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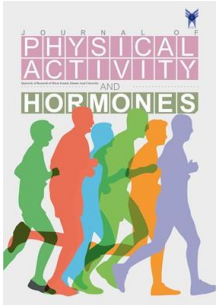

Relationship between functional movement screen and athletic and karate performance in female adolescent karateka

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Abstract

Introduction: The athletic and functional performance tests are widely used to determine physical ability and set performance goals. This study aimed to evaluate the relationship between functional movement and physical and karate-specific performance in female adolescents.

Material & Methods: Karate technique) gedan barai،gedan barai/gyako zuki ،Edgren side-step test ،triangle step and mawashi geri), athletic performance) 20-m(10-m) sprint as a standard assessment of speed and acceleration; agility t-test; single-leg horizontal jump; 1-minute sit-up and push-up tests; standing toe reach flexibility(, and Functional Movement Screen (FMS^{TM}) were evaluated in 51 female adolescent karateka (age: 14 ± 1.18 years, weight: 51.13 ± 10.92 kg, height: 1.58 ± 0.08 cm). Correlation analysis determined the association between the various tests, and stepwise linear regression established performance prediction models.

Results: Only individual FMS^{TM} tests of hurdle step ،in-line lunge and rotary stability significantly correlated with gedan barai،gedan barai/gyako zuki ،Edgren side-step test and mawashi geri (r=0.33, r=0.35, r=-0.24, r=0.33, respectively). Muscular endurance, power, and agility significantly ($p < 0.05$) correlated with karate side-step and gedan barai/jaku zuki.

Conclusion: A compound of functional and athletic tests is probably used to assess young athletes' predisposition to karate. The training concentrated in young karateka should be on expanding basic movement capacity along with fundamental sport-specific skills to let the young athlete's natural physical development.

1. Introduction

Karate is one of the oldest and most popular forms of Japanese martial arts. Previous research shows that participation in karate increases strength, speed, balance, posture, and coordination (1). Karate is a philosophy, a way of life (2). Martial arts originated from China, Korea, and Japan and include techniques for fighting using different parts of the body. The most important benefits of these exercises are increases in physical fitness, self-defense, flexibility, and self-confidence. The martial arts have gained popularity over the years, and these Eastern sports are now practiced all over the world. Karate is recognized as one of the most popular martial arts in the world, and its popularity continues to increase in Iran (3). Today, karate is one of the most popular sports in Iran, and many champions such as Abbas Ali, Mehdizadeh, Amozadeh, Batovani and Rouhani brothers, Ganjzadeh, etc. have been introduced to karate in the world. Currently, this discipline is in all the provinces of our country.

It is active and there are karate boards and clubs in most cities of the country (4). However, as the popularity increases, the emphasis on youth participation is shifting from recreational enjoyment-driven activity to a structured sport-specific skill development with concentration on excelling through different levels. In this regard, children and adolescents need to develop proficiency in fundamental movement skills as specialized sport-specific skills required for level progression (5, 6).

The martial art of karate requires highly developed technical skills, which, amongst others, include control of static and dynamic movements. Karate has a complex structure, and the competitors' physical fitness, technique, tactics, and mental state all affect successful performance (7). Previous research shows that participation in karate increases strength, speed, balance, posture, and coordination, and is, therefore, a recommended physical(1,8). Yet, to our knowledge, for martial arts and karate, there is limited data on trustworthy screening strategies that coaches may use in aiming young karateka. Functional Movement Screen (FMS) has become a widely used tool to identify fundamental movement limitations and assess movement quality, muscle strength, flexibility, range of motion, balance, and coordination(8,9,10). Functional movement skills, however, refer to the movement pattern that underpins all other movements and is needed for successful engagement in health-enhancing physical activity and sports performance. The concept of functional movement is well-established in the literature. The Functional Movement Screen has been established as the predominant tool used for functional movement assessment. The FMS is comprised of seven movements aimed at the assessment of mobility, flexion, extension, and stability. The squat, lunge, and hurdle step tests are described as higher-level patterns that are proposed to examine the three essential foot positions taken up in sports. The rotary stability and press-up tests are known as transitionary patterns and predominantly assess tri-planar and sagittal stability. Finally, the lower-level mobility patterns of the body are assessed by the active straight leg raise and the shoulder mobility tests (8,9)

