Dymel Piotr, Szylińska Aleksandra. Functional assessment of people practicing Brazilian martial art – Capoeira. Journal of Education, Health and Sport. 2020;10(4):55-67. eISSN 2391-8306. DOI http://dx.doi.org/10.12775/JEHS.2020.10.04.007
https://apcz.umk.pl/czasopisma/index.php/JEHS/article/view/JEHS.2020.10.04.007
https://zenodo.org/record/3746524

The journal has had 5 points in Ministry of Science and Higher Education parametric evaluation. § 8. 2) and § 12. 1. 2) 22.02.2019.
© The Authors 2020;
This article is published with open access at Licensee Open Journal Systems of Nicolaus Copernicus University in Torun, Poland
Open Access. This article is distributed under the terms of the Creative Commons Attribution Noncommercial License which permits any noncommercial use, distribution, and reproduction in any medium, provided the original author (s) and source are credited. This is an open access article licensed under the terms of the Creative Commons Attribution Non commercial license Share alike. (http://creativecommons.org/licenses/by-nc-sa/4.0/) which permits unrestricted, non commercial use, distribution and reproduction in any medium, provided the work is properly cited.
The authors declare that there is no conflict of interests regarding the publication of this paper.

Received: 10.03.2020. Revised: 18.03.2020. Accepted: 08.04.2020.

Functional assessment of people practicing Brazilian martial art – Capoeira

Piotr Dymel[1], Aleksandra Szylińska[2]

1. Physiotherapy student, Faculty of Health Sciences, Pomeranian Medical University, Szczecin, Poland
2. Department of Medical Rehabilitation and Clinical Physiotherapy, Pomeranian Medical University, Żołnierska 54, 70-204 Szczecin, Poland

Abstract **Introduction:** Due to the growing interest in the subject of health and fitness in the general public, people began to reach for various forms of self-improvement. One of these methods is Capoeira, which is becoming increasingly popular among all age groups and genders. It combines elements of both a fight and a dance. It's mainly based on kicks, dodges and acrobatics.

Aim: The main goal of the study was to conduct a functional assessment of people practicing the Brazilian martial art – Capoeira, and an assessment of the risk of injury.

Materials and methods: A total of 25 people were tested in two groups of 13 and 12 people each. The first group consisted of people between the ages of 19 and 43 (mean age 30.92±7.99) who have trained Capoeira for at least one year. The second group was a control group and consisted of people from 21 to 49 years of age (mean age 36.08±10.09) exercising regularly.

Results: In the Capoeira group consisting of 13 people, the average final score of the FMS test was 16 points out of 21 achievable. The average score of a control group is 14.5 points. According to the FMS test, 41.67% of people in the non-Capoeira group are at increased risk of injury in sports, while in the Capoeira group of people there is no increased risk of injury (p=0,035).

Conclusions: Capoeira group achieved significantly higher results in FMS. According to FMS, Control group showed an increased risk of injury. In the group of active people who did not train martial arts, almost half were characterized by an increased risk of injury.

Key words: martial arts; injury; movement; prevention; ability

Introduction

A healthy lifestyle is one of the most important factors that allow maintaining both mental and physical vitality. Nowadays, more and more people reach for various methods that allow them to maintain health in both professional and amateur segments of sports activity. The society is paying more attention to its fitness and all ways to improve it. The increase in awareness about physical activity, its impact on the body and the effects of its absence is, with high probability caused by easier access to information and scientific research. [1,2,3]

One of the definitions of physical fitness that can be found in foreign literature states that it is a way or attitude against stress and fatigue and that it is something more than a state of absence of the disease or a state of appropriate "form". It is the ability to perform everyday activities with pleasure, without excessive fatigue and with the right amount of energy for active leisure. It refers to both physical and mental features. Another definition speaks of a person's lifestyle reflecting the system of values and "resourcefulness" of movement at work, sport and everyday life. It is the sum of three characteristics: kinesthetic abilities, motor skills and appropriate involvement in various activities. The functionality consists of several elements that allow the most controlled, safe and ergonomic movements. The first element is mobility, which allows movements in the full range of joint motion necessary in various areas of sport or during everyday life. Another element is balance, which allows the organization of the body in space during movement or in various positions. The next element is the optima movement pattern, which is possible due to the appropriate activation of specific muscle groups by the nervous system. And last the symmetry of movements, i.e. corresponding movements around the axis of the body. All of the above concepts and phenomena allow for appropriate management of forces so as to perform even the most complex motor tasks in an efficient and safe way for the body. [4,5,6]

