). A new approach to evaluating karate punch techniques. *National College of P. E. 8 Sports*, 60–64.
- Conrad, C., Chamlian, T. R., Ogasowara, M. S., Pinto, M. A. G. S., & Masiero, D. (2015). Tradução para o português, adaptação cultural e validação do questionário de avaliação de próteses. *Jornal Vascular Brasileiro*, 14(2), 110–114. <https://doi.org/10.1590/1677-5449.0038>
- Cooper, J. M. and G. R. B. (1976). *Kinesiology*, 4th edn. (4th edn). St. Louis, MO: Mosby.
- Daniel, P., Carrara, S., Harumi, M., & Tsukamoto, M. (2010). Ginástica artística e especialização precoce: cedo demais para especializar, tarde demais para ser

campeão! *Rev. Bras. Educ. Fís. Esporte, São Paulo, v.24, n.3, p.305-14, 24, n.3, 305–314.*

Davide Gomes. (2016). *Avaliação da força no karate: O membro superior pontuador na ação de Gyaku-Tsuki*. Universidade de Lisboa, Faculdade de Motricidade Humana.

De Quel, Ó. M., Ara, I., Izquierdo, M., & Ayán, C. (2020). Does physical fitness predict future karate success? A study in young female karatekas. *International Journal of Sports Physiology and Performance, 15*(6), 868–873.
<https://doi.org/10.1123/ijsp.2019-0435>

Doria, C., Veicsteinas, A., Limonta, E., Maggioni, M. A., Aschieri, P., Eusebi, F., Fanò, G., & Pietrangelo, T. (2009). Energetics of karate (kata and kumite techniques) in top-level athletes. *European Journal of Applied Physiology, 107*(5), 603–610. <https://doi.org/10.1007/s00421-009-1154-y>

Ferreira, J. F., De Estudos, I., & De Fafe, S. (2011). *Modelo Estrutura e conhecimento para a modalidade Karate 2011 Modelo Estrutura e conhecimento para a modalidade Karate Teoria e Metodologia do Treino Desportivo, Documento não editado.*

Giampietro, M., Pujia, A., & Bertini, I. (2003). Anthropometric features and body composition of young athletes practicing karate at a high and medium competitive level. *Acta Diabetologica, 40*(SUPPL. 1).
<https://doi.org/10.1007/s00592-003-0049-3>

- Hachaj, T., Ogiela, M. R., & Piekarczyk, M. (2014). Real-time recognition of selected karate techniques using GDL approach. *Advances in Intelligent Systems and Computing*, 233, 99–106. https://doi.org/10.1007/978-3-319-01622-1_12
- Hariri, S., & Sadeghi, H. (2018). Biomechanical Analysis of Mawashi-Geri in Technique in Karate: Review Article. *International Journal of Sport Studies for Health, In Press(In Press)*. <https://doi.org/10.5812/intjssh.84349>
- Hay, J. G. , & Reid, J. G. (1982). *The anatomical and mechanical bases of human motion*. (Prentice Hall).
- Ibáñez, R., Lapresa, D., Arana, J., Camerino, O., & Anguera, M. T. (2018). Observational Analysis of the Technical-Tactical Performance of Elite Karate Contestants. *Cultura_ciencia_deporte*, 13(37), 61–70. <https://doi.org/10.12800/ccd.v13i37.1039>
- Iide, K., Imamura, H., Yoshimura, Y., Yamashita, A., Miyahara, K., Miyamoto, N., & Moriwaki, C. (2008a). Physiological Responses of Simulated Karate Sparring Matches in Young Men and Boys. *Journal of Strength and Conditioning Research*, 22(3), 839–844. <https://doi.org/10.1519/JSC.0b013e31816a5af6>
- Iide, K., Imamura, H., Yoshimura, Y., Yamashita, A., Miyahara, K., Miyamoto, N., & Moriwaki, C. (2008b). *Physiological responses of simulated karate sparring matches in young men and boys*. www.nsca-jscr.org
- Junior, N. K. M. (2015). Velocity of the offensive technique of the karate for the mixed martial arts fighter: a systematic review. , 29-62. *Revista Observatorio Del Deporte*, 1(4), 29–62.

- Kautzner, N., & Junior, M. (2022). PUNCH AND KICK IMPACT OF THE KARATE: A REVIEW. *Independent Researcher*, XIV(2). <https://doi.org/10.24818/mrt>
- Kawamori, N. , & H. G. G. (2004). The optimal training load for the development of muscular power. *Journal of Strength and Conditioning Research*, 18(3), 675–684.
- Kayihan Gurhan. (2014). Comparison of physical fitness levels of adolescents according to sports participation: martial arts, team sports and non-sports. *Archives of Budo*, 10, 227–232. www.archbudo.com
- Keshishian Hovik. (2013). *Motor Fitness Profiling of Elite and Novice Karate Practitioners*. Australian Catholic University.
- Koropanovski, N. (2008). *CHARACTERISTICS OF POINTING ACTIONS OF TOP MALE COMPETITORS IN KARATE AT WORLD AND EUROPEAN LEVEL* "Management of the police organization in preventing and mitigating threats to security in the Republic of Serbia" View project *Faecal occult blood screening for colorectal cancer in Serbia: a pilot study* View project. <https://www.researchgate.net/publication/280492438>
- Koropanovski, N. , D. M. , & J. S. (2008). Characteristics of pointing actions of top male competitors in karate at world and European level. *Brazilian Journal of Biomotricity*, 2(4), 241–251. www.kombatklub.com
- Koropanovski, N., Berjan, B., Bozic, P. R., Pazin, N., Sanader, A., Jovanovic, S., & Jaric, S. (2011). Anthropometric and physical performance profiles of elite

- karate kumite and kata competitors. *Journal of Human Kinetics*, 30(1), 107–114. <https://doi.org/10.2478/v10078-011-0078-x>
- Kostikiadis, I. N., Methenitis, S., Tsoukos, A., Veligekas, P., Terzis, G., & Bogdanis, G. C. (2018). The Effect of Short-Term Sport-Specific Strength and Conditioning Training on Physical Fitness of Well-Trained Mixed Martial Arts Athletes. *Journal of Sports Science & Medicine*, 17(3), 348–358. <http://www.ncbi.nlm.nih.gov/pubmed/30116107>
- Laird, P., & McLeod, K. (2009). Notational analysis of scoring techniques in competitive men's karate. *International Journal of Performance Analysis in Sport*, 9(2), 171–187. <https://doi.org/10.1080/24748668.2009.11868475>
- Loturco, I., Artioli, G. G., Kobal, R., Gil, S., & Franchini, E. (2014). Predicting Punching Acceleration From Selected Strength and Power Variables in Elite Karate Athletes. *Journal of Strength and Conditioning Research*, 28(7), 1826–1832. <https://doi.org/10.1519/JSC.0000000000000329>
- Marquezin, M. R. , Medin, J. , Campos, F. D. S. , Teixeira, A. S. , Flores, L. J. F. , & Nunes, R. F. (2019). Comparação das características antropométricas e da potência aeróbia de atletas de futebol em diferentes categorias e estágios maturacionais. *R. Bras. Ci. e Mov*, 27(3), 84–92.
- Mendes, R., Clemente, F., Rocha, R., & Damásio, A. S. (2012). Observação como instrumento no processo de avaliação em Educação Física. *Exedra: Revista Científica* 57, 6, 57–70.

- Milovan, B., Kahrović, I., Nurkić, M., Bratić, M., Jovanović, S., & Radenković, O. (2014). Differences between karate practitioners of varied competition orientations in specific motor tests results. In *Physical Education and Sport* (Vol. 12, Issue 3). <https://www.researchgate.net/publication/341541138>
- Molinaro, L., Taborri, J., Montecchiani, M., & Rossi, S. (2020). Assessing the effects of kata and kumite techniques on physical performance in elite karatekas. *Sensors (Switzerland)*, 20(11), 1–19. <https://doi.org/10.3390/s20113186>
- Nunan, D. (2006). Development of a sports specific aerobic capacity test for karate - a pilot study. *Journal of Sports Science & Medicine*, 5(CSSI), 47–53. <http://www.ncbi.nlm.nih.gov/pubmed/24357976>
- Obradović, B., Madić, D., Drid, P. , Bogdanovski, M. , & Sporiš, G. (2017). *Muscle strength assessment of upper and lower limbs in elite male karate athletes: comparative study between different age groups.* <https://www.researchgate.net/publication/316601749>
- Ojeda-Aravena, A., Herrera-Valenzuela, T., Garcia, J. M. G., & Ramirez-Campillo, R. (2020). Six weeks of HIIT based on repeated 5-meter sprints vs. countermovement jumps: Effects on physical performance among karate athletes. A pilot-study. *Ido Movement for Culture*, 20(2), 24–32. <https://doi.org/10.14589/ido.20.2.4>
- Przybylski, P., Janiak, A., Szewczyk, P., Wieliński, D., & Domaszewska, K. (2021). Morphological and motor fitness determinants of shotokan karate performance.

International Journal of Environmental Research and Public Health, 18(9).

<https://doi.org/10.3390/ijerph18094423>

Quinzi, F., Camomilla, V., Di Mario, A., Felici, F., & Sbriccoli, P. (2016). Repeated kicking actions in karate: Effect on technical execution in elite practitioners.

International Journal of Sports Physiology and Performance, 11(3), 363–369.

<https://doi.org/10.1123/ijsp.2015-0162>

Rakita, D., Rakonjac, D., Vukadinović-Jurišić, M., & Obradović, J. (2018). The influence of morphological characteristics on the specific motor skills of junior-age karate athletes. *Exercise and Quality of Life*, 10(1).

<https://doi.org/10.31382/eqol.180605>

Rangel, E. (2011). Análisis Biomecánico del Ura Mawashi Geri. *Universidad de Los Andes Facultad de Humanidades y Educacion*.

Ravier, G., Grappe, F., & Rouillon, J. D. (2003). Comparaison de deux méthodes d'analyse des variables maximales de vitesse, force et puissance dans l'évaluation fonctionnelle en karaté. *Science and Sports*, 18(3), 134–140.

[https://doi.org/10.1016/S0765-1597\(03\)00114-X](https://doi.org/10.1016/S0765-1597(03)00114-X)

Ribas, M. R., Pereira, M. A. S., Barbosa, T. A., Lass, A. D., & Bassan, J. C. (2020a).

Tactical and technical performance analysis of the Male 65 kg category at the Brazilian Shotokan Karate Championship. *Journal of Physical Education*

(*Maringá*), 31(1). <https://doi.org/10.4025/JPHYSEDUC.V31I1.3106>

Ribas, M. R., Pereira, M. A. S., Barbosa, T. A., Lass, A. D., & Bassan, J. C. (2020b).

Tactical and technical performance analysis of the Male 65 kg category at the

- Brazilian Shotokan Karate Championship. *Journal of Physical Education (Maringa)*, 31(1). <https://doi.org/10.4025/JPHYSEDUC.V31I1.3106>
- Rodrigues, J., & Louro, H. (2016a). *Observação e análise das habilidades desportivas*.
- Rodrigues, J., & Louro, H. (2016b). *Observação e análise das habilidades desportivas 1. Observação como ferramenta do processo de treino*.
- Rosa, B., & Gonçalves J. (2007, July 7). "Percepção&Acção"-O Processo de Tomada de Decisão no Karaté. *Confederação Portuguesa Das Associações de Treinadores*.
- Sastre, V., Lapresa, D., Arana, J., Ibáñez, R., & Anguera, M. T. (2021). Observational analysis of technical-tactical performance in initiation to combat in karate. *International Journal of Performance Analysis in Sport*, 21(1), 126–138. <https://doi.org/10.1080/24748668.2020.1853450>
- Slankamenac, J., Bjelica, D., Jaksic, D., Trivic, T., Drapsin, M., Vujkov, S., Modric, T., Milosevic, Z., Drid, P., Campa, F., & Greco, G. (2021). Somatotype Profiles of Montenegrin Karatekas: An Observational Study. *Public Health*, 18, 12914. <https://doi.org/10.3390/ijerph>
- Spigolon, D., Hartz, C. S., Junqueira, C. M., Longo¹, A. R., Tavares¹, V., Fayçal¹, H., De Paula¹, M., Jacinto¹, L. C., & Moreno, M. A. (2018). The Correlation of Anthropometric Variables and Jump Power Performance in Elite Karate Athletes. *Journal of Exercise Physiologyonline February*, 21(1).