Based on this, Krkeljas et al (8), tested the relationship between functional movement and physical and karate-specific performance in adolescents. The primary found of this study indicate that the total FMSTM score had no significant relationship with karate-specific or fitness tests in participants. Fitness tests had a significant moderate-to-large association with karate performance. Atalay et al (10), tested the Effect of Taekwondo Training on Children's Functional Movement Screen (FMS) Scores and Athletic Performance Parameters. No significant difference was found between groups in FMS, strength, balance, and vertical jump measurements. Katie Davies et al (9), this study systematically reviews the literature examining the relationship between Functional Movement Screen (FMS) scores and athletic performance in youth. The results of this systematic review suggest that children and youth who are highly on the FMS also tend to have better scores for agility, running speed, strength, and cardiovascular endurance.

Yet, despite these differences, there is limited data on using FMS to evaluate functional movement capacity in karateka. Furthermore, even with its widespread application, studies have reported equivocal results in FMS's relationship to athletic performance and its use in evaluating young athletes. Therefore, in order to help coaches and trainers develop karate-specific screening tests that might be employed to identify physical and functional deficiencies in young karateka,primary aim of this study was to determine if a relationship exists between FMS, athletic performance, and karate-specific techniques in young athletes.

2. Materials and methods

Overall, 51 female adolescent karate athletes (average age 14 ± 1.18 years, weight 51.13 ± 10.92 kg, height 1.58 ± 0.08 cm) volunteered for the study. The participants had 3.5 ± 2.42 years of karate experience on average, with belt color ranging from orange to black. They were eligible for the study if they (1) were aged 13-16 years; (2) were free of any musculoskeletal injuries; (3) were able to complete all the required tests; (4) had at least 1 year of continuous karate practice; and (5) provided their assent and a written consent from their parents/guardians to participate in the study. All tests were performed across 3 different sessions: FMSTM, athletic performance, and karate performance. The study was reviewed and approved by the Human Ethics Committee of the Rash Branch, Islamic Azad University (IR.IAU.RASHT.REC.1401.033).

2.1. Functional Movement Screen (FMSTM)

FMSTM constitutes a battery of 7 tests which were explained in detail by Cook (11). Briefly, the participants were evaluated on the execution of a deep squat (DS), hurdle step (HS), in-line lunge (ILL), shoulder mobility (SM), active straight leg raise (ASLR), trunk stability push-up (TSPU), and rotary stability (RS). Each test was scored on an ordinal scale of 1–3, in accordance with the standardized criteria set by Cook (11). The functional screen assessment was performed by a qualified sports scientists with Level 2 FMSTM certification (10, 12).

2.2. Athletic performance

The following tests of athletic performance were selected from prior studies that identified their association with karate performance (13); therefore, only a concise description of each test will be provided: 20-m(10-m) sprint as a standard assessment of speed and acceleration (14); agility t-test (15); single-leg horizontal jump to assess leg power and bilateral functional asymmetry (16); 1-minute sit-up and push-up tests (17); standing toe reach flexibility (18). The athletes performed 3 trials with a 5-minute rest interval for each test.