Due to the growing interest in the subject of health and fitness in the general public, people began to reach for various forms of self-improvement. One of these methods is Capoeira, which is becoming increasingly popular among all age groups and genders. Capoeira is a martial art originating in Brazil, although its roots can be traced to Africa. It combines elements of both a fight and a dance. It's mainly based on kicks, dodges and acrobatics. Common techniques are also various types of undercuts and everything is executed with almost a dance-like smoothness. Therefore, it is a discipline that requires trainers to have adequate strength, endurance and proper motor coordination. All this happens in the rhythm of traditional Brazilian music. Regular Capoeira training not only increases the efficiency and fitness of the body, but also helps in gaining new motor skills. Properly conducted martial arts training can be a key element in maintaining an

appropriate level of broadly understood fitness of human body. [7,8]

The main goal of the study was to conduct a functional assessment of people practicing the Brazilian martial art – Capoeira, and an assessment of the risk of injury. In addition, to demonstrate that practicing martial arts has a positive impact on human vague.

Materials and methods

A total of 25 people were tested in two groups of 13 and 12 people each.

The study received a waiver from the Bioethical Committee of the Pomeranian Medical University in Szczecin, Poland, (decision no. KB-0012/169/06/19, dated 10.06.2019).

The first group consisted of people between the ages of 19 and 43 (mean age 30.92±7.99) who have trained Capoeira for at least one year. The second group was a control group and consisted of people from 21 to 49 years of age (mean age 36.08±10.09) exercising regularly. The characteristics of the entire study group are presented in Table 1.

Table 1. Characteristics of the group

		Capoeira group (n=13)	Control group (n=12)	**p**
Age (mean±SD; Me)		30,92±7,99; 33,0	36,08±10,09; 38,0	0,121
Weight (mean±SD; Me)		75,23±12,92; 76,0	77,33±16,97; 76,5	0,786
Height (mean±SD; Me)		172,0±7,92; 175,0	176,75±8,3; 176,5	0,211
BMI (mean±SD; Me)		25,38±3,35; 24,6	24,32±3,52; 24,25	0,497
Sex, n (%)	Female	6 (46,15%)	5 (41,67%)	0,859
	Male	7 (53,58%)	7 (58,33%)	

Abbreviations: BMI- body mass index; SD-standard deviation; Me-median; n-number of patients; p-statistical significance.

Both groups were asked to perform the Functional Movement Screen test. Seven tests consist of: deep squat (DS), hurdle step (HS), in-line lunge (ILL), shoulder mobility (SM), active straight leg raise (ASLR), trunk stability push-up (TSPU), rotational stability (RS). Each test was performed three times and evaluated by a physiotherapist. The best attempt of a given test was rated on a scale of 0-3. [9]

1. Deep Squat, which evaluates the mobility of the hip, knee and ankle joints on both sides. The stick above the head helps to assess the mobility of the shoulder girdle and thoracic spine. The starting position is standing with the stick above the head. The subject is recommended to do the lowest squat they can without lifting heels from the ground. In order to receive three points, the

subject’s heels must be in contact with the ground, the torso must be parallel to the tibia or in a vertical direction, the femur is below the horizontal plane, the knees are aligned with the axis of the lower limbs and the arms are an extension of the torso. For two points, the test subject must correctly complete a pattern with a five-centimeter stand under the heels. One point is awarded when the examined person is not able to perform the correct pattern with their heels elevated.

2. Hurdle Step allows assessing the mobility and stability of the lower limb and torso. In addition, it also checks the balance of the examined person. The crossbar is set at the height of the tibial tuberosity of the subject. The feet are set on the width of the hips and touch the base of the "FMS test kit". The rod rests on the shoulders of the examined person parallel to the ground. The task of the examined person is to walk with one leg above the crossbar, touch the ground with the heel and return to the starting position. Three points are obtained when the joints of the lower limb are set in the sagittal plane, the rod is parallel to the crossbar and the mobility in the hip joints is symmetrical. Two points are awarded when the joints of the lower limb are not aligned in the sagittal plane, there is no parallel alignment of the rod with the crossbar or increased movement of the lumbar spine is observed during movement. A person receives one point when they are unable to perform the pattern correctly, e.g. due to any imbalances.