- Tabben, M., Coquart, J., Chaabène, H., Franchini, E., Chamari, K., & Tourny, C. (2014). Validity and reliability of a new karate-specific aerobic field test for karatekas. *International Journal of Sports Physiology and Performance*, 9(6), 953–958. <https://doi.org/10.1123/ijsp.2013-0465>
- Wainer, Howard., Braun, H. I., & Educational Testing Service. (2013). *Test Validity* (H. Wainer & H. I. Braun, Eds.). Routledge. <https://doi.org/10.4324/9780203056905>
- Zätterström, R., Fridén, T., Lindstrand, A., & Moritz, U. (2000). Rehabilitation following acute anterior cruciate ligament injuries-a 12-month follow-up of a randomized clinical trial. *J Med Sci Sports*, 10, 156–163.

PAPER 2

Ferreira, J. F., Silva, R., Badicu, G., & Clemente, F. M.. Differences in the technical performance of karate athletes based on age and experience, and their relationships with anthropometric measures and physical fitness. (Submitted in Heliyon journal).

Differences in the technical performance of karate athletes based on age and experience, and their relationships with anthropometric measures and physical fitness

Joaquim Filipe Ferreira¹, Rui Miguel Silva^{1,2}, Georgia Badicu³, Filipe Manuel Clemente^{1,2,4}

¹School of Sports and Leisure, Polytechnic Institute of Viana do Castelo, Rua Escola Industrial e Comercial de Nun'Álvares, 4900-347 Viana do Castelo, Portugal

²Research Center in Sports Performance, Recreation, Innovation and Technology – SPRINT, 4900-347 Viana do Castelo, Portugal

³Transilvania University of Brasov

⁴Institute of Telecommunications, Delegation of Covilhã, 1049-001 Lisbon, Portugal

ABSTRACT

Objectives: The objectives of this study were: (i) to compare differences in anthropometric measures, physical fitness, and technical gesture quality in karate among practitioners of different age groups and years of experience; (ii) to test the dependence relationship between the quality of execution of the technical gesture in karate and anthropometric and physical fitness measures.

Methods: An observational cross-sectional study design was implemented in a non-probabilistic convenience sample. Fifty-three athletes aged 5 to 55 years participated. All participants were evaluated in the following dimensions/tests: anthropometry (body mass, height, seated height); handgrip strength; isometric mid-thigh pull (IMTP); squat jump; countermovement jump; single-leg hop test; System for the Technical Assessment of Kumite (STAK). Participants were grouped into the following age groups: 5-9 years; 10-14 years; 15-19 years; and >19 years. Simultaneously, athletes were grouped according to years of experience in the sport: 0-2 years; 3-5 years; >5 years. **Results:** Statistically significant differences were found between age groups in body mass ($p<0.001$), height ($p<0.001$), body mass index ($p<0.001$), IMTP ($p<0.001$), standardized IMTP ($p=0.003$), SJ ($p<0.001$), CMJ ($p<0.001$), right SLH ($p<0.001$), right handgrip strength ($p<0.001$), and left handgrip strength ($p<0.001$). Additionally, statistically significant differences were found between age groups in the variables of Gyaku ($H=8.485$; $p=0.037$), Mawashi Geri ($H=8.574$; $p=0.036$), and Ura Mawashi Geri ($H=13.950$; $p=0.003$), with no statistically significant differences in the Kizami test ($H=5.895$; $p=0.117$). Spearman's Rho correlation test identified a significant moderate to large correlation between years of experience and the quality of Kizami ($\rho=0.388$; $p=0.004$), Gyaku ($\rho=0.436$; $p=0.001$), Mawashi Geri ($\rho=0.603$; $p<0.001$), and Ura Mawashi

Geri ($\rho=0.477$; $p<0.001$). **Conclusions:** It was found that years of experience significantly influence the values of physical fitness and technical proficiency of karate athletes, and the technical observation instrument showed significant dependence relationships with experience, indicating the sensitivity of the instrument to differentiate the effect of experience on the quality of movement in karate athletes.

Keywords: Karate, Physical Qualities, Technique, Kumite.

INTRODUCTION

Karate is a martial art that requires specific technical and physical skills to be practiced successfully (Przybylski et al., 2021). The technical skills include precise strikes, both in attack and defense, stances, dodges, and movement in space to dominate distance. In institutional Karate, competition is held through two disciplines: Kata and Kumite. Kata is defined as a performance of pre-defined sequences of basic techniques (stances, hand strikes, and leg strikes) in a fight against an imaginary opponent (N. Koropanovski et al., 2011). The Kumite represents a process of combat game using specific motor skills of Karate that mimic a real fight, but with controlled techniques executed by two opponents. The Kumite requires from the karateka a quick programming of the appropriate action responses to the defense and/or attack process. (Abd El-Kader, 2010).

The technical-tactical performance in the initiation of karate kumite by younger athletes (Sastre et al., 2021) On the other hand, kizami Zuki is more frequent in experienced athletes compared to beginners. It is also noted that the circular kick Mawashi Geri is more used by beginners, followed by Ura Mawashi Geri, while the lateral kick Yoko Geri has a lower expression, as well as the Ushiro Geri (back kick) and Mae Geri (front kick), results observed in the study with beginners are also observed with experts (Ibáñez et al., 2018). On the other hand, kizami Zuki is more frequent in experienced athletes compared to beginners. Similarly, it is observed that circular punches (Ura Waza) are very limited or almost non-existent. All these results are in line with other publications analyzing the most used techniques in World Karate Federation competition. (Ibáñez, 2018; Laird & McLeod, 2009; Koropanovski et al., 2008)

In addition to the technical skills associated with Karate, which can differentiate novice from expert athletes, it is also observed that physical qualities can differentiate levels of expertise (Przybylski et al., 2021). In Karate, physical qualities that seem to support better actions and performance are associated with strength, endurance, flexibility, specific speed, and motor coordination (Ravier et al., 2003). Explosive strength, speed, and coordination have a dominant effect on success in Karate (Blažević et al., 2006). In terms of energy systems, both aerobic and anaerobic capacities are highly present in the literature (Doria et al., 2009). It is well established that Karate practice requires both aerobic and anaerobic capacities, and is defined by explosive, intermittent, and rapid movements executed by the upper or lower body of the athlete (Chaahène et al., 2012).

Physical qualities are also determining factors in distinguishing the competitive level of athletes. Candeias, et al. (2018) conducted a systematic review of published studies that identified factors that distinguish Karatekas with better competitive performance, and the results revealed that there are distinctive factors between Elite and Non-Elite Athletes. The distinctive factors were as follows: mostly ecto-mesomorphic somatotype; higher levels of aerobic capacity; lower blood lactate concentration; higher levels of maximum strength and muscle power. Meanwhile, Drid, (2017) compared muscle strength between hamstrings and quadriceps in male Karate athletes of different ages and concluded that isokinetic parameters of the lower and upper limbs were significantly higher in senior athletes than in juniors, and juniors were higher than cadets in comparison.

Considering that performance in Karate depends on both technical and physical factors, there is an inherent attempt to analyze the dependence relationships between these dimensions. A study by Rakita et al. (2018) determined the relationship between morphological characteristics and specific motor skills of junior karate athletes and concluded that there is a relationship between morphological characteristics and specific motor skills of junior karate athletes, namely body height, lean body mass, and total body water. Despite these examples, the study of relationships is scarce and should be expanded in different contexts.

Although some studies (Candeias et al., 2018; Drid, 2017; Rakita et al., 2018; Ravier et al., 2003) have shown that novice and experienced Karate practitioners seem to differentiate in

technical performance and physical abilities, there is still a need to compare the influence of experience in the modality on technical performance and physical aptitude. Additionally, considering the relevance of technical performance, it is important to understand how the execution of these elements may depend on physical factors. From this knowledge, it will be possible to identify differentiating factors between age groups and experience, as well as identify how the factors interrelate, guiding the combined training for performance optimization. Therefore, the objectives of this study were: (i) to compare the differences in anthropometry measures, physical aptitude, and technical gesture quality in Karate, among practitioners of different age groups and years of experience; (ii) to test the dependence relationship between the quality of technical gesture execution in Karate and anthropometric and physical aptitude measures. Understanding these factors can help athletes improve their skills and training strategies, as well as help coaches adjust techniques and training methods according to each athlete's individual characteristics.

METHODS

Experimental approach

Observational cross-sectional study. The sampling method selected was non-probabilistic, for convenience. The eligibility criteria were defined as being practitioners of Karate with at least two months of practice, with no pre-existing condition of illness or injury that could affect the results. Participants were invited to participate in the study and those who expressed interest underwent eligibility criteria analysis and selection. The evaluations took place on January 30th, 31st, and February 1st and 2nd, 2023, corresponding to the middle of the sports season. The evaluation for each group of practitioners started at 5 pm and ended at 7 pm, taking place indoors (dojos) and conditioned at a temperature of 20°C. The evaluation day presented 48 hours of recovery from the last training session. The study protocol was reviewed and approved by the Ethics and Scientific Committee of the School of Sport and Leisure of the Polytechnic Institute of Viana do Castelo, with the code CTC-ESDL-CE005-2021.

Participants

Fifty-three federated Karate practitioners participated in this study, all belonging to the Youth Karate Association Portugal, divided into three clubs: Karate Club Guimarães, Social

Center Club of VN de Sande, and Karate School of the Social Center of Brito. Athletes aged 5 to 55 participated in the study, organized by the following age groups: (i) 16 athletes between 5 and 9 years old, (ii) 18 athletes between 10 and 14 years old, (iii) 10 athletes between 15 and 19 years old, and (iv) 9 athletes over 19 years old. The weekly training frequency for practitioners aged 5 to 9 and 10 to 14 consisted of two 45-minute sessions. Practitioners aged 15 to 19 had a weekly training frequency of three 60-minute sessions. Practitioners over 19 had a weekly training frequency of two 60-minute sessions.

Physical fitness assessment

Anthropometry

The following anthropometric measurements were conducted: (i) body mass measured with a Kern scale (with a margin of error of 5 g), (ii) height, (iii) standing height (distance between the iliac crest and the external malleolus of the foot), for vertical jump analysis using the MyJump2 smartphone application, and (iv) sitting height (with knees flexed at 90°, the distance between the iliac crest and the external malleolus of the foot) for vertical jump analysis using the MyJump2 application, measured with a measuring tape.

Manual grip strength

Manual muscle strength was assessed using a properly calibrated Hydraulic Hand Dynamometer from the brand SAEHAN (Saehan Corporation - SH 5001). The same position was adopted for all participants, regardless of gender, and its application followed the recommendations of the American Society of Hand Therapists (ASHT). Initially, an image containing an individual holding the device correctly was made available to the participant. The participant was instructed to sit with a straight back, keep their feet flat on the ground, hold the dynamometer with their shoulder adducted and neutrally rotated, elbow flexed at 90°, forearm and wrist in a neutral position. The contralateral hand should rest on the leg and it was not allowed to support the device. After adopting the recommended posture and, upon the evaluator's voice

command authorizing the start of the test, the participant was instructed to take a breath cycle and, at the end of expiration, perform a voluntary muscle force. All participants performed three repetitions on each upper limb, with a 15-second interval time between the three attempts, and the best one for data analysis was obtained. The collected measurement was the manual grip strength for each limb (left and right) measured in kilograms.

Isometric maximum force in the *isometric mid-thigh pull test* (IMTP)

The test was performed on a Back Strength Dynamometer (BACK-D, TAKEI), which has shown reliability in the tests described in the literature (James et al., 2017). The maximum force of the participants was evaluated with a familiarization execution followed by three repetitions for each athlete. The IMTP test required participants to position themselves on the force platform with their feet approximately hip-width apart, which was then standardized for all tests performed. The height of the bar was adjusted to correspond to the medial part of the participants' thighs. The participants held the bar with a double pronated grip, and the distance from the bar to the force platform was measured by the evaluator to ensure that the positions were replicated in each test session. Three repetitions were performed with at least 15 seconds of rest between each repetition, and the result was estimated in kilograms of weight.

Countermovement jump

The My Jump2 app (Balsalobre-Fernández et al., 2015), was used on an iPhone 8 Plus to estimate the vertical power of the lower limbs. Participants performed the CMJ with their hands on their hips, standing in a static position, and with their legs in extension in the flight phase of the jump, after performing a lower limb flexion of 90° without stopping. Each participant was instructed to perform the jumps as high as possible according to the specifications given above, repeating a total of 3 jumps, with at least 15 seconds of rest between each repetition, and the result was estimated in centimeters.

Squat jump

The My Jump2 app was used on an iPhone 8 Plus to estimate the vertical power of the lower limbs. Participants performed the SJ with their hands on their hips, standing in a static position in a static flexion of the lower limbs at 90°, and at the voice command of the investigator, performed a jump with their legs in extension in the flight phase, after pausing. Each participant was instructed to perform the jumps as high as possible according to the specifications given above, repeating a total of 3 jumps, with at least 15 seconds of rest between each repetition, and the result was estimated in centimeters.