2.3. Karate performance

The chosen tests of karate performance were also formerly validated (19, 20, 21, 22); therefore, only a brief description will be provided. Side-step is a karate modification of the Edgren side-step test. The participants were asked to 'shuffle' 6 times the distance of 5 meters as fast as possible while holding the combat karate position, fudo dachi (19, 20, 21, 22). The triangle step is used to estimate specific movement speed by moving as fast as possible in a guard position along the sides of an equilateral triangle with 3-m long sides (19, 20, 22). The combination of a blockade and a blow, gedan barai/ gyako zuki, is one of the fundamental combinations in karate, and the subjects were asked to perform this combination 5 times at a maximal speed while hitting a bag (19, 20, 22). Lastly, the athletes were

assessed on the speed of a blocking technique, gedan barai, by performing a maximum number of blockades in 30 seconds (19, 20,22), as well as on the speed of a karate kick, mawashi geri, by performing as many kicks against a punch bag as possible in 30 seconds. The height of the kick was marked on the bag equivalent to the participant's neck height (19, 20, 22). The participants were to perform each kick from the same starting position, and had to at least touch the indicated line to be counted. The correct execution of the karate techniques was evaluated by a black belt karate instructor, and the best of 3 trials was used for analysis (22).

2.4. Statistical Methods

The statistical analysis was performed with SPSS version 27. A two-tailed Pearson correlation analysis to determine the association between the fitness tests, FMSTM, and the karate-specific tests. A stepwise multiple regression analysis was used to establish the impact of performance variables on each karate performance variable. The statistical significance of the results was accepted at $p < 0.05$.

3. Results

Table 1 presents the participants' performance data.

Table1. *Test results for all performance variables*

Variable	Mean ± SD	95% CI
Sit-and-reach (cm)	33.55±8.76	31.08-36.01
FMS^{TM} score	13.27±2.70	12.51-14.04
10-m sprint (s)	2.86±0.38	2.75-2.96
20-m sprint (s)	5.40±0.56	5.24-5.56
Agility t-test (s)	14.41±1.49	13.99-14.83
Hop test (cm)	9.07±23.51	1.27-1.41
Sit-up (n)	40.94±8.71	38.49-43.39
Push-up (n)	10.16±7.15	8.14-12.17
Side-step (s)	21.64±3.78	20.57-22.70
Triangle step (s)	9.32±1.41	8.92-9.72
Gedan barai/gyaku zuki (s)	7.13±1.68	6.65-7.60
Gedan barai (n)	21.80±4.46	20.55-23.06
Mawashi geri (n)	36.02±15.43	31.68-40.36

The inferential analysis (Table 2) shows that several FMS^{TM} tests in-line lunge (ILL), hurdle step (HS), and rotary stability (RS) demonstrated significant associations with specific components of karate performance.

The relationship between fitness and karate tests is presented in Table 3, which indicates that the fitness tests had a significant moderate-to-large association with karate performance. The inferential analysis (Table 3) shows that several fitness tests – Flexibility, Sit-up, 10-m and 20-m sprint, Agility t-test, and Hop test – demonstrated significant associations with specific components of karate performance.

Table 2. *Pearson correlation between karate performance and FMSTM tests*

	Side-step	Triangle step	Gedan barai/ gyaku zuki	Gedan barai	Mawashi geri
Deep squat	0.045	-0.092	-0.11	0.056	-0.005
Hurdle step	-0.199	-0.133	0.357*	0.334*	0.2
In-line lunge	-0.244*	0.022	-0.151	-0.059	-0.225
Shoulder mobility	-0.029	-0.01	-0.209	0.176	0.038
Active straight leg raise	-0.201	0.015	-0.23	0.197	-0.042
Push-up	-0.064	0.074	-0.154	0.03	-0.146
Rotary stability	-0.078	0.011	-0.147	0.197	0.335*

Note: *Anova significant differences ($p<0.05$)