3. In-Line Lunge, which allows to assess the mobility and stability of the torso, pelvis, hip, knee and ankle joints. It also assesses the torso's ability to prevent rotational forces. In this test, the test person stands on the platform with his legs aligned, the distance between the feet determines the length of the shin from the ground to the knee gap. The rod is behind the examined person's back so that the ipsilateral upper limb in relation to the lower limb grips the rod at the height of the cervical spine, and the opposite at the height of the lumbar spine. The purpose of the subject is to make a lunge. At three points, the knee of the transverse limb touches the base behind the heel of the transverse limb, the movement of the torso is minimal or absent and the rod is vertical and touches the curvature of the spine. At two points, there is no linear alignment of the lower limb joints, the knee of the limb does not touch the base, there is no contact of the rod with the spine of the examined person, the rod and the examined person's foot do not remain in the sagittal plane or there is significant movement of the torso. At one point, the subject is unable to make a pattern, e.g. due to imbalance..

4. Shoulder Mobility assesses the mobility of the shoulder girdle. The examined person clenches his hands into fists and performs with one upper limb maximum adduction with internal rotation in the shoulder joint, while the other gives maximum abduction with external rotation in the shoulder joint. The distance between the fists of the subject is estimated. Before performing the test, a Near provocation test is performed. Three points are obtained if the distance between the fists is less than or equal to the length of the hand, two points are awarded if the distance between the fists

does not exceed one and a half lengths of the hand and one if the distance between the fists exceeds one and a half times the length of the hand of the examined person.

5. Active Straight Leg Raise allows you to assess the elasticity and extension of the posterior group of thigh muscles and gastrocnemius muscle. In addition, the test assesses the so-called passive flexibility of the lumbar muscle on the opposite side to the examined one. The test subject lies on their back and the base lies under their knees. Their task is to raise the erect lower limb in the knee joint and bent in the ankle joint. The opposite limb must be straightened and keep in contact with the ground. Three points are obtained if the medial ankle stick falls between the anterior superior iliac spine and the mid-thigh point. Two if the medial ankle stick is between the mid-thigh point and the center of the patella of the limb resting on the ground. One when the medial ankle is below the point defined by the center of the patella of the limb resting on the ground.

6. Trunk Stability Push-Up allows to assess the stability of the torso during symmetrical arm work. Before attempting to the pattern, a provocative test should be performed, which involves performing a hyperextension of the spine in the lumbar region and lying on the stomach. The tested person lies on their stomach and his hands are at the eyebrow height - for men and at the jaw height for women. The goal of the subject is to move from the supine position to the front support. The test person receives three points when: a man makes one test with the thumbs placed at the eyebrow height or a woman makes one test with the thumbs placed at the jaw height. Two points when: a man makes one test with the thumbs placed at the level of the jaw or a woman makes one test with the thumbs at the height of the collarbone. One when the test person is unable to make the pattern.

7. Rotational Stability enables assessment of torso stability in the sagittal plane. Before attempting to the pattern, a provocative test would be performed consisting of extending the thoracic segment in a kneeling posture. The starting position for the test is a propped up kneeling position. Shoulder and hip joints should be bent to 90 °. The FMS base is located between the knees and hands of the subject. The goal of the subject is to simultaneously raise the lower and upper limbs on the same side of the body, then touch the knee to the elbow and return to the starting position. The subject receives three points if they perform the test without tilting sideways while maintaining a parallel torso line in relation to the ground. They receive two points if they are unable to perform the test, but they do an asymmetrical movement of the limbs. One point is awarded when the subject is unable to make the pattern.