Single leg hop test

In the Single-Leg Hop Test, participants were instructed to jump as far as possible on a single support. The test was performed three times for each limb, alternating between right and left. The distance of each jump was measured in centimeters from the starting position of the test to the point of support. They were required to make a perfect landing, and if not done perfectly, they repeated the jump. The best score achieved in the three attempts was considered as the test value. The modified version of the Single-Leg Hop Test was used in this study, which allows free movement of the arms during the jump, aiming for greater functionality in its execution (Zätterström et al., 2000). At least 15 seconds of rest were taken between each repetition, and the result was estimated in meters.

Kumite Technical Evaluation System

The test was performed using a removable target, with a perforated sponge ball that served as a target for the 4 technical tests, 3 at head height and 1 at abdomen height. Practitioners started the test in Kamae and away from the target at the preparation distance, which means a distance that allowed reaching the target with only one Yori ashi movement in full extension of the lower or upper limb in the finishing phase. It was also important to ensure that the action covered the same distance in the recovery phase. The targets were placed at head height of the participants. In Gyaku Tsuki Chudan, they were placed in the middle zone (trunk) of the participant. Participants were asked to perform all techniques according to these 4 qualitative technical evaluation criteria for the Kumite tests of the WKF: Good form, martial attitude, correct distance, and vigorous application. The techniques were evaluated according to the STAK (System for the Technical Assessment of Kumite) references for the four specific motor actions of the Kumite discipline:

Kizami, Gyaku Zuki, Mawashi Geri, and Ura Mawashi Geri. One attempt was made for adaptation to the test, and the second attempt generated the final evaluation. All data were immediately entered into an Excel sheet designed for this purpose, to be later treated with appropriate statistical procedures for the study.

Statistical Procedures

Descriptive statistics were performed by calculating the mean and standard deviation for continuous scale measures, while for ordinal scale measures, mode, minimum and maximum values, and median were used. Intra-practitioner variability for each test performed with more than one repetition was calculated using the coefficient of variation expressed as a percentage. The observed practitioners were grouped by age ranges (5-9 years, 10-14 years, 15-19 years, and >19 years) as well as by years of experience (0-2 years, 3-5 years, and >5 years). These groupings allowed for the creation of nominal variables used later to analyze variance for the different measures. In the case of comparisons between age groups and years of experience, for dependent variables on continuous scales, the Kolmogorov-Smirnov test for normality and Levene's homogeneity test were used to test the requirements. Once confirmed ($p>0.05$), a one-way ANOVA test followed by the Bonferroni post-hoc test was used. The eta square test was used as a measure of effect size. For ordinal scale measures, the non-parametric Kruskal-Wallis test was used, followed by the Mann-Whitney U test for pairwise comparisons. The relationships between the quality of technical gestures and the variables of age, experience, anthropometrics, and physical fitness were analyzed by performing the Spearman's Rho test. All statistical procedures were performed using the SPSS software (version 28.0.0.0, IBM, Chicago, USA) for $p<0.05$.

RESULTS

Considering that the measures resulting from the IMTP, SJ, CMJ, SLH, and manual grip strength tests were the best of three attempts, it is important, first of all, to present the average values of intra-individual variability in each test. The coefficient of variation in the IMTP test between the three attempts was $6.4\pm 4.4\%$, while it reached $9.5\pm 5.6\%$ in the SJ and $9.9\pm 6.8\%$ in

the CMJ. Regarding the SLH with the right limb, a coefficient of variation of $5.7\pm 5.6\%$ was observed, while in the left limb, it was $3.9\pm 3.2\%$. Finally, in the manual grip strength test, a coefficient of variation of $5.1\pm 5.2\%$ was observed in the left limb and $4.7\pm 5.6\%$ in the right.

Table 1 presents the mean and standard deviation values of the anthropometric and physical fitness variables measured on a continuous scale. The one-way ANOVA test performed between age groups showed statistically significant differences between age ranges in the variables of age ($p<0.001$), experience ($p<0.001$), body mass ($p<0.001$), height ($p<0.001$), body mass index ($p<0.001$), IMTP ($p<0.001$), standardized IMTP ($p=0.003$), SJ ($p<0.001$), CMJ ($p<0.001$), SLH right ($p<0.001$), manual grip strength right ($p<0.001$), and left ($p<0.001$). Table 1 also shows the results of the Bonferroni post-hoc test.

Table 1. Descriptive statistics (mean $\pm$ standard deviation) for the anthropometric and physical fitness variables organized by age groups.

	5-9 years of age (n=16)	10-14 years of age (n=18)	15-19 years of age (n=10)	>19 years of age (n=9)	Teste ANOVA F p-value η^2
Age (years)	6.9 $\pm$ 1.4 ^{b,c,d}	11.8 $\pm$ 1.2 ^{a,d}	16.8 $\pm$ 1.1 ^{a,d}	33.9 $\pm$ 12.0 ^{a,b,c}	60.596 <0.001 0.788
Experience (years)	2.5 $\pm$ 1.7 ^{c,d}	4.6 $\pm$ 2.4 ^d	7.5 $\pm$ 2.8 ^a	11.4 $\pm$ 6.3 ^{a,b}	15.968 <0.001 0.494
Body mass (kg)	26.1 $\pm$ 5.1 ^{b,c,d}	44.2 $\pm$ 6.1 ^{a,c,d}	64.3 $\pm$ 14.5 ^{a,b}	71.9 $\pm$ 13.8 ^{a,b}	57.866 <0.001 0.780
Height (cm)	127.2 $\pm$ 10.6 ^{b,c,d}	157.4 $\pm$ 8.8 ^{a,c,d}	167.9 $\pm$ 10.1 ^{a,b}	176.2 $\pm$ 7.4 ^{a,b}	68.234 <0.001 0.807
IMC (kg/m ²)	16.1 $\pm$ 1.7 ^{c,d}	17.8 $\pm$ 1.4 ^{c,d}	22.6 $\pm$ 3.0 ^{a,b}	23.0 $\pm$ 3.1 ^{a,b}	30.170 <0.001 0.649
IMTP (kg)	42.2 $\pm$ 10.7 ^{c,d}	61.1 $\pm$ 13.5 ^d	84.5 $\pm$ 25.6 ^{a,d}	127.4 $\pm$ 32.8 ^{a,b,c}	25.229 <0.001 0.660
Normalized IMTP (kg/kg)	1.4 $\pm$ 0.3	1.4 $\pm$ 0.2	1.3 $\pm$ 0.3 ^d	1.8 $\pm$ 0.2 ^c	5.413 0.003 0.294
SJ (cm)	20.3 $\pm$ 4.5 ^{c,d}	26.6 $\pm$ 6.2 ^d	28.7 $\pm$ 6.6 ^a	34.6 $\pm$ 11.3 ^{a,b}	8.670 <0.001 0.347

CMJ (cm)	21.9±5.7 ^d	28.6±7.1	30.5±8.8	37.4±12.4 ^a	7.279 <0.001 0.308
Left SLH (cm)	-	142.0±26.2	166.2±28.0	164.0±44.0	2.376 0.109 0.126
Right SLH (cm)	111.8±14.3 ^{b,c,d}	144.5±23.2 ^a	158.7±29.7 ^a	164.8±36.8 ^a	7.910 <0.001 0.356
Right handgrip (kg)	29.9±11.0 ^{b,c,d}	49.1±5.9 ^{a,c,d}	63.4±17.4 ^{a,b}	76.2±9.3 ^{a,b}	40.513 <0.001 0.713
Left handgrip (kg)	27.4±10.1 ^{a,b,c}	47.8±7.4 ^{a,d}	60.8±12.3 ^{a,d}	80.9±21.9 ^{a,b,c}	38.304 <0.001 0.701

MC: Body mass index; IMTP: Isometric mid-thigh pull test; SJ: Squat jump; CMJ: Countermovement jump; SLH: Single leg hop test; significantly different from a5-9 years of age; b10-14 years of age; c15-19 years of age; d>19 years of age for p<0.05

Table 2 presents the mode, minimum, and maximum values for the measures on an ordinal scale resulting from the battery of technical evaluation tests for karate practitioners. The median values for Kizami were 2.5 for the age range of 5-9 years, 3.0 for the age range of 10-14 years, 2.5 for the age range of 15-19 years, and 3.0 for the age range of >19 years. The median values for Gyaku were 2.0 for the age range of 5-9 years, 3.0 for the age range of 10-14 years, 3.0 for the age range of 15-19 years, and 3.0 for the age range of >19 years. The median values for Mawashi Geri were 2.0 for the age range of 5-9 years, 3.0 for the age range of 10-14 years, 3.0 for the age range of 15-19 years, and 3.0 for the age range of >19 years. The median values for Ura Mawashi Geri were 2.0 for the age range of 5-9 years, 3.0 for the age range of 10-14 years, 3.0 for the age range of 15-19 years, and 3.0 for the age range of >19 years.

The Kruskal-Wallis test was performed to analyze the variation between age groups in the values of the four technical tests. Statistically significant differences were found between age groups in the variables of Gyaku (H=8.485; p=0.037), Mawashi Geri (H=8.574; p=0.036), and Ura Mawashi Geri (H=13.950; p=0.003), but no statistically significant differences were found in the Kizami test (H=5.895; p=0.117).

Table 2. Descriptive statistics (mode [minimum; maximum]) for ordinal variables associated with technical tests.

	5-9 years of age (n=16)	10-14 years age (n=18)	15-19 years of age (n=10)	>19 years of age (n=9)	Kruskal- Wallis H p- value
Kizami (U.A.)	3 [1;3]	3 [2;3]	2 [2;3]	3 [2;3]	5.895 0.117
Gyaku (U.A.)	2 [1;3]	3 [2;3]	3 [2;3]	3 [2;3]	8.485 0.037
Mawashi Geri (U.A.)	2 [1;3]	3 [2;3]	3 [2;3]	3 [1;3]	8.574 0.036
Ura Mawashi Geri (U.A.)	1 [1;3]	3 [2;3]	3 [2;3]	3 [1;3]	13.950 0.003

After observing the differences, the Mann-Whitney U test was performed to analyze the variations between pairs of age groups (Table 3). It was found that the 10-14 age group had significantly higher values than the 5-9 age group in Gyaku ($p=0.016$), Mawashi Geri ($p=0.012$), and Ura Mawashi Geri ($p<0.001$). It was also found that the 15-19 age group had statistically higher values of Mawashi Geri ($p=0.028$) and Ura Mawashi Geri ($p=0.003$) in relation to the 5-9 age group.

Table 3. Mann-Whitney U (Z) values and p-values for comparison between pairs of age groups.

	5-9 vs. 10-14 years	5-9 vs. 15-19 years	5-9 vs. >19 years	10-14 vs. 15-19 years	10-14 vs. >19 years	15-19 vs. >19 years
Kizami (U.A.)	Z=-1.637 p=0.102	Z=-0.295 p=0.768	Z=-1.940 p=0.052	Z=-1.323 p=0.186	Z=-0.723 p=0.469	Z=-1.772 p=0.076
Gyaku (U.A.)	Z=-2.420 p=0.016*	Z=-1.352 p=0.176	Z=-2.174 p=0.030	Z=-0.809 p=0.418	Z=-0.376 p=0.707	Z=-0.981 p=0.326
Mawashi Geri (U.A.)	Z=-2.513 p=0.012*	Z=-2.195 p=0.028*	Z=-1.670 p=0.095	Z=-0.030 p=0.976	Z=-0.353 p=0.724	Z=-0.301 p=0.764
Ura Mawashi Geri (U.A.)	Z=-3.503 p<0.001*	Z=-2.927 p=0.003*	Z=-1.446 p=0.148	Z=-0.057 p=0.955	Z=-0.882 p=0.378	Z=-0.737 p=0.469

Table 4 presents the mode, minimum, and maximum values for the ordinal scale measurements resulting from the battery of technical evaluation tests of the karatekas in consideration of years of experience. The median values of Kizami were 2.0 in the 0-2 years of experience group, 3.0 in the 3-5 years of experience group, and 3.0 in the >5 years of experience group. The median values of Gyaku were 2.0 in the 0-2 years of experience group, 3.0 in the 3-5 years of experience group, and 3.0 in the >5 years of experience group. The median values of Mawashi Geri were 2.0 in the 0-2 years of experience group, 3.0 in the 3-5 years of experience group, and 3.0 in the >5 years of experience group. The median values of Ura Mawashi Geri were 1.0 in the 0-2 years of experience group, 2.0 in the 3-5 years of experience group, and 3.0 in the >5 years of experience group.

The Kruskal-Wallis test was performed to analyze the variation between experience groups in the values of the four technical tests. Statistically significant differences were found between experience groups in the Kizami variable ($H=10.669$; $p=0.005$), Gyaku ($H=11.178$; $p=0.004$), Mawashi Geri ($H=23.577$; $p<0.001$), and Ura Mawashi Geri ($H=11.013$; $p=0.004$).