Table 3. *Pearson correlation between karate performance and athletic screen*

	Side-step	Triangle step	Gedan barai/ gyaku zuki	Gedan barai	Mawashi geri
Flexibility	-0.237	-0.324*	-0.133	0.231	0.174
Sit-up	-0.408*	-0.290*	-0.461*	0.456*	0.477*
Push-up	-0.167	-0.182	-0.233	0.092	0.066
10-m sprint	0.359*	0.376*	0.353*	-0.401*	-0.365*
20-m sprint	0.441*	0.383*	0.217	-0.178	-0.345*
Agility t-test	0.417*	0.25*	0.32*	-0.258*	-0.225
Hop test	-0.352*	-0.119	-0.291*	0.491*	0.445*

Note: *Anova significant differences ($p<0.05$)

4. Discussion

The findings of this study indicate that the total FMS^{TM} score had no significant relationship with karate-specific or fitness tests in our participants. However, the individual tests focusing on core strength and control, hip mobility, and flexibility (ILL, HS, and RS, respectively) were associated with karate performance and may be suitable for screening motor control in young karateka. In addition, sit-ups, Agility t-test, 10-20m sprints, Hop test, and Flexibility seem to be significant predictors of karate-specific performance in young athletes.

Firstly, the HS test score corresponded with gedan barai and gedan barai gyaku zuki. As the name designates, the HS test design is a necessary piece of motion and speeding up. This movement challenges the body's step and step mechanics while testing the stability and control in a single-leg position and need respective mobility and stability of hips, knees, and lower legs (23). Hurdle step test additionally adds difficulties of stability and control of the pelvis and center as it offers a chance to watch functional balance (24). Therefore, during the gedan barai/gyaku zuki combination, karateka starts and finishes the combination in the zankutsu dachi position (front stance), while keeping a straight and stable posture. The mobility and stability needed to transition between subsequent stance positions enable karateka to avoid the opponent's attack (8).In the same way, during the HS test, the stance leg provides stability, while the forward leg (hip) has to demonstrate adequate mobility to step over the hurdle (23). The karateka must maintain a stable and erect trunk position to assume the optimal position for the follow-up block/blow combination (8).

Similarly, the Side-step test was associated with the ILL test, both tests, let us assess the mobility and stability of the torso, pelvis, hip, knee, and ankle joints. Side-step test is a specialized test to measure agility. Agility consists of deceleration, stop, and reacceleration processes. During deceleration athlete benefits from eccentric contraction (25). In the In-line Lunge Test, the effectiveness of eccentric contraction is one of the abilities that is examined it means testing of deceleration. The test assesses the mobility of hip joints and knee joints, as well as the flexibility of the quadriceps which is accountable for knee stability (26).

The Mawashi geri test was associated with the RS test, Rotational Stability assesses torso stability in the sagittal plane (23). The rotary stability test evaluates complex torso stability during alternating limb movement. A condition to perform this task is the ability to stabilize the torso in the transverse and sagittal planes asymmetrically. Numerous functional activities in sports require proper stability of the torso to transfer strength from asymmetrical upper limbs to

lower limbs and vice versus If the torso does not have proper stability during the activities, kinetic energy can be lost which will lead to low efficiency and an increased risk of injuries (26). In Karate kicks to the head zones bring more points and to take these points, the athlete should apply more force to the ground and jump up higher levels to make kicking easier (25). The Mawashi Geri kick technique is carried out centered on the lower extremity of the body. This part has an important role in providing balance and supporting the body when performing kick techniques. The kicking technique needs balance and coordination in a range of motion involving the trunk, hips, knees, ankles, and feet that allow hip-to-toe linkage due to activation of neuromuscular support in the lower extremities also when performing the Mawashi Geri kick and one foot remains on the floor so that the balance of the body is maintained. The foot of support becomes the center of balance which provides power to the other foot, used for kicking (27).