In all of the above tests and provocation tests, the occurrence of pain results in the award of zero points for a given test. An increased risk of injury occurs with results below 14 points in the FMS test. [9]

In addition, participants were asked to perform a shortened version of the T-Agility test and to complete the IPAQ questionnaire on the basis of which the level of physical activity was

calculated. T-Agility consists in completing the T-shaped track as quickly as possible. The examined person should run all the time in one direction. The first segment is five meters long, then two segments two and a half meters long each, the last element is the return to the first segment while running backward. The reduced dimensions of the T-Agility Test were due to the limited space in the training room where the tests were conducted. [10,11]

Statistical analysis

The statistical analysis was performed using the STATISTICA 13 software package. (StatSoft, USA). Data are mainly presented using the mean, median, standard deviation and percentages The Shapiro-Wilk test was used to check normality of distribution. The differences between group were assessed using the nonparametric Mann-Whitney U test. Qualitative variables were analyzed using the Chi-square test or Chi-square test with Yates correction. We used Spearman's correlation. Statistical significance was defined as p value <0.05.

Results

In the Capoeira group consisting of 13 people, the average final score of the FMS test was 16 points out of 21 achievable. The average score of a control group is 14.5 points. The differences between the groups were statistically significant (p = 0.032). The results are presented in Table 2.

Table 2. Total results in FMS.

	Capoeira group (n=13)	**Control Group (n=12)**	**p**
FMS Total (mean±SD; Me)	17,07±1,49; 16,0	14,33±3,37; 14,5	**0,032**

Abbreviations: SD-standard deviation; Me-median; n-number of patients; p-statistical significance

According to the FMS test, 41.67% of people in the non-Capoeira group are at increased risk of injury in sports, while in the Capoeira group of people there is no increased risk of injury (p=0,035). (Table 3.)

Table 3. Higher risk of injury according to FMS.

		Capoeira group (n=13)	Control group (n=12)	p
Higher risk of injury, n (%)	0	**13 (100,00%)**	7 (58,33%)	**0,035**
	1	0 (0,00%)	5 (41,67%)	

Abbreviations: SD-standard deviation; Me-median; n-number of patients; p-statistical significance

In the first test with FMS (deep squat) in the Capoeira group, five subjects obtained the maximum result and eight obtained two points. In the control group, seven subjects scored two points and only two people obtained the maximum result. In addition, two people (16.67%) scored one point in the control group and one (8.33%) scored no point because of pain during the test. No statistical significance was demonstrated.

In Hurdle-Step in the Capoeira group, eight people scored two points and five people three points. In the control group, seven people obtained two points and only two managed to obtain the maximum points. In this group, two people (16.67%) scored one point. No statistical significance was demonstrated.

In In-Line Lunge, the differences between the two groups were noticeably bigger. In the Capoeira group, as many as 11 people (86.62%) obtained the maximum number of points and only two people (15.38%) obtained two points. In the control group, 50% scored two points, 33.33% scored three points, and two people (16.67%) did not get any points due to the pain occurring during the test. The results of this test were statistically significant ($p = 0.028$). The results are presented in Table 4..

In Shoulder Mobility in the Capoeira group, more than half (61.54%) scored two points, two scored three points and three scored one point. In the control group, 58.33% of respondents scored the maximum number of points, 25% scored two points and 16.67% one point. No statistical significance was demonstrated.

In Active Single Leg Raise in the Capoeira group nine people (69.23%) achieved the maximum result, three people (23.08%) two points and one (7.69%) one point. In the control group, four people (33.33%) scored the maximum result and eight people (66.67%) scored two points. No statistical significance was demonstrated

In Trunk Stability Push-Up in the Capoeira group, 92.31% of respondents scored the maximum result and only one person (7.69%) obtained two points. In the control group, seven people (58.33%) scored three points, four people (33.33%) one point and one person (8.33%) did

not receive points for this test due to occurring pain. No statistical significance was demonstrated.

In the last FMS (Rotational Stability) test, one person obtained the maximum result, 11 people (84.62%) scored two points and one one point. In the control group, none of the subjects obtained the maximum result, seven people (58.33%) scored two points and five people (41.67%) scored one point. No statistical significance was demonstrated. The results are presented in Table 4.

Table 4. Results of individual tests from functional movement screen.