Table 4. Descriptive statistics (mode [minimum; maximum]) for ordinal variables associated with experience levels in the sport.

	0-2 years of experience (n=15)	3-5 years of experience (n=17)	>5 years of experience (n=21)	Kruskal- Wallis H p- value
Kizami (U.A.)	2 [1;3]	3 [1;3]	3 [2;3]	10.669 0.005
Gyaku (U.A.)	2 [1;3]	3 [2;3]	3 [2;3]	11.178 0.004
Mawashi Geri (U.A.)	1 [1;3]	3 [2;3]	3 [2;3]	23.577 <0.001
Ura Mawashi Geri (U.A.)	1 [1;3]	2 [2;3]	3 [1;3]	11.013 0.004

After verifying the differences between experience levels, a Mann-Whitney U test was performed to analyze variations between pairs of age groups (Table 5), confirming that greater experience tended to lead to higher values of quality in the execution of technical gestures in the different analyzed movements.

Table 5. Mann-Whitney U (Z) values and p-values in the comparison between pairs of experience levels.

	0-2 vs. 3-5 years	0-2 vs. >5 years	3-5 vs. >5 years
Kizami (U.A.)	Z=-1.113 p=0.266	Z=-3.244 p=0.001*	Z=-2.283 p=0.022*

Gyaku (U.A.)	Z=-0.819 p=0.413	Z=-3.280 p=0.001*	Z=-2.701 p=0.007*
Mawashi Geri (U.A.)	Z=-3.501 p<0.001*	Z=-4.449 p<0.001*	Z=-1.495 p=0.135
Ura Mawashi Geri (U.A.)	Z=-2.097 p=0.036*	Z=-2.950 p=0.003*	Z=-2.094 p=0.036*

Looking to verify the dependencies between age, years of experience, and quality of technical execution in the four analyzed movements, the Spearman's Rho correlation test was performed. The Spearman's Rho correlation test identified a moderate and significant correlation between age and the technical execution quality of Gyaku ($\rho=0.331$; $p=0.015$), Mawashi Geri ($\rho=0.301$; $p=0.028$), and Ura Mawashi Geri ($\rho=0.358$; $p=0.009$), but not in Kizami ($\rho=0.223$; $p=0.109$). The Spearman's Rho correlation test identified a moderate to large and significant correlation between years of experience and the technical execution quality of Kizami ($\rho=0.388$; $p=0.004$), Gyaku ($\rho=0.436$; $p=0.001$), Mawashi Geri ($\rho=0.603$; $p<0.001$), and Ura Mawashi Geri ($\rho=0.477$; $p<0.001$). Table 6 presents the correlation values between the quality of technical execution of the movements and the anthropometric and physical fitness variables.

Table 6. Correlation matrix (Rho) between the quality of execution of technical movements and anthropometric and physical fitness variables.

	Kizami	Gyaku	Mawashi Geri	Ura Mawashi Geri
Body mass (kg)	Rho=0.147; p=0.292	Rho=0.273; p=0.048*	Rho=0.295; p=0.032*	Rho=0.347; p=0.011*
Height(cm)	Rho=0.236; p=0.089	Rho=0.353; p=0.010*	Rho=0.323; p=0.018*	Rho=0.389; p=0.004*
IMC (kg/m ²)	Rho=0.001; p=0.999	Rho=0.126; p=0.367	Rho=0.195; p=0.163	Rho=0.241; p=0.082
IMTP (kg)	Rho=0.233; p=0.133	Rho=0.333; p=0.029*	Rho=0.266; p=0.085	Rho=0.230; p=0.138
Standardized IMTP (kg/kg)	Rho=0.358; p=0.019*	Rho=0.395; p=0.009*	Rho=0.453; p=0.002*	Rho=0.319; p=0.037*
SJ (cm)	Rho=0.347; p=0.011*	Rho=0.472; p<0.001*	Rho=0.488; p<0.001*	Rho=0.583; p<0.001*

CMJ (cm)	Rho=0.284; p=0.040*	Rho=0.411; p=0.002*	Rho=0.402; p=0.003*	Rho=0.487; p<0.001*
Left SLH (cm)	Rho=0.103; p=0.550	Rho=0.004; p=0.983	Rho=0.374; p=0.025*	Rho=0.243; p=0.153
Right SLH (cm)	Rho=0.333; p=0.022*	Rho=0.394; p=0.006*	Rho=0.594; p<0.001*	Rho=0.480; p<0.001*
Right hand grip strength (kg)	Rho=0.228; p=0.100	Rho=0.341; p=0.013*	Rho=0.325; p=0.018*	Rho=0.378; p=0.005*
Left hand grip strength (kg)	Rho=0.247; p=0.074	Rho=0.341; p=0.012*	Rho=0.389; p=0.004*	Rho=0.407; p=0.003

DISCUSSION

The main objectives of this study were to analyze the differences in physical fitness and technical gesture quality in karate movements among practitioners of different age groups and years of experience, and to test the correlations between the quality of execution of karate technical gestures and physical fitness measures. The main evidence found revealed significant differences in anthropometric and physical fitness measures between different age groups. In addition, the performance of technical gestures varied significantly among different age groups and years of experience in the sport. This study also tested the correlations between the quality of execution of karate technical gestures and physical fitness measures. The main evidence found is that performance in physical fitness tests has a strong dependency relationship with performance in karate technical gestures. The technical gestures Kizami, Gyakuzuki Chudan, Mawashi Geri, and Ura Mawashi Geri varied significantly. The performances of technical gestures presented significant differences when considering years of experience in the sport. The differences found between age groups and competitive experience regarding physical fitness may be explained by the fact that regular karate training and practice can lead to specific physiological adaptations that improve the athlete's physical fitness. Alesi et al. (2014), It was demonstrated in the study that karate practitioners improved their physical and cognitive abilities with training. Studies by Hakkinen and Komi, (in Kawamori & Haff, 2004) showed that 24 weeks of explosive training,

using various types of jumps with light loads, resulted in a 21% increase in jump height, demonstrating that training creates physiological adaptations.

The physiological and cognitive adaptations resulting from karate training can be explained by a series of factors. Firstly, regular and systematic karate training can lead to an improvement in body composition, increasing muscle mass and decreasing body fat, which contributes to better physical fitness performance (Chaabe et al., 2016). In addition, karate training involves high-intensity and explosiveness movements, which contribute to the development of aerobic and anaerobic energy systems, improving endurance and muscular power (Molinaro et al., 2020). Karate training can also improve flexibility, agility, and motor coordination, important characteristics for performing precise technical movements (Iide et al., 2008a).

As children grow and develop physically, their motor skills also improve (Figueredo & Alves, 2019). Changes in muscle size and strength, balance, and coordination can lead to improvements in motor performance (António Vencesbrito et al., 2019), as seems to be the case with the studied techniques. In addition, the process of biological maturation, which occurs during adolescence, can also influence physical fitness and sports performance (Keshishian Hovik, 2013 ; Branco et al., 2019; Kayihan, 2014).

Marquezin et al. (2018) conducted a study with 53 athletes divided into several age groups in football formation and concluded that chronological age and maturation stages play an important role in relation to anthropometric variables and aerobic power. In addition, more experienced players showed better results in strength and power tests compared to less experienced players.

Regarding technical performance, a study by Arazi & Izadi. (2017). compared the performance of karate techniques among practitioners of different age groups and experiences in the sport. The results showed that more experienced kumite practitioners executed the techniques with greater precision and speed than Kata athletes, regardless of age. However, athletes who were not yet specialized in one discipline performed better than those who were. Age and experience are two important factors that can influence the performance of karate practitioners. Generally, karate practitioners with more practice time (experience) tend to have better physical conditioning, faster reaction times, and greater flexibility compared to older practitioners (Kayihan Gurhan, 2014). Possible contradictions with published evidence can be found in results that show that the

competition factor can influence the performance of athletes, Chaahène et al. (2012) suggest that athletes who compete regularly may be more motivated and need to obtain better physical and technical indices to win the competitions.

The relationship between technical performance and physical fitness appears to be correlated, as several studies suggest that physical fitness improves body composition is correlated with performance power in karate athletes (Arazi & Izadi, 2017; Slankamenac et al., 2021). A study with 51 elite karate athletes demonstrated a positive correlation between physical fitness and performance in karate techniques. The results showed that athletes with lower muscle mass and higher body fat performed worse in lower limb power (Spigolon et al., 2018).

Performance in competitive events and its relationship with physical fitness was studied by De Quel et al. (2020), who analyzed 98 female athletes in Spain's selection works, with the objective of predicting their performance in competition and the relationship with physical and anthropometric conditioning. The result was that athletes who were classified as elite and who won national and international competitions showed significant differences in agility, upper and lower body muscular strength, and overall fitness compared to those who were classified as sub-elite. The evaluation tests used in our study (IMTP, SJ, CMJ, and SLH) and the associated physical qualities (i.e., maximum strength and muscular power) were decisive in all analyzed technical movements. Strength and power seem to be determinants of technical performance.

A study by Loturco et al. (2014) examined the relationship between punch acceleration and selected strength and power variables in 19 professional Karate athletes. Punch acceleration was evaluated in four different conditions. Upper and lower body power and maximum dynamic strength variables were positively correlated with punch acceleration in all conditions. Predictive variables were identified: relative mean propulsive power in the squat jump (CMJ) and maximum dynamic strength in bench press and machine squat exercises. Impact-oriented instruction and self-selected distance were crucial to achieving the highest acceleration during the punch.

Quinzi et al. (2016) advise karate coaches to consider the inclusion of specific strength exercises for the hamstring and knee flexors, after studying whether repetition of technical actions during karate training alters proper technical execution, limiting training effectiveness during competition. The researchers found that knee flexion, median frequency of the hamstring, hip

abduction, knee extension angular velocity, and antagonist activation of the hamstring decreased significantly, while hip flexion increased along the Mawashi Geri strike sequence, suggesting that training protocols combining severe fatigue and technical actions should be proposed with care to avoid improper technical adaptations.

It is important to highlight that the instrument used to evaluate technical performance, the SATK, proved to be sensitive to the practice experience of the evaluated athletes. Both age and experience in the sport seem to influence physical fitness and technical performance of Karate practitioners. The relevance of this evidence is that Karate practitioners and coaches should be aware of differences in physical fitness and technical gesture quality in relation to age and years of experience in the sport, as well as the importance of physical fitness for technical gesture quality in order to individualize athlete training and development according to their individual needs. This evidence may assist the Karate coach in guiding training and development of technical skills in different age groups and levels of experience in the sport. However, more studies on the technical dimension related to experience and physical fitness are needed.

CONCLUSIONS

This study showed that older and more experienced Karate athletes are generally significantly stronger, more powerful, and have better technical proficiency in the execution of specific gestures of the sport. It was also found that experience is the factor with the greatest dependency relationship with technical proficiency. Finally, it was found that athletes with better values of muscular strength and power are the same ones with better levels of technical execution. It is recommended, therefore, that the training of physical qualities and technical development can be related in order to optimize the final performance of the Karate athlete. Additionally, this study showed that the technical observation instrument was sensitive to differentiation between years of experience, and can be used to classify Karate athletes of different levels.

Institutional Review Board statement

The study was conducted in accordance with the guidelines of the Helsinki Declaration, and the protocol was approved by the Ethics and Scientific Committee of the School of Sport and Leisure of the Polytechnic Institute of Viana do Castelo.

References

- Abd El-Kader, A. M. (2010). Efficacy of static and dynamic distance perception on kumite performance in karate. *World J Sport Sci*, 3(S), 205-209.
- Alesi, M., Bianco, A., Padulo, J., Vella, F. P., Petrucci, M., Paoli, A., ... & Pepi, A. (2014). Motor and cognitive development: the role of karate. *Muscles, ligaments and tendons journal*, 4(2), 114.
- Alves, L. L. F. V. (2019). *Influência da educação física no desenvolvimento motor da criança na educação infantil: Uma breve revisão bibliográfica*. Brasília, Brasil: Faculdade de Ciências da Educação e Saúde, Centro Universitário de Brasília.
- Arazi, H., & Izadi, M. (2017). Physical and physiological profile of Iranian world-class karate athletes. *Biomedical Human Kinetics*, 9(1), 115-123.
- Balsalobre-Fernández, C., Glaister, M., & Lockey, R. A. (2015). The validity and reliability of an iPhone app for measuring vertical jump performance. *Journal of sports sciences*, 33(15), 1574-1579.