The findings obtained from the present study in connection with the determination of the relationship between motor function screening and the execution of karate movements in teenage karate girls are in line with the research of Krkeljas et al(8), Ervuz et al(28), Silva et al(29). Inconsistent with the researches of Boguszewski et al (30), Chalobinska et al (31). Among the reasons for the alignment, in the article by Krkeljas et al (8), the active leg raising test and the sit-up and Swedish swimming tests were related to karate performance. Horizon was also related to the karate horsemanship test, and these results were also obtained in the present study. In the article by Ervuz et al (28), swimming mastery had a significant relationship with the obstacle stepping test, which in the present study is also this athlete. In the article by Silva et al (29). The individual scores of the motor performance screening test were able to evaluate the performance of surfing athletes better than the total score of the motor performance screening test, which in the present study also showed a correlation between the total score of the motor performance screening test and the performance of karate. There was no, but there were significant correlations between the individual motor performance screening tests and karate movements. Among the reasons for the discrepancy, in the article by Boguszewski et al(30), the performance of martial athletes was related to the tests of stepping over an obstacle and active leg raising, and they were weaker in rotational stability. In Taekwondo, there is a correlation in the active leg raising test. In the present study, there was no relationship between the active leg raising test and karate performance, and the rotational stability test had a significant relationship with karate performance. In the article by Chalobinska et al (31), the total score of the motor performance screening was the criterion and its relationship with the movement patterns of canoe slalom athletes was positive, and in the present study there was no correlation between the total score of the movement performance screening. There was no karate movement.

This study indicates that the karate performance tests were associated with the athletic performance tests. Sports performance is defined as a combination of specific physical routines or methods performed by someone who is trained or skilled in physical activity and influenced by physiological, psychological, and sociocultural factors and the pursuit of excellence where a sportsman measures his or her performance quantitatively or qualitatively to move towards his or her desired goal (32, 33). The performance of elite athletes depends on neuromotor performance, efficient cortical control, intellectual, and motor memory, coordination, visual cueing, balance, focus, cardiorespiratory endurance, hormonal control, and efficient energy metabolism and karate also needs these factors and very advanced technical skills, which, amongst others, include control of static and dynamic movements (7, 34). Karate is a highly dynamic tournament sport and has a complex structure, and the competitors' physical fitness, technique, tactics, and mental state all affect successful performance(7). In performing karate movement, supporting factors are needed, one of the important factors is a good physical condition. To get a good physical condition, physical exercise needs to be done on an ongoing basis (35).

In the kumite category, agility means the ability to move forward, backward, and sideways and change direction quickly. Agility is extremely essential in karate kumite athletes because all the movements made during the match require physical agility (36). Karate athletes must have good power, so can perform every movement in karate perfectly (35). During a kumite fight, attacks need to be executed at maximum speed to ensure that the attacker's hand or foot reaches the target without the opponent being able to respond. Karate competitors' actions are based on acyclic movements, and numerous muscle groups and all four limbs are engaged during combat (7). In Karate kicks to the head zones bring more points and to take these points, the athlete should apply more force to the ground and jump up higher levels to make kicking easier. In the FMS, this ability can be measured with Deep squat and Hurdle Steps (25), in the athletic performance, this ability can be measured with the horizontal jump test, and in the karate performance can be measured with mawashi geri test (8). In the current research, the sports performance tests were related to the performance of karate movements. According to our findings, it seems although sports performance includes strength, speed, endurance, coordination, and flexibility, and these factors of physical fitness are mandatory for karate practitioners, and probably the individual and one-to-one communication of sports performance tests and karate movements can be used to evaluate karate. These tests pursues a specific goal, so it is not possible to evaluate the performance of karate athletes with the total score of sports performance. The findings obtained from the present research about the relationship between sports performance and the execution of karate movements of teenage karate girls are in line with the researches of Kabadaei et al (18), Przybylski et al (7), Pal et al (28), De Quel et al(38), Ben Hassan et al(39), krkeljas et al(8), Doder et al(40) and there was no disparity in this research review. Due to the alignment, in all the mentioned articles, physical fitness assessment with sports performance tests affects karate performance and has improved performance in karate kicks. In the present study, there was no significant relationship between the total score of the functional movement screen test and athletic performance factors. It seems that the functional movement screen test has taken into consideration the quality of movements and basic movements and emphasized the factors of physical fitness and sports skills. Each of these tests pursues specific goals, so athletic performance factors cannot be explained with the total score of the functional movement screen. The assessment of functional movement typically involves the measurement of postural control, stability, flexibility,