FMS TEST		Capoeira group (n=13)		Control group (n=12)		p
		n	%	n	%	
DS	0	0	0,00%	1	8,33%	0,229
	1	0	0,00%	2	16,67%	
	2	8	61,54%	7	58,33%	
	3	5	38,46%	2	16,67%	
HS	1	0	0,00%	2	16,67%	0,282
	2	8	61,54%	7	58,33%	
	3	5	38,46%	3	25,00%	
ILL	0	0	0,00%	2	16,67%	**0,028**
	2	2	15,38%	6	50,00%	
	3	**11**	**84,62%**	4	33,33%	
SM	1	3	23,08%	2	16,67%	0,074
	2	8	61,54%	3	25,00%	
	3	2	15,38%	7	58,33%	
ASLR	1	1	7,69%	0	0,00%	0,075
	2	3	23,08%	8	66,67%	
	3	9	69,23%	4	33,33%	
TSPU	0	0	0,00%	1	8,33%	0,063
	1	0	0,00%	4	33,33%	
	2	1	7,69%	0	0,00%	
	3	**12**	**92,31%**	7	58,33%	
RS	1	1	7,69%	5	41,67%	0,104
	2	**11**	**84,62%**	7	58,33%	
	3	1	7,69%	0	0,00%	

Abbreviations: DS.- deep squat; HS- Hurdle-Step; ILL- In-Line Lunge; SM- Shoulder Mobility; ASLR- Active Single Leg Raise; TSPU- Trunk Stability Push-Up; RS- Rotational Stability; FMS-Functional Movement Screen; n-number of patients; p-statistical significance.

In Agility T-test during the first measurement, the average time for the Capoeira group was T1 = 7.570s and for the control group T1 = 9.01s, statistically significant differences (p = 0.006) were obtained. During the second measurement, the average for the Capoeira group was T2 = 7.446s and for the control group T2 = 8.74s, statistically significant differences (p = 0.007) were obtained. The average level of physical activity based on the IPAQ questionnaire for the Capoeira group was 8134,500 MET-minute / week and for the control group 13767,18 METminute / week, no statistical significance was obtained (p = 0.878). The results are presented in Table 5.

Table 5. Results of Agility T-test [s] and level of physical activity based on IPAQ [MET-minute/week].

	Capoeira group (n=13)	**Control group (n=12)**	**p**
T1 (mean±SD; Me)	7,57±0,59; 7,68	9,01±1,36; 8,54	**0,006**
T2 (mean±SD; Me)	7,44±0,43; 7,38	8,74±1,31; 8,62	**0,007**
IPAQ (mean±SD; Me)	8134,50±5076,82; 5707,5	13767,18±13625,79; 7161	0,878

Abbreviations: IPAQ-International Physical Activity Questionnaire; T- time of test T-Agility; SD-standard deviation; Me-median; p-statistical significance.

Correlation analysis is presented in Table 6. The training of Capoeira recorded significantly shorter times in the T-Agility test. A strong negative correlation was statistically significant both in T1 measurement (r = -0.572; p = 0.003) and in T2 measurement (r = -0.555; p = 0.004). Capoeira trainers also showed a statistically significant decrease in injury risk (r = -0.520; p = 0.008). Considering individual tests with FMS, a significant positive correlation was found in three standards: ILL (r = 0.538; p = 0.006), TSPU (r = 0.431; p = 0.031) and RS (r = 0.425; p = 0.034). All three tests were statistically significant. Summarizing the results, a statistically significant increase in the final FMS score was also found (r = 0.455; p = 0.022). In the study, the least statistically significant decrease for the group of Capoeira trainers was the final result of the IPAQ questionnaire (r = -0.039; 0.858) and the weight of the subjects (r = -0.061; p = 0.772).