- Branco, M. A., Brito, A. V., Seabra, A. P., Mercê, C., Rodrigues Ferreira, M. A., Milheiro, V., & Catela, D. (2019). Exploratory study on maturation and competition level in young karate practitioners. *Revista de Artes Marciales Asiáticas*, 14(1), 1-8.
- Candeias Pedro, Martins, P. J., & Correia Candeias, P. M. (2018). *Fatores que Distinguem os Karatecas com Melhor Desempenho Competitivo*. Universidade de Lisboa Faculdade de Motricidade Humana.
- Chaabene, H., Hachana, Y., Franchini, E., Mkaouer, B., & Chamari, K. (2012). Physical and physiological profile of elite karate athletes. *Sports medicine*, 42, 829-843.
- De Quel, Ó. M., Ara, I., Izquierdo, M., & Ayán, C. (2020). Does physical fitness predict future karate success? A study in young female karatekas. *International journal of sports physiology and performance*, 15(6), 868-873.
- Doria, C., Veicsteinas, A., Limonta, E., Maggioni, M. A., Aschieri, P., Eusebi, F., ... & Pietrangeli, T. (2009). Energetics of karate (kata and kumite techniques) in top-level athletes. *European journal of applied physiology*, 107(5), 603.
- Obradović, B., Madić, D., Drid, P., Bogdanovski, M., & Sporiš, G. (2017). Muscle strength assessment of upper and lower limbs in elite male karate athletes: comparative study between different age groups. *Acta Kinesiologica*, 11(1), 94-99.
- Ibáñez, R., Lapresa, D., Arana, J., Camerino Foguet, O., & Anguera, M. T. (2018). Observational analysis of the technical-tactical performance of elite karate contestants. *Cultura, Ciencia y Deporte*, 2018, vol. 13, núm. 37, p. 61-70.

- Iide, K., Imamura, H., Yoshimura, Y., Yamashita, A., Miyahara, K., Miyamoto, N., & Moriwaki, C. (2008). Physiological responses of simulated karate sparring matches in young men and boys. *The Journal of Strength & Conditioning Research*, 22(3), 839-844.
- Kawamori, N., & Haff, G. G. (2004). The optimal training load for the development of muscular power. *The Journal of Strength & Conditioning Research*, 18(3), 675-684.
- Kayihan, G. (2014). Comparison of physical fitness levels of adolescents according to sports participation Martial arts, team sports and non-sports. *Archives of Budo*, 10, 227-232.
- Keshishian, H. (2013). Motor fitness profiling of elite and novice karate practitioners (Doctoral dissertation, Australian Catholic University).
- Koropanovski, N., Berjan, B., Bozic, P., Pazin, N., Sanader, A., Jovanovic, S., & Jaric, S. (2011). Anthropometric and physical performance profiles of elite karate kumite and kata competitors. *Journal of human kinetics*, 30(2011), 107-114.
- Koropanovski, N., Dopsaj, M., & Jovanovic, S. (2008). Characteristics of pointing actions of top male competitors in karate at world and European level. *Brazilian Journal of Biomechanics*, 2(4), 241-251.
- Laird, P., & McLeod, K. (2009). Notational analysis of scoring techniques in competitive men's karate. *International Journal of Performance Analysis in Sport*, 9(2), 171-187.
- Loturco, I., Artioli, G. G., Koba, R., Gil, S., & Franchini, E. (2014). Predicting punching acceleration from selected strength and power variables in elite karate athletes: a multiple regression analysis. *The Journal of Strength & Conditioning Research*, 28(7), 1826-1832.

- Marquezin, M. R., Medin, J., Campos, F. D. S., Teixeira, A. S., Flores, L. J. F., & Nunes, R. F. (2019). Comparação das características antropométricas e da potência aeróbia de atletas de futebol em diferentes categorias e estágios maturacionais. *R. bras. Ci. e Mov*, 27(3), 84-92.
- Molinaro, L., Taborri, J., Montecchiani, M., & Rossi, S. (2020). Assessing the effects of kata and kumite techniques on physical performance in elite karatekas. *Sensors*, 20(11), 3186.
- Nikookheslat, S. D., Faraji, H., Fatollahi, S., & Alizadeh, M. (2016). Physical and physiological profile of elite Iranian karate athletes. *International Journal of Applied Exercise Physiology*, 5(4), 35-44.
- Przybylski, P., Janiak, A., Szewczyk, P., Wieliński, D., & Domaszewska, K. (2021). Morphological and motor fitness determinants of shotokan karate performance. *International journal of environmental research and public health*, 18(9), 4423.
- Quinzi, F., Camomilla, V., Di Mario, A., Felici, F., & Sbriccoli, P. (2016). Repeated kicking actions in karate: Effect on technical execution in elite practitioners. *International journal of sports physiology and performance*, 11(3), 363-369.
- Rakita, D., Rakonjac, D., Jurisic, M., & Obradovic, J. (2018). The influence of morphological characteristics on the specific motor skills of junior-age karate athletes. *EQOL Journal*, 10(1), 43-49.
- Ravier, G., Grappe, F., & Rouillon, J. D. (2003). Comparaison de deux méthodes d'analyse des variables maximales de vitesse, force et puissance dans l'évaluation fonctionnelle en karaté. *Science & sports*, 18(3), 134-140.

- Sastre, V., Lapresa, D., Arana, J., Ibáñez, R., & Anguera, M. T. (2021). Observational analysis of technical-tactical performance in initiation to combat in karate. *International Journal of Performance Analysis in Sport*, 21(1), 126-138.
- Slankamenac, J., Bjelica, D., Jaksic, D., Trivic, T., Drapsin, M., Vujkov, S., ... & Drid, P. (2021). Somatotype profiles of montenegrin karatekas: An observational study. *International Journal of Environmental Research and Public Health*, 18(24), 12914.
- Spigolon, D., Hartz, C. S., Junqueira, C. M., Ariel, R., & Vitor, F. H. (2018). The correlation of anthropometric variables and jump power performance in elite karate athletes. *Journal of Exercise Physiology* 21(1), 139-148.
- Zätterström, R., Friden, T., Lindstrand, A., & Moritz, U. (2000). Rehabilitation following acute anterior cruciate ligament injuries—a 12-month follow-up of a randomized clinical trial. *Scandinavian journal of medicine & science in sports*, 10(3), 156-163.

CHAPTER IV – GENERAL DISCUSSION

GENERAL DISCUSSION

Summary of findings

This dissertation aimed to make a significant contribution to the field of karate by addressing the lack of a technical evaluation instrument for karate athletes in the existing literature. To fill this gap, we developed and validated an instrument designed to assess the technical skills of karate athletes.

In order to evaluate the reliability of the instrument, we conducted a content and construct validation model using a sample of twenty karate practitioners ranging in age from 10 to 22 years. The results of this validation process demonstrated that the instrument exhibited reliability both between and within observers. Furthermore, the instrument was shown to be valid for experts, as indicated by the construct validity established in study 2.

Notably, the second study also provided insights into the performance of older and more experienced karate athletes. It was observed that these athletes generally displayed greater strength, power, and technical proficiency when executing specific karate movements. Importantly, the instrument was able to effectively differentiate between levels of experience, indicating its construct validity and specificity.

Additionally, our findings revealed a correlation between technical composites and major physical qualities, suggesting that the development of technical skills in karate may also depend on factors that promote stability in their execution.

In summary, this dissertation successfully addressed the lack of a technical evaluation instrument for karate athletes and contributed valuable insights into the relationship between technical proficiency, experience levels, and physical qualities. The developed instrument demonstrated reliability and validity, highlighting its potential as a valuable tool for future research and assessment in the field of karate.

Discussion about the Kumite Technical Assessment System

The techniques chosen to compose the Kumite Technical Assessment System (STAK) were those that, according to the literature, were most studied and among the most used in WKF Kumite competitions. Studies have shown that the most frequently used techniques to score points in karate competitions were Kizami zuki, Gyaku zuki, Mawashi Geri, Ura Mawashi Geri, and Oi Tsuki.

Ribas et al. (2020b) analyzed the techniques used by medalists and non-medalist athletes during the 2017 Brazilian Shotokan Karate Championship. Mawashi Geri was the most common attack, being performed 26.3 times per bout, followed by Gyaku Zuki with 19.5 times. The Mawashi Geri attack was more used by winning athletes (71.4%) compared to non-winning athletes (28.5%). It was concluded that Mawashi Geri was the most successful decision in the category.

The construction of the STAK was based on techniques that have been extensively analyzed through scientific evidence from a biomechanical and kinetic perspective. In line with this objective, Kautzner & Junior, (2022) conducted a study specifically focused on investigating the impact of Keri and Tsuki Waza techniques in karate. The study specifically measured the impacts of two key strikes: Gyaku Zuki and Mawashi Geri. This study provides valuable insights into the significance of understanding the impact of strikes in karate and its potential to enhance athletes' performance. By examining the effects of these specific techniques, it sheds light on the biomechanical and kinetic aspects that underlie successful execution. These findings contribute to the body of scientific knowledge surrounding karate, helping to refine training methodologies and improve athletes' overall performance. The study underscores the importance of considering the impact forces generated during strikes, highlighting their role in optimizing technique and enhancing competitive outcomes. In summary, the study conducted by Kautzner and Junior on the impact of Keri and Tsuki Waza in karate, particularly focusing on Gyaku Zuki and Mawashi Geri strikes, underscores the significance of comprehending strike dynamics to enhance athletes' performance. This research contributes to the existing scientific knowledge base in karate and provides valuable insights for practitioners and coaches to optimize training methods and promote athlete development. It was also demonstrated, through a systematic review by Junior Marques, (2015) that Mawashi Geri and Gyaku Zuki attacks are the fastest, and the speed of Tsuki Waza (punches) is faster than that of Keri Waza (kicks).

Can the newly Kumite Technical Assessment System effectively differentiate between varying levels of karate experience?

The findings from the second study demonstrated that the Kumite Technical Assessment System effectively differentiated karate practitioners based on their years of experience, rather than their ages. This highlights the specificity of the instrument in discerning variations in skill levels attributed to experience, which serves as a potential predictor of overall technical performance. These results confirm the construct validity of the Kumite Technical Assessment System, further substantiating its ability to accurately evaluate and classify karate practitioners based on their technical proficiency.

These findings align with a study conducted by Milovan et al., (2014) which examined the disparities among karate practitioners participating in different competitive disciplines through specific motor tests. Milovan et al.'s study demonstrated that competitors specializing in kata displayed the lowest performance results across all tests, whereas individuals engaged in both kata and kumite exhibited the highest performance outcomes. Notably, the disparities observed were more pronounced within older age groups, further emphasizing the influence of experience and age on technique. It is possible that a deeper comprehension of technique or the instructions provided by coaches may underlie these observations within such research investigations.

The studies carried out in this dissertation concluded that anthropometric measures had an influence on technique, which is in accordance with existing literature (Giampietro et al., 2003; N. Koropanovski et al., 2011; Spigolon et al., 2018). In Giampietro et al.'s (2003) study, relationships were established between morphological characteristics and specific motor skills of young karate athletes. Twenty-five athletes with karate experience were tested for their physical characteristics and specific motor the results showed a significant influence of predictor variables on performance, concluding that physical characteristics have an impact on the performance of karate athletes.

Candeias Pedro et al. (2018) reviewed the factors that distinguish high-performance karate athletes and provided reference data for elite athletes' performance, including areas such as maximum strength, muscle power, and speed. It was identified that elite athletes have an ectomorphic somatotype, higher aerobic capacity, lower blood lactate concentration, greater maximum strength and muscle power, better coordination, better balance control, greater capacity

for mental imagery, a more offensive combat strategy, and greater psychological ability to face combat, as evidenced in studies from this dissertation. It is clear that there is a strong correlation between muscular strength and technical ability, as demonstrated in the study by Iide et al. (2008b), which investigated cardiovascular, metabolic, and perceptual responses during simulated karate fights of 2 and 3 minutes. The study concluded that karate practitioners should perform specific weight training, plyometric exercises, and interval training to increase their ability to dampen muscle and blood acid concentrations and develop lean mass, strength, and power to develop the specific motor skills necessary for combat.

Similar results have been found in other combat sports. A study conducted by Kostikiadis et al. (2018) investigated the effect of a short-term, high-intensity strength and conditioning training program on national MMA athletes. The specific training group showed significant improvements in physical fitness, strength, power, speed, and body composition, while the regular training group showed no significant improvements. The results indicated that a high-intensity, low-volume strength and conditioning training program may result in improvements.

Given the strong association between physical fitness and overall karate performance, it is important to acknowledge that the newly developed instrument demonstrates the potential to not only differentiate karate participants based on technical skills but also to effectively discern variations in physical fitness levels. This aspect holds significant implications for enhancing karate performance overall. By incorporating physical fitness assessment within the instrument, it becomes a comprehensive tool capable of capturing the entirety of performance, while distinguishing between individuals who possess higher levels of fitness and those who do not. This integrated approach allows for a more holistic evaluation, promoting a deeper understanding of the interplay between technical proficiency and physical fitness in karate. Ultimately, the instrument has the potential to contribute to significant improvements in karate performance by effectively assessing and differentiating individuals based on both technical and physical fitness aspects.