neuromuscular coordination, and balance (9). Therefore, our research supports the recommendation that children in the first 2 stages of sports development concentrate on general physical development, as the basis for further development of specific motor abilities that lead to transition to specialization (5, 6, 41, 22). Considering that in the present study, most of the subjects were weak to moderate in muscle endurance, speed, agility, strength and power of the lower limbs, which are the main factors in karate sports, it is recommended to sports trainers that by doing exercises Expertise and principles to strengthen these main factors in the athletes of this field. In addition, sports coaches and experts in this field perform poor tests and screenings to identify, evaluate and determine factors of physical fitness and karate specific performance. Therefore, it is suggested to use the tests and articles of this research, which are more accurate, to periodically evaluate and screen their athletes and provide their athletes with the results of their evaluations accurately. It is also suggested that due to the fact that the present study was conducted on karate girls and due to the fact that puberty was not considered in the present study,It is recommended to investigate pre-puberty and post-puberty assessment and their relationship in future research.

5. Conclusion

According to the findings of this study, the relationship between functional movement screen, sports performance, and karate is weak to moderate, which indicates that functional movement screen can partially measure the factors of balance, proprioception, strength, flexibility, coordination, and range of motion. When designing a Performance evaluation process for beginner and young karateka coaches should use both functional and physical performance tests to devise a comprehensive assessment strategy. Specifically, while the FMS^{TM} score may not be useful as an indicator of athletic or karate performance, the individual tests designed to asses specific functional limitations, such as ASLR, ILL, RS, and HS, may provide valuable information about the athlete's functional capacity. Tests of athletic performance for agility, speed, and power may also be useful tools for Performance evaluation in young karateka because, in karate, athletes need explosive movement patterns such as punches and kicks. During these lower and upper limb movements, activation of the trunk begins earlier, whether the limb movements are fast or not. Therefore, coaches need to identify special screening tools before participating, so that they can screen and identify young athletes with physical fitness and performance ability to perform specific karate skills at the expected level. While both technique and physical characteristics of young athletes are strong Performance indices, emphasis should continue to be placed on developing a correct fundamental movement technique in young athletes.

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References

[1] Boguszewski D, Jakubowska K, Adamczyk JG, Białoszewski D. The assessment of movement patterns of children practicing karate using the Functional Movement Screen test. J Combat Sports Martial Arts. 2015 Jan 1;6(1):21-6.

[2] Mamadaliyeva N, Nurmamatova S. The History of the Origin and Development of the Sport Karate. Theoretical aspects in the formation of pedagogical sciences. 2023 Apr 6;2(9):62-4.

[3] Naserpour H, Baker JS, Letafatkar A, Rossettini G, Dutheil F. An investigation of knee injury profiles among Iranian elite karatekas: Observations from a cross-sectional study. International Journal of Environmental Research and Public Health. 2021 Jun 27;18(13):6888.

[4] Batavani MR, Ghaedi K. Comparison of Total Genotype Score (TGS) of Power/Strength Responsible ACE, HIF1α and IGF1 Polymorphisms of Elite, Amateur Karate-kas vs. non-Athletes. Sport Physiology. 2022 Apr 21;14(53):176-49.

[5] Lubans DR, Morgan PJ, Cliff DP, Barnett LM, Okely AD. Fundamental movement skills in children and adolescents: review of associated health benefits. Sports medicine. 2010 Dec;40:1019-35.

[6] Protic-Gava B, Drid P, Krkeljas Z. Effects of judo participation on anthropometric characteristics, motor abilities, and posture in young judo athletes. Human Movement. 2019;20(3):10-5.