Table 6. Correlation for people who train Capoeira

	R	p
Age	-0,323	0,116
Weight	-0,061	0,772
Height	-0,261	0,207
DS	0,369	0,070
HS	0,237	0,254
ILL	**0,538**	**0,006**
SM	-0,359	0,078
ASLR	0,303	0,141
TSPU	**0,431**	**0,031**
RS	**0,425**	**0,034**
FMS Total	**0,455**	**0,022**
T 1	**-0,572**	**0,003**
T 2	**-0,555**	**0,004**
IPAQ	-0,039	0,858
BMI	0,144	0,491
Higher Risk of Injury	**-0,520**	**0,008**

Abbreviations: DS.- deep squat; HS- Hurdle-Step; ILL- In-Line Lunge; SM- Shoulder Mobility; ASLR- Active Single Leg Raise; TSPU- Trunk Stability Push-Up ; RS- Rotational Stability; FMS-Functional Movement Screen; T- time of test T-Agility; IPAQ-International Physical Activity Questionnaire; BMI-body mass index; R-correlation; p-statistical significance.

Discussion

Practicing any sport is associated with the risk of injury. In combat sports, injuries not only arise due to overloads that the movement system must face but also because of external forces associated with direct contact with the opponent. Injuries depend on the individual predispositions of the players and also on the specifies of a given martial art. Both boxing and capoeira will have different injuries associated with them. According to Boguszewski, the most common damage is knee joint damage. However, the most common type of damage was bruising, tearing and breaking of tendons and ligaments. The reasons for the injury were an inadequate warm-up or a poorly performed exercise. Therefore, taking into account the diversity of martial arts, the complexity of the techniques performed and, above all, the direct contact with the opponent, this group of sports can predispose to any damage to the musculoskeletal system. Training subordinated to martial arts and sports involves not only the optimal work of specific muscles or their groups but also contains shaping specific motor features, which are ultimately most useful during a direct clash with the opponent. This is based on teaching a player certain movement patterns, in which some muscle groups are responsible for the movement performed and others for the appropriate stabilization of the kinematic chain members. However, in the event of incorrect work with one of the members,

others take over its function and there is some compensation. One or more members are overloaded, which results in an increased risk of damage to the locomotor system. To minimize the risk of injury, proper functional assessment of players is necessary. [12,13]

Martial arts are unique disciplines characterized by the versatility of training and technical complexity. Therefore, cultivating them may cause an increased risk of injury, not only through direct contact with the opponent [Mala 2016]. The most common cause of these damages is repetition of incorrect movement patterns, which in turn leads to excessive wear of the locomotor system [Nabhan 2016]. Correlations between the quality of movement patterns and susceptibility to damage and the level of motor preparation were demonstrated, among others, by Stawikowska [2015] and Barbado et al. [2016]. The goal of Functional Movement Screen is to assess the functional limitations that lead to pain and increased susceptibility to injury [Razi 2016]. Athletes struggling with pain during specific tasks related to a given discipline can perform them less effectively [Boguszewski 2017]. The FMS test allows for early prevention of injuries. Correlation between FMS results and future body injuries was shown by Garrison et al. [2015] and Tee et al. [2016]. Therefore, after reliable diagnosis of the player, the necessary element is appropriate work, which consists in reducing the existing asymmetries, improving the stability of individual members. As part of this study, the subject of the analysis was the fitness of people training Brazilian martial art - Capoeira. The existence of significant differences between the two groups has been shown, which may be a proof of the positive impact of Capoeira cultivation on functional efficiency. The reliability of the FMS test is emphasized in his work by Teyhen et al. [2012]. Martial arts athletes are characterized by a higher level of pro-health behavior [Boguszewski 2017]. This may prove that these forms of physical activity as well as the values transmitted during martial arts training have a positive impact on lifestyle. [14,15,16,17,18,19,20]

Conclusions

1. Capoeira group achieved significantly higher results in FMS.

2. According to FMS, Control group showed an increased risk of injury. In the group of active people who did not train martial arts, almost half were characterized by an increased risk of injury.

3. In the Functional Movement Screen test, the biggest differences in both groups concerned In-Line Lunge, Trunk Stability Push-Up and Rotational Stability. This may indicate a much better central stability of Capoeira group.

4. Test Functional Movement Screen can be a helpful tool in the functional diagnostics of martial arts players. In addition, the use of appropriate complementary training based on FMS results can help reduce body damage.

5. In the Agility T-test, the Capoeira group showed greater agility than the control group.

6. Further and more thorough research on a Capoeira group is needed to obtain more accurate information on its impact on functionality and performance.