Future research

There are several avenues for future research that can contribute to a deeper understanding of the topic, building upon the studies conducted in this master's dissertation. The following research possibilities are worth exploring:

1. **Usability of the New Observational Instrument:** Future researchers can investigate the applicability and effectiveness of the newly developed observational instrument in assessing the technical level of karate practitioners. By integrating this instrument into their practices, researchers can validate its usability and explore its potential for broader adoption in the field.
2. **Comparative Studies Across Martial Arts and Sports:** Conducting comparative studies between athletes from different martial arts or sports can provide valuable insights into the generalizability of the conclusions drawn from this study. Exploring similarities and differences in technical skill development and performance across various sporting contexts can enrich our understanding of the factors influencing athlete performance.
3. **Psychological Factors and Performance:** Incorporating psychological factors, such as personality traits and coping strategies, into research designs can enhance our comprehension of how these variables influence athlete performance in competitive settings. Investigating the interplay between psychological factors and technical proficiency can contribute to a more holistic understanding of performance outcomes.
4. **Real-World Performance Analysis:** Studies that analyze athlete performance in settings closer to real competitive environments can evaluate the transferability of results obtained in controlled laboratory conditions. Examining whether findings from controlled studies align with actual performance outcomes in competitive settings can provide valuable insights for training and preparation strategies.
5. **Longitudinal Studies:** Longitudinal studies that track athletes over an extended period can offer valuable insights into how performance and evaluated variables evolve with age and experience. By capturing the developmental trajectories of

karate practitioners, researchers can gain a deeper understanding of the factors influencing performance across different stages of an athlete's career.

6. Integrative Approaches: Conducting studies that combine multiple evaluation techniques, such as psychological assessments, physical measurements, and performance evaluations in real competitions, can yield a comprehensive understanding of the multifaceted factors influencing athlete performance. Integrating different evaluation methods can provide a more holistic perspective on the complex interplay between various factors.

By pursuing these research directions, we can expand the current knowledge base, refine assessment methodologies, and gain a deeper understanding of the factors that impact karate performance.

Dissertation limitations

Limitations of this study should be acknowledged. Firstly, the development of the instrument was based on a set of criteria, making it subjective to the level of analysis conducted by the observer. However, the validity assessment conducted by experts, along with the established construct validity and data reliability, provide some assurance regarding its usability and effectiveness.

Another limitation pertains to the small sample size and the use of convenience sampling. The limited sample size and non-random selection process may hinder the generalizability of the findings from the second study. Consequently, caution must be exercised when extrapolating the results, as they may primarily reflect local and situational characteristics. Therefore, it is essential to conduct further research to validate these findings across different populations and contexts.

By acknowledging these limitations, we can ensure a transparent and objective evaluation of the study's outcomes. Future research endeavors should address these limitations and strive to overcome them, enabling more robust conclusions and broader generalizability of the findings.

CHAPTER V – GENERAL CONCLUSION

GENERAL CONCLUSION

Karate is a martial art that originated in the Ryukyu Islands and developed through indigenous fighting methods and Chinese Kempo (Doria et al., 2009). It has now become one of the most widely practiced martial arts in the world, with over 10 million athletes and 100 million practitioners (Alesi et al., 2014). With its inclusion in the 2020 Tokyo Olympics as a demonstration sport, Karate has gained greater media attention, resulting in a need for greater scientific evidence to develop sports Karate to higher levels through science. While there is some scientific evidence available for characterizing the physiological and biological effort of Kumite practitioners (Chaabène et al., 2012; Gunawan, 2021; Herrera-Valenzuela et al., 2021; Pinto-Escalona et al., 2021), there is a lack of evidence-based technical guidelines for training and competition in the Kumite discipline of Karate.

This master's dissertation provided a significant contribution to the field of karate by developing and validating an observation tool for karateka's technical skills. The research involved 20 karate practitioners aged between 10 and 22 years and used a content and construct validation model to evaluate the instrument's reliability. The results indicated that older and more experienced athletes generally exhibited greater strength, power, and technical proficiency in executing specific karate movements.

The techniques chosen to compose the Kumite Technical Assessment System (STAK) were selected based on their importance and frequency in WKF Kumite competitions. A strong relationship was observed between experience and technical proficiency, as well as between muscular strength and technical ability. Therefore, it is recommended that physical and technical skills training be related to optimizing the final performance of karate athletes.

In addition, the study demonstrated that the technical observation instrument is sensitive to differentiation between the years of experience of karate athletes, allowing coaches to objectively evaluate their athletes' technical competence. This finding may be useful in helping coaches select and classify athletes of different levels of technical ability. The Kumite Technical Assessment System (STAK) was constructed based on the techniques most studied and among the most used in WKF Kumite competitions. Alinaghypour et al. (2020); and Alinaghypour & Zareian. (2016) presented research on the techniques most often used to score points in karate competitions at the

2016 World Championships. Ribas et al. (2020) analyzed the techniques used by medal-winning and defeated athletes during the Brazilian Shotokan Karate Championship in 2017. Kautzner and Junior (2022) conducted a study to determine the impact of Keri and Tsuki Waza (punches and kicks) in karate, while Junior Marques, (2015) demonstrated that Mawashi Geri and Gyaku Zuki attacks are the fastest.

Our research demonstrated that practice experience and age were decisive factors in obtaining better technique, which was consistent with the findings of Milovan et al. (2014) and Candeias Pedro et al. (2018). Anthropometric measurements also influenced technique, as identified by Giampietro et al. (2003), Arazi & Izadi (2017), Chaabe et al. (2016), and Koroponovski et al. (2011). The studies in this dissertation also showed a strong correlation between muscular strength and technical ability, which was consistent with the findings of Iide et al. (2008) and Kostikiadis et al. (2018). In addition, the performance of technical gestures varied significantly among different age groups and years of experience in the sport (Arazi & Izadi, 2017).

The physiological and cognitive adaptations resulting from karate training can be explained by a series of factors. Firstly, regular and systematic karate training can lead to an improvement in body composition by increasing muscle mass and decreasing body fat, which contributes to better physical fitness performance (Chaabe et al., 2016). In addition, karate training involves high-intensity and explosive movements, which contribute to the development of aerobic and anaerobic energy systems, improving endurance and muscular power (Molinaro et al., 2020). Karate training can also improve flexibility, agility, and motor coordination—important characteristics for performing precise technical movements (Iide et al., 2008a).

As children grow and develop physically, their motor skills also improve (Figueredo & Alves, 2019). Changes in muscle size and strength, balance, and coordination can lead to improvements in motor performance (Branco et al., 2019), as seems to be the case with the studied techniques. In addition, the process of biological maturation, which occurs during adolescence, can also influence physical fitness and sports performance (Keshishian Hovik, 2013; Branco et al., 2019; Kayihan, 2014).

This study is important for understanding the relationship between experience, muscular strength, and technical ability in kumite, as well as for the development of technical evaluation tools for karate athletes. It also highlights the importance of training programs that aim to develop

both physical and technical skills to maximize athlete's performance. In short, this research can contribute to the improvement of training and technical evaluation of karate athletes, as well as provide a basis for future studies on the topic.

REFERENCES

Abd El-Kader, A. M. (2010). Efficacy of static and dynamic distance perception on kumite performance in karate. *World J Sport Sci*, 3(S), 205-209.

Alesi, M., Bianco, A., Padulo, J., Vella, F. P., Petrucci, M., Paoli, A., ... & Pepi, A. (2014). Motor and cognitive development: the role of karate. *Muscles, ligaments and tendons journal*, 4(2), 114.

Alinaghipour, M., Zareian, E., & Pooraghaei Ardakani, Z. (2020). The scoring techniques in the final competitions of the Karate World Championships 2016. *Annals of Applied Sport Science*, 8(1), 1-7.

Alves, L. L. F. V. (2019). *Influência da educação física no desenvolvimento motor da criança na educação infantil: Uma breve revisão bibliográfica*. Brasília, Brasil: Faculdade de Ciências da Educação e Saúde, Centro Universitário de Brasília.

American College of Sports Medicine. (2012). *ACSM's resource manual for guidelines for exercise testing and prescription*. Lippincott Williams & Wilkins.

Angera M, Moreno Rosset, & Carmen. (2003). *Evaluación psicológica : concepto, proceso y aplicación en las áreas del desarrollo y de la inteligencia*. Sanz y Torres.

- Anguera, M. T. (2010). Posibilidades y relevancia de la observación sistemática por el profesional de la Psicología. *Papeles del psicólogo*, 31(1), 122-130.
- Arazi, H., & Izadi, M. (2017). Physical and physiological profile of Iranian world-class karate athletes. *Biomedical Human Kinetics*, 9(1), 115-123.
- Beneke, R., Beyer, T., Jachner, C., Erasmus, J., & Hütler, M. (2004). Energetics of karate kumite. *European journal of applied physiology*, 92, 518-523.
- Balsalobre-Fernández, C., Glaister, M., & Lockey, R. A. (2015). The validity and reliability of an iPhone app for measuring vertical jump performance. *Journal of sports sciences*, 33(15), 1574-1579.
- Bartlett, R. (1999). *Sports biomechanics: reducing injury and improving performance*. Taylor & Francis.
- Bober, T. (1981). Biomechanical aspects of sports techniques. In *Biomechanics VII-A*, 501–550.
- Borba, F. D. S. C. D. (2013). *Teste de avaliação da performance em luta* (Doctoral dissertation).
- Božanić, A., & Bešlija, T. (2010). Relations between fundamental motor skills and specific karate technique in 57 year old beginners. *Sport science*, 3(1), 79-83.
- Branco, M. A., Brito, A. V., Seabra, A. P., Mercê, C., Rodrigues Ferreira, M. A., Milheiro, V., & Catela, D. (2019). Exploratory study on maturation and competition level in young karate practitioners. *Revista de Artes Marciales Asiáticas*, 14(1), 1-8.

- Candeias, P. M. C. (2018). Fatores que distinguem os karatecas com melhor desempenho competitivo: uma revisão da literatura (Doctoral dissertation, Universidade de Lisboa (Portugal)).
- Čavala, M. , J. J. , & Č. M. (2015). The influence of the specific motoric abilities and knowledges on the karate kata performance in young karate players. *Acta Kinesiologica*, 9(2), 18–22.
- Chaabene, H., Hachana, Y., Franchini, E., Mkaouer, B., & Chamari, K. (2012). Physical and physiological profile of elite karate athletes. *Sports medicine*, 42, 829-843.
- Chaabène, H., Hachana, Y., Franchini, E., Mkaouer, B., Montassar, M., & Chamari, K. (2012). Reliability and construct validity of the karate-specific aerobic test. *The Journal of Strength & Conditioning Research*, 26(12), 3454-3460.
- Chaabene, H., Hachana, Y., Franchini, E., Mkaouer, B., & Chamari, K. (2012). Physical and physiological profile of elite karate athletes. *Sports medicine*, 42, 829-843.
- Chiu, H.T., & Shiang, T.-Y. (1999). A new approach to evaluating karate punch techniques. *17th International Symposium on Biomechanics in Sport*. p. 61-4.
- Conrad, C., Chamlian, T. R., Ogasowara, M. S., Pinto, M. A. G. S., & Masiero, D. (2015). Tradução para o português, adaptação cultural e validação do Questionário de Avaliação de Próteses. *Jornal Vascular Brasileiro*, 14(2), 110-114.
- Cooper, J. M. and G. R. B. (1976). *Kinesiology*, fourth edition, Saint Louis: Mosby.

Corcoran, John, Farkas, Emil (1988), *Martial Arts - Traditions, History, People*. New York: Gallery Books.

di Placido, Matteo. 2020. “Blending martial arts and yoga for health: From the last samurai to the first Odaka yoga warrior.” *Frontiers in Sociology* 5, (90).

Daniel, P., Carrara, S., Harumi, M., & Tsukamoto, M. (2010). Ginástica artística e especialização precoce: cedo demais para especializar, tarde demais para ser campeão! *Rev. Bras. Educ. Fís. Esporte*, São Paulo, v.24, n.3, p.305-14, 24, n.3, 305–314.

De Quel, Ó. M., Ara, I., Izquierdo, M., & Ayán, C. (2020). Does physical fitness predict future karate success? A study in young female karatekas. *International journal of sports physiology and performance*, 15(6), 868-873.

Doria, C., Veicsteinas, A., Limonta, E., Maggioni, M. A., Aschieri, P., Eusebi, F., ... & Pietrangelo, T. (2009). Energetics of karate (kata and kumite techniques) in top-level athletes. *European journal of applied physiology*, 107(5), 603.