[7] Przybylski P, Janiak A, Szewczyk P, Wieliński D, Domaszewska K. Morphological and motor fitness determinants of shotokan karate performance. International journal of environmental research and public health. 2021 Apr 21;18(9):4423.

[8] Krkeljas Z, Kovac D. Relationship between functional movement screen, athletic and karate performance in adolescents. Human Movement. 2021;22(2):16-21.

[9] Fitton Davies K, Sacko RS, Lyons MA, Duncan MJ. Association between functional movement screen scores and athletic performance in adolescents: a systematic review. Sports. 2022 Feb 22;10(3):28.

[10] Atalay G, Atalay ES. The effect of taekwondo training on children's functional movement screen (FMS) scores and athletic performance parameters. International Journal of Disabilities Sports and Health Sciences. 2021;4(2):80-5.

[11] Cook G, Burton L, Kiesel K, Rose G, Bryan MF. Movement: Functional Movement Systems: Screening, Assessment, Corrective Strategies, Foreword J. Torine. Strength and Conditioning Coach. Indianapolis Colts. 2011 Sep 1.

[12] Cook G, Burton L, Hoogenboom BJ, Voight M. Functional movement screening: the use of fundamental movements as an assessment of function - part 1. International journal of sports physical therapy. 2014 May;9(3):396.

[13] Chaabene H. Karate kumite: how to optimize performance. Physical Determinants of Karate Kumite. OMICS. 2015.

[14] Streetman A, Paspalj D, Zlojutro N, Božić D, Dawes JJ, Kukić F. Association of shorter and longer distance sprint running to change of direction speed in police students. NBP. Nauka, bezbednost, policija. 2022;27(1):5-13.

[15] Wijethunga WM, Perera LM. Gender-specific influences of balance, speed, and power on agility performance of karate players.

[16] Willigenburg N, Hewett TE. Performance on the Functional Movement Screen is related to hop performance but not to hip and knee strength in collegiate football players. Clinical journal of sport medicine. 2017 Mar 1;27(2):119-26.

[17] Teichmann J, Soyza AP, Harb AH, Allan KS, Ee RT. Effects of a 5-Week Linear Periodization Program on Maximal Strength and Speed on Elite Squash Players. Advances in Physical Education. 2021 Sep 28;11(4):369-86.

[18] Kabadayı M, Karadeniz S, Yılmaz AK, Karaduman E, Bostancı Ö, Akyildiz Z, Clemente FM, Silva AF. Effects of core training in physical fitness of youth karate athletes: A controlled study design. International journal of environmental research and public health. 2022 May 10;19(10):5816.

[19] Protic-Gava B, Drid P, Krkeljas Z. Effects of judo participation on anthropometric characteristics, motor abilities, and posture in young judo athletes. Human Movement. 2019;20(3):10-5.

[20] Katić R, Jukić J, Glavan I, Ivanišević S, Gudelj I. The impact of specific motoricity on karate performance in young karateka. Collegium antropologicum. 2009 Mar 1;33(1):123-30.

[21] Sertić H, Vidranski T, Segedi I. Construction and validation of measurement tools for the evaluation of specific agility in karate. Ido Movement for Culture: journal of martial arts anthropology:

theory of culture, psychophysical culture, cultural tourism, anthropology of martial arts, combat sports. 2011;11(1-4):139-43.
[22] Katić R, Jukić J, Čavala M, Vučić D, Blažević S. Motor determinants of fighting efficacy in Croatian youth karateka. Collegium antropologicum. 2013 May 23;37(2):1-8.
[23] Dymel P, Szylińska A. Functional assessment of people practicing Brazilian martial art–Capoeira. Journal of Education, Health and Sport. 2020 Apr 8;10(4):55-67.
[24] Raza A, Tabassum Y, Hao W. Functional Movement Screening: A study on National Level Judo Players of Pakistan. sjesr. 2021 Mar 6;4(1):295-303.
[25] Yildiz S. Relationship between Functional Movement Screen and Some Athletic Abilities in Karate Athletes. Journal of Education and Training Studies. 2018 Aug;6(8):66-9.
[26] Boguszewski D, Jakubowska K, Adamczyk JG, Białoszewski D. The assessment of movement patterns of children practicing karate using the Functional Movement Screen test. J Combat Sports Martial Arts. 2015 Jan 1;6(1):21-6.
[27] Irawan FA, Jannah SP, Permana DF, Nurrachmad L, Anam K. Mawashi geri in karate junior cadet class: kinematic analysis. Journal of Hunan University Natural Sciences. 2021;48(9).
[28] Ervuz E, Yildirim M, Gumusdag H. A study on the relationship between functional movement screen scores and short lane freestyle swimming degrees in student swimmers. Pakistan Journal of Medical & Health Sciences. 2022 Jul 29;16(06):525-.
[29] Silva B, Clemente FM, Martins FM. Associations between functional movement screen scores and performance variables in surf athletes. The Journal of sports medicine and physical fitness. 2017 Feb 22;58(5):583-90.
[30] Boguszewski D, Adamczyk JG, Boguszewska K, Wrzosek D, Mrozek N, Waloch M, Białoszewski D. Functional assessment of women practising combat sports and team sports using the Functional Movement Screen. Biomedical Human Kinetics. 2019;11(1):90-6.
[31] Chałubińska D, Truszczyńska-Baszak A, Reszelewska A, Targosiński P, Rekowski W. Twelve-week sensorimotor training as a factor influencing movement patterns of canoe slalom athletes, assessed by the Functional Movement Screen. Biomedical Human Kinetics. 2020 Apr 6;12(1):10-6.
[32] PAVLÍKOVÁ, J. Specifický kondiční test karate—aplikace ve vybrané skupině.
[33] Chuckravanen D, Bulut SÜ, Kürklü GB, Yapali G. Review of exercise-induced physiological control models to explain the development of fatigue to improve sports performance and future trend. Science & Sports. 2019 Jun 1;34(3):131-40.
[34] Chandrasekaran B, Fernandes S, Davis F. Science of sleep and sports performance–a scoping review. Science & Sports. 2020 Feb 1;35(1):3-11.
[35] Anto F, Wijono W. PROFIL KONDISI FISIK ATLET KARATE PUTRA DOJO CANGGU KARATE KLUB, KECAMATAN JETIS, KABUPATEN MOJOKERTO. Jurnal Prestasi Olahraga. 2022 Mar 31;5(3):76-82.
[36] Chindarkar R, Sharma S, Kumar A. A cross sectional study to assess agility skills of kumite karate players aged 15-20 years in Mumbai suburban area. International Journal of Health Sciences and Research. 2021;11(9):252-8.
[37] Pal S. Effects of plyometrics and Pilates training on phy...
[38] de Quel ÓM, Ara I, Izquierdo M, Ayán C. Does physical fitness predict future karate success? A study in young female karatekas. International journal of sports physiology and performance. 2020 Mar 9;15(6):868-73.
[39] Ben Hassen S, Negra Y, Uthoff A, Chtara M, Jarraya M. Reliability, Validity, and Sensitivity of a Specific Agility Test and Its Relationship With Physical Fitness in Karate Athletes. Frontiers in Physiology. 2022 Mar 23;13:841498.
[40] Doder LR, Doder D, Vidranski T, Duđak L. Influence of karate training on morphological characteristics, motor abilities and skills in boys. Croatian Journal of Education: Hrvatski časopis za odgoj i obrazovanje. 2021 Sep 3;23(2.):545-68.
[41] Pion J, Fransen J, Lenoir M, Segers V. The value of non-sport-specific characteristics for talent orientation in young male judo, karate and taekwondo athletes. Archives of Budo. 2014 Jun 20.