Federação Mundial de Karate [Em Linha] disponível em:

http://www.wkf.net/index.php?option=com_wrapper&view=wrapper&Itemid=54

[consultado em 18-02-2022]

Federação Nacional de Karate-Portugal. [Em Linha]. Disponível em: <http://www.fnkp.pt/home/>

[consultado em 19-02-2022]

- Ferreira, J. F., De Estudos, I., & De Fafe, S. (2011). Modelo Estrutura e conhecimento para a modalidade Karate 2011 Modelo Estrutura e conhecimento para a modalidade Karate Teoria e Metodologia do Treino Desportivo, (Documento não editado).
- Figueiredo, A. (2005). Teoria e Metodologia do Treino de Karate. Lisboa: Centro de Formação de Treinadores da Federação Nacional de Karate – Portugal.
- Figueiredo, A. (2006). A INSTITUCIONALIZAÇÃO DO KARATÉ – Os Modelos Organizacionais do Karaté em Portugal. Tese de Doutoramento – FADEUP: Porto.
- Figueiredo, A. (Novembro-Dezembro de 1987). O Significado Actual do Karaté – Arte Marcial / Desporto de Combate. Revista de Educação Física e Desporto – Horizonte, pp. Dossier I-VII.
- Figueiredo, A., & Dias, J. (2002). Teoria e Metodologia do Treino de Karaté: Módulo de Metodologia do Treino de Karaté (Fatores, Princípios, Componentes, Planeamento). Federação Nacional de Karaté – Portugal, Setor Técnico – Departamento de Formação, Centro de Formação de Treinadores (não publicado).
- Glaister, M. (2005). Multiple sprint work: physiological responses, mechanisms of fatigue and the influence of aerobic fitness. *Sports medicine*, 35, 757-777.
- Giampietro, M., Pujia, A., & Bertini, I. (2003). Anthropometric features and body composition of young athletes practicing karate at a high and medium competitive level. *Acta diabetologica*, 40, s145-s148.

- Gomes, D. M. A. D. R. (2016). Avaliação da Força no Karate: O Membro Superior Pontuador na Ação de Gyaku-Tsuki (Doctoral dissertation, Universidade de Lisboa (Portugal)).
- Gunawan, G. (2021). Comparison of the physical fitness of karate and taekwondo elite athletes. *Journal of Education, Health and Sport*, 11(10), 221-228.
- Hachaj, T., Ogiela, M. R., & Piekarczyk, M. (2014). Real-time recognition of selected karate techniques using GDL approach. In *Image Processing and Communications Challenges 5* (pp. 99-106). Springer International Publishing.
- Hariri, S., & Sadeghi, H. (2018). Biomechanical analysis of mawashi-geri technique in karate. *International Journal of Sport Studies for Health*, 1(4), 843-849.
- Hay, J. G., & Reid, J. G. (1982). *The anatomical and mechanical bases of human motion*. Prentice Hall.
- Ibáñez, R., Lapresa, D., Arana, J., Camerino Foguet, O., & Anguera, M. T. (2018). Observational analysis of the technical-tactical performance of elite karate contestants. *Cultura, Ciencia y Deporte*, 2018, vol. 13, núm. 37, p. 61-70.
- Iide, K., Imamura, H., Yoshimura, Y., Yamashita, A., Miyahara, K., Miyamoto, N., & Moriwaki, C. (2008). Physiological responses of simulated karate sparring matches in young men and boys. *The Journal of Strength & Conditioning Research*, 22(3), 839-844.
- Junior, N. K. M. (2015). Velocity of the offensive technique of the karate for the mixed martial arts fighter: a systematic review. *Revista Observatorio del Deporte*, 29-62.

- Junior, N. K. M. (2022) Punch and Kick Impact of the Karate: A Review. Independent Researcher, Niteroi, Rio de Janeiro, 14(2), 66-76.
- Kahrović, I. H., Nurkic, M., Bratic, M., Jovanovic, S., & Radenkovic, O. (2015). Differences between Karate Practitioners of Varied Competition Orientations in Specific Motor Tests Results. *Facta Universitatis, Series: Physical Education and Sport*, 227-239.
- Kawamori, N. , & H. G. G. (2004). The optimal training load for the development of muscular power. *Journal of Strength and Conditioning Research*, 18(3), 675–684.
- Kayihan Gurhan. (2014). Comparison of physical fitness levels of adolescents according to sports participation: martial arts, team sports and non-sports. *Archives of Budo*, 10, 227–232. www.archbudo.com
- Kazemi, M., Waalen, J., Morgan, C., & White, A. R. (2006). A profile of Olympic taekwondo competitors. *Journal of sports science & medicine*, 5(CSSI), 114-121.
- Keshishian Hovik. (2013). *Motor Fitness Profiling of Elite and Novice Karate Practitioners*. Australian Catholic University.
- Koropanovski, N. , D. M. , & J. S. (2008). Characteristics of pointing actions of top male competitors in karate at world and European level. *Brazilian Journal of Biomotricity*, 2(4), 241–251. www.kombatklub.com
- Koropanovski, N., Berjan, B., Bozic, P., Pazin, N., Sanader, A., Jovanovic, S., & Jaric, S. (2011). Anthropometric and physical performance profiles of elite karate kumite and kata competitors. *Journal of human kinetics*, 30(2011), 107-114.

- Kostikiadis, I. N., Methenitis, S., Tsoukos, A., Veligekas, P., Terzis, G., & Bogdanis, G. C. (2018). The effect of short-term sport-specific strength and conditioning training on physical fitness of well-trained mixed martial arts athletes. *Journal of sports science & medicine*, 17(3), 348.
- Laird, P., & McLeod, K. (2009). Notational analysis of scoring techniques in competitive men's karate. *International Journal of Performance Analysis in Sport*, 9(2), 171-187.
- Loturco, I., Artioli, G. G., Kobal, R., Gil, S., & Franchini, E. (2014). Predicting punching acceleration from selected strength and power variables in elite karate athletes: a multiple regression analysis. *The Journal of Strength & Conditioning Research*, 28(7), 1826-1832.
- MacDonald, A. M. (1972). *Chambers 20th century dictionary*. WR Chambers, Edinburgh.
- Malina, R.; Bouchard, C.; Shoup, R.; Demirjian, A. & Lariviere, G. (1982). Growth and maturity status of montreal olympic athletes less than 18 years of age. *Medicine Sport*, 16: 117-127. Karger, Basel
- Marquezin, M. R. , Medin, J. , Campos, F. D. S. , Teixeira, A. S. , Flores, L. J. F. , & Nunes, R. F. (2019). Comparação das características antropométricas e da potência aeróbia de atletas de futebol em diferentes categorias e estágios maturacionais. *R. Bras. Ci. e Mov*, 27(3), 84–92.
- Mendes, R., Clemente, F., Rocha, R., & Damásio, A. S. (2012). Observação como instrumento no processo de avaliação em Educação Física. *Exedra: Revista Científica* 57, 6, 57–70.

- Molinaro, L., Taborri, J., Montecchiani, M., & Rossi, S. (2020). Assessing the effects of kata and kumite techniques on physical performance in elite karatekas. *Sensors*, 20(11), 3186.
- Moura, R. M. F. D., Gonçalves, G. S., Navarro, T. P., Britto, R. R., & Dias, R. C. (2011). Adaptação transcultural do questionário VEINES/QOL-SYM: avaliação da qualidade de vida e sintomas na doença venosa crônica. *Jornal Vascular Brasileiro*, 10, 17-23.
- Nunan, D. (2006). Development of a sports specific aerobic capacity test for karate-a pilot study. *Journal of sports science & medicine*, 5(CSSI), 47-53.
- Obradović, B., Madić, D., Drid, P., Bogdanovski, M., & Sporiš, G. (2017). Muscle strength assessment of upper and lower limbs in elite male karate athletes: comparative study between different age groups. *Acta Kinesiol*, 11(1), 94-99.
- Ojeda-Aravena, A., Herrera-Valenzuela, T., Garcia Garcia, J. M., & Ramirez-Campillo, R. (2020). Six weeks of HIIT based on repeated 5-meter sprints vs. countermovement jumps: effects on physical performance among karate athletes. A pilot-study. *Ido Movement for Culture. Journal of Martial Arts Anthropology*, 20(2), 17-23.
- Loturco, I., Artioli, G. G., Kopal, R., Gil, S., & Franchini, E. (2014). Predicting punching acceleration from selected strength and power variables in elite karate athletes: a multiple regression analysis. *The Journal of Strength & Conditioning Research*, 28(7), 1826-1832.
- Pinto-Escalona, T., Gobbi, E., Valenzuela, P. L., Bennett, S. J., Aschieri, P., Martin-Loeches, M., Paoli, A., & Martinez-de-Quel, O. (2021). Effects of a school-based karate intervention on academic achievement, psychosocial functioning, and physical fitness: A multi-country

cluster randomized controlled trial. *Journal of Sport and Health Science*, Advance Online Publication.

Przybylski, P., Janiak, A., Szewczyk, P., Wieliński, D., & Domaszewska, K. (2021).

Morphological and motor fitness determinants of shotokan karate performance.

International journal of environmental research and public health, 18(9), 4423.

Quinzi, F., Camomilla, V., Di Mario, A., Felici, F., & Sbriccoli, P. (2016). Repeated kicking

actions in karate: Effect on technical execution in elite practitioners. *International journal of sports physiology and performance*, 11(3), 363-369.

Rakita, D., Rakonjac, D., Jurisic, M., & Obradovic, J. (2018). The influence of morphological

characteristics on the specific motor skills of junior-age karate athletes. *EQOL Journal*, 10(1), 43-49.

Rangel, E. (2011). Análisis Biomecánico del Ura Mawashi Geri. *Universidad de Los Andes*

Facultad de Humanidades y Educacion. (Doctoral dissertation, (Spain)).

Ravier, G., Grappe, F., & Rouillon, J. D. (2003). Comparaison de deux méthodes d'analyse des

variables maximales de vitesse, force et puissance dans l'évaluation fonctionnelle en karaté. *Science & sports*, 18(3), 134-140.

Ribas, M. R., Pereira, M. A. S., Barbosa, T. A., Lass, A. D., & Bassan, J. C. (2020). Tactical and

technical performance analysis of the male 65 kg category at the Brazilian shotokan karate championship. *Journal of Physical Education*, 31(-), 1-7.

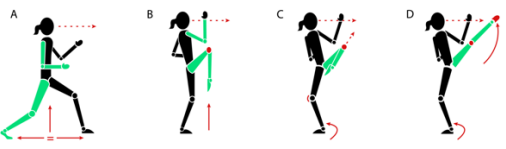
- Rodrigues, J., & Louro, H. (2016). Observação e análise das habilidades desportivas. In IPDJ-DFQ (Ed), Referenciais de Formação Geral–Cursos de Treinadores de Desporto (Grau I) Plano Nacional de Formação de Treinadores
- Rosa, B., & Gonçalves J. (2007, July 7). “Percepção&Acção”-O Processo de Tomada de Decisão no Karaté. *Confederação Portuguesa Das Associações de Treinadores*.
- Sastre, V., Lapresa, D., Arana, J., Ibáñez, R., & Anguera, M. T. (2021). Observational analysis of technical-tactical performance in initiation to combat in karate. *International Journal of Performance Analysis in Sport*, 21(1), 126-138.
- Slankamenac, J., Bjelica, D., Jaksic, D., Trivic, T., Drapsin, M., Vujkov, S., ... & Drid, P. (2021). Somatotype profiles of montenegrin karatekas: An observational study. *International Journal of Environmental Research and Public Health*, 18(24), 12914.
- Spigolon, D., Hartz, C. S., Junqueira, C. M., Longo¹, A. R., Tavares¹, V., Fayçal¹, H., De Paula¹, M., Jacinto¹, L. C., & Moreno, M. A. (2018). The Correlation of Anthropometric Variables and Jump Power Performance in Elite Karate Athletes. *Journal of Exercise Physiologyonline February*, 21(1), 139-148.
- Styriak, R., Billman, M., & Augustovicova, D. (2020). Karate agility: The new competition category for children’s physical development with very high test/re-test reliability. Ido Movement for Culture. *Journal of Martial Arts Anthropology*, 20(3), 32-27.
- Swennen, F., & Matsui, K. (2000). The Evolution of Karate: From Secret Martial Art to Worldwide Cultural Sport. International Budo University, Japan.

- Szczęsna, A., Błaszczyzyn, M., & Pawlyta, M. (2021). Optical motion capture dataset of selected techniques in beginner and advanced Kyokushin karate athletes. *Scientific Data*, 8(1), 13.
- Tabben, M., Coquart, J., Chaabène, H., Franchini, E., Chamari, K., & Tourny, C. (2014). Validity and reliability of a new karate-specific aerobic field test for karatekas. *International journal of sports physiology and performance*, 9(6), 953-958.
- Wainer, H., & Braun, H.I. (Eds.). (1988). *Test Validity* (1st ed.). New York: Routledge.
- Zätterström, R., Fridén, T., Lindstrand, A., & Moritz, U. (2000). Rehabilitation following acute anterior cruciate ligament injuries-a 12-month follow-up of a randomized clinical trial. *J Med Sci Sports*, 10, 156–163.
- Zehr, E. P., & Sale, D. G. (1993). Oxygen uptake, heartrate and blood lactate responses to the Chito-Ryu Seisan kata in skilled karate practitioners. *International Journal of Sports Medicine*, 14(05), 269-274.

ATTACHEMENTS

Observation sheet - Level I

6 Mawashi geri jodan (Observation and Success Criteria)

• Foot with light touch (skin touch) on the target or up to 5 centimeters away. • <i>Kamae</i> • Always run with the back foot (switch) • Raise the knee, • Rotate in block with the support between 135 and 180 • Foot in extension at the end of the technique, knee extended and oriented horizontally, look at the target. • <i>Hiki ashi</i> (technique recovery/heel to gluteal), support the foot next to the other and exchange the guard..							
	<table border="1"> <tr> <td data-bbox="771 787 820 924"></td><td data-bbox="820 787 1307 924"> 3) Excellent (can perform with all success criteria) </td></tr> <tr> <td data-bbox="771 924 820 1155"></td><td data-bbox="820 924 1307 1155"> 2) Medium (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard). </td></tr> <tr> <td data-bbox="771 1155 820 1375"></td><td data-bbox="820 1155 1307 1375"> 1) Bad (fails in any of these aspects, does not lateralize the torso during the execution phase, does not orient the action horizontally when finishing, and does not change the guard) </td></tr> </table>		3) Excellent (can perform with all success criteria)		2) Medium (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard).		1) Bad (fails in any of these aspects, does not lateralize the torso during the execution phase, does not orient the action horizontally when finishing, and does not change the guard)
	3) Excellent (can perform with all success criteria)						
	2) Medium (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard).						
	1) Bad (fails in any of these aspects, does not lateralize the torso during the execution phase, does not orient the action horizontally when finishing, and does not change the guard)						

6 Jodan Kizami Tsuki (Observation and Success Criteria)

1nd Preparation: Start from the position of Kamae (guard) 2nd The execution phase: Complete extension of the front upper limb, simultaneously with the entrance of the lower limb to the front, moving the center of mass to the control distance between 0.1 and 10 cm from the target, support directed to the front. 3nd Recovery Phase: Do Gyaku Kamae, slightly remove the anterior lower limb with the foot at 20° internal degrees, remove in a straight line the upper limb that performed the strike and return in line the back support rotates the anterior third to allow the total rotation of the hip. Swap midway through the exercise	<table border="1"> <tr> <td data-bbox="768 506 824 646"></td><td data-bbox="824 506 1304 646"> 3) Excellent (can perform with all success criteria). </td></tr> <tr> <td data-bbox="768 646 824 877"></td><td data-bbox="824 646 1304 877"> 2) Medium (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard in place). </td></tr> <tr> <td data-bbox="768 877 824 1100"></td><td data-bbox="824 877 1304 1100"> 1) Bad (fails in any of these aspects, does not lateralize the torso in the recovery phase, does not move the center of mass in the technique, and does not exchange the guard correctly). </td></tr> </table>		3) Excellent (can perform with all success criteria).		2) Medium (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard in place).		1) Bad (fails in any of these aspects, does not lateralize the torso in the recovery phase, does not move the center of mass in the technique, and does not exchange the guard correctly).
	3) Excellent (can perform with all success criteria).						
	2) Medium (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard in place).						
	1) Bad (fails in any of these aspects, does not lateralize the torso in the recovery phase, does not move the center of mass in the technique, and does not exchange the guard correctly).						

6 Chudan Gyakuzuki (Observation and Success Criteria)

1st In the preparation phase the torso should be positioned between 10° and 20°, the supports slightly apart and bent, and the CG (Chudan Gyakuzuki) slightly lower. 2nd In the execution phase, an external rotation of the torso between 90° and 135° should be performed. Rapid, direct, and linear extension of the upper body to the target, there must be a controlled impact at the final moment of the action, the opposite upper body must rise slightly, protecting the opposite zone. The center of mass should remain lower and closer to the support of the front hand. Coordinate the movement of the upper limb extension, the rotation of the torso and hip, the displacement and flexion of the front upper limb, simultaneously. 3rd In the recovery phase, the torso should return to a position close to 10° to 20°. Perform a fast approach to anterior support. Change in the middle of the exercise	<table border="1" data-bbox="771 745 1307 1346"> <tr> <td data-bbox="771 745 820 892"></td><td data-bbox="820 745 1307 892"> 3) Excellent (can perform with all success criteria) </td></tr> <tr> <td data-bbox="771 892 820 1123"></td><td data-bbox="820 892 1307 1123"> 2) Medium (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard in place). </td></tr> <tr> <td data-bbox="771 1123 820 1346"></td><td data-bbox="820 1123 1307 1346"> 1) Bad (fails in any of these aspects, does not lateralize the torso in the recovery phase, does not move the center of mass in the technique, and does not exchange the guard correctly) </td></tr> </table>		3) Excellent (can perform with all success criteria)		2) Medium (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard in place).		1) Bad (fails in any of these aspects, does not lateralize the torso in the recovery phase, does not move the center of mass in the technique, and does not exchange the guard correctly)
	3) Excellent (can perform with all success criteria)						
	2) Medium (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard in place).						
	1) Bad (fails in any of these aspects, does not lateralize the torso in the recovery phase, does not move the center of mass in the technique, and does not exchange the guard correctly)						

6 Ura Mawashi Geri (Observation and Success Criteria)

1st Preparation phase of the base guard. 2nd In the execution phase, the upper limb should be lifted from behind to the midline of the trunk using body compression, then quickly rotated in anterior rotation of the torso, expanding the leg by external circular extension of the upper limb, and placing the foot in extension. The body segments must always be completely aligned in the previous phases (lower limb support, hip joint, trunk, and lower limb in elevation aligned). 3rd In the recovery phase, you should return to the guard position by changing the supports and guard to execute again.	<table border="1" data-bbox="769 506 1304 1100"> <tr> <td data-bbox="769 506 824 646"></td><td data-bbox="824 506 1304 646"> 3) Excellent (can perform with all success criteria) </td></tr> <tr> <td data-bbox="769 646 824 877"></td><td data-bbox="824 646 1304 877"> 2) Medium (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard in place). </td></tr> <tr> <td data-bbox="769 877 824 1100"></td><td data-bbox="824 877 1304 1100"> 1) Bad (fails in any of these aspects, does not lateralize the torso in the recovery phase, does not move the center of mass in the technique, and does not exchange the guard correctly) </td></tr> </table>		3) Excellent (can perform with all success criteria)		2) Medium (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard in place).		1) Bad (fails in any of these aspects, does not lateralize the torso in the recovery phase, does not move the center of mass in the technique, and does not exchange the guard correctly)
	3) Excellent (can perform with all success criteria)						
	2) Medium (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard in place).						
	1) Bad (fails in any of these aspects, does not lateralize the torso in the recovery phase, does not move the center of mass in the technique, and does not exchange the guard correctly)						

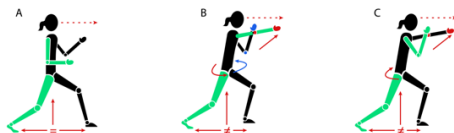
Observation sheet - Level II

10 Mawashi geri jodan (Observation and Success Criteria)

1st Preparation phase of the base guard. 2nd In the execution phase, the upper limb should be lifted from behind to the midline of the trunk using body compression, then quickly rotated in anterior rotation of the torso, expanding the leg by external circular extension of the upper limb, and placing the foot in extension. The body segments must always be completely aligned in the previous phases (lower limb support, hip joint, trunk, and lower limb in elevation aligned). 3rd In the recovery phase, you should return to the guard position by changing the supports and guard to execute again.	<table border="1" data-bbox="768 489 1304 1083"> <tr> <td data-bbox="768 489 824 625"></td><td data-bbox="824 489 1304 625"> 3) Excellent (can perform with all success criteria) </td></tr> <tr> <td data-bbox="768 625 824 856"></td><td data-bbox="824 625 1304 856"> 2) Medium (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard). </td></tr> <tr> <td data-bbox="768 856 824 1083"></td><td data-bbox="824 856 1304 1083"> 1) Bad (fails in any of these aspects, does not lateralize the torso during the execution phase, does not orient the action horizontally when finishing, and does not change the guard) </td></tr> </table>		3) Excellent (can perform with all success criteria)		2) Medium (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard).		1) Bad (fails in any of these aspects, does not lateralize the torso during the execution phase, does not orient the action horizontally when finishing, and does not change the guard)
	3) Excellent (can perform with all success criteria)						
	2) Medium (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard).						
	1) Bad (fails in any of these aspects, does not lateralize the torso during the execution phase, does not orient the action horizontally when finishing, and does not change the guard)						

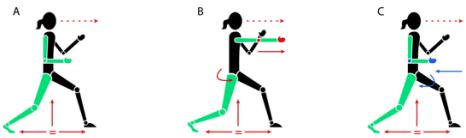
10 Jodan Kizami Tsuki (Observation and Success Criteria)

1nd Preparation: Start from the position of Kamae (guard) 2nd The execution phase: Complete extension of the front upper limb, simultaneously with the entrance of the lower limb to the front, moving the center of mass to the control distance between 0.1 and 10 cm from the target, support directed to the front. 3nd Recovery Phase: Recovery Phase, perform the posterior hayumiashi leaving at 45° to the guard, and one more short posterior Yori ashi	<table border="1" data-bbox="768 1638 1304 1866"> <tr> <td data-bbox="768 1638 824 1774"></td><td data-bbox="824 1638 1304 1774"> 3) Excellent (can perform with all success criteria). </td></tr> <tr> <td data-bbox="768 1774 824 1866"></td><td data-bbox="824 1774 1304 1866"> 2) Medium (misses some success criteria, however, manages to execute the </td></tr> </table>		3) Excellent (can perform with all success criteria).		2) Medium (misses some success criteria, however, manages to execute the
	3) Excellent (can perform with all success criteria).				
	2) Medium (misses some success criteria, however, manages to execute the				

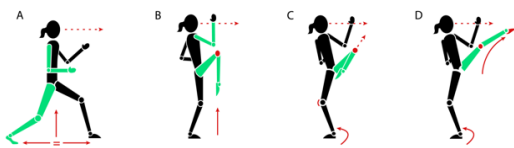
of preparation, in Hidari Kamae (left guard in front). Execution in reversed V		action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard in place).
		1) Bad (fails in any of these aspects, does not lateralize the torso in the recovery phase, does not move the center of mass in the technique, and does not exchange the guard correctly).
		

10 Chudan Gyakuzuki (Observation and Success Criteria)

1rd In the preparation phase the torso should be positioned between 10° and 20°, the supports slightly apart and bent and the CG slightly lower with Hidari Kamae at 25° degrees from the front. 2rd In the execution phase, an external rotation of the trunk between 90° and 135° must be performed. Quick, direct, and linear extension of the upper limb to the target, there must be a controlled impact in the final moment of the Action, the opposite upper limb must rise slightly protecting the opposite zone. The center of mass must remain lower and closer to the front upper limb support. Coordinate the movement of the upper limb extension, the rotation of the trunk and hip joint, the displacement and flexion of the lower limb forward, simultaneously. 3rd In the recovery phase the torso must return to an initial position, perform a lateral displacement in Yoko Yori ashi (lateral		
		3) Excellent (can perform with all success criteria)
		2) Medium (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes

displacement) with the previous support, to prepare a new action in Migi Kamae. Pyramid Execution.		the torso well, and rebalances correctly by changing the guard in place).
		1) Bad (fails in any of these aspects, does not lateralize the torso in the recovery phase, does not move the center of mass in the technique, and does not exchange the guard correctly)
		

10 Ura Mawashi Geri (Observation and Success Criteria)

1st Preparation phase of the base guard. 2nd In the execution phase, the upper limb should be lifted from behind to the midline of the trunk using body compression, then quickly rotated in anterior rotation of the torso, expanding the leg by external circular extension of the upper limb, and placing the foot in extension. The body segments must always be completely aligned in the previous phases (lower limb support, hip joint, trunk, and lower limb in elevation aligned). 3rd In the recovery phase, you should return to the guard position by changing the supports and guard to execute again.		
		3) Excellent (can perform with all success criteria)
		2) Medium (misses some success criteria, however, manages to execute the action in the correct distance, lateralizes the torso well, and rebalances correctly by changing the guard in place).
		1) Bad (fails in any of these aspects, does not lateralize the torso in the recovery phase, does not move the center of mass in the technique, and does not exchange the guard correctly)