References

1. Raczek J, Czy rzeczywiście nowa i zasadna koncepcja klasyfikacji struktury motoryczności człowieka? [Is it really a new and reasonable concept for classifying human motor structure?]. Antropomotoryka 1990, 4, 71-84. Polish.

2. Kozłowski S, Znaczenie aktywności ruchowej w rozwoju fizycznym człowieka. [The importance of physical activity in human physical development.] W: Czynniki rozwoju człowieka [Human development factors] /N. Wolański-red/ PWN. Warszawa 1981 /wyd. II/. 239-290. Polish.

3. Przewęda R, Uwarunkowania poziomu sprawności fizycznej polskiej młodzieży szkolnej. [Determinants of the level of physical fitness of Polish school youth] AWF. Warszawa 1985. Polish.

4. Rzepka R, Mikołajec K. Wykorzystanie treningu funkcjonalnego w przygotowaniu motorycznym [The use of functional training in motor preparation]. W: Zając A i wsp. Współczesny trening siły mięśniowej [Contemporary muscle strength training]. AWF Katowice, 2009; 271-306. Polish.

5. Cook G, Burton L, Hoenboom B: The use of fundamental movements as an assessment of function – Part 1. NAJSPT, 2006; 1:62-72.

6. Smith CA, Chimera NJ, Wright N, Warren M. Interrater and Intrarater Reliability of the Functional Movement Screen. Journal of Strength and Conditioning Research: April 2013 - Volume 27 - Issue 4 - p 982-987.

7. Kiesel K, Plisky PJ, Voight ML. Can serious injury in professional footbal be predicted by preseason Functional Movement Screen? North Am J Sports Phys Ther. 2007; 2: 147-158.

8. Cook G, Burton L, Hoenboom B. Pre-participation screening: The use of fundamental movements as an assessment of function – Part 2. NAJSPT. 2006; 1: 132-139.

9. Biernat E, Stupnicki R (2005) An overview of internationally applicable questionnaires designed for assessing physical activity. Phys.Edu.Sport 49:32-42.

10.Semenick D. Testing protocols and procedures. In: Essentials of Strength Training and Conditioning. Champaign, IL: Human Kinetics, 1994. pp. 258–273.

11. Sadowski J, Jaszczuk J, Mazurek T. [2001] Poziom koordynacyjnych zdolności motorycznych w zależności od zaawansowania sportowego i rodzaju sportu walki [The level of motor coordination skills depending on the sporting advancement and type of combat sport]., Rocznik Naukowy ZWWF Biała Podlaska, 8, 231-242. Polish.

12. Cynarski WJ, 2010, Medycyna w tradycji sztuk walki [Medicine in the martial arts tradition]. Przegląd Medyczny Uniwersytetu Rzeszowskiego [Medical Review of the University of Rzeszów];

1, 77-86. Wydawnictwo UR, 2010 ISSN: 1730-3524. Polish

13. Barbado D, Lopez-Valenciano A, JuanRecio C, Montero-Carretero C, van Dieën JH, VeraGarcia FJ, [2016] Trunk Stability, Trunk Strenght and Sport Performance Level in Judo. PLoS ONE 11950, e0156267. DOI:10.1371/journal.pone.0156267.

14. Mala L, Maly T, Zahalka F. [2016] Influence of maximal anaerobic performance on body posture stability in elite senior and junior male judo athletes. Archives of Budo; 12, 117-124.

15. Nabhan D, Walden T, Street J, Linden H, Moreau B. [2016] Sports injury and illness epidemiology during the 2014 Youth Olympic Games: United States Olympic team surveillance. British Journal of Sports Medicine; 50, 688-693.

16. Razi M. [2016] Normative data for the functional movement screen in healthy taekwondo athletes. Medicina Sportiva: Journal of Romanian Sports Medicine Society; 12(1), 2691-2697.

17. Garrison M, Westrick R, Johnson MR, Benenson J. [2015] Association between the functional movement screen and injury development in college athletes. International Journal of Sports Physical Therapy; 10(1), 21-28.

18. Stawikowska Z. [2015] Ocena funkcjonalna jako element profilaktyki uszkodzeń ciała kobiet uprawiających piłkę nożną [Functional assessment as an element of preventing injury to women practicing football]. Praca magisterska. Warszawski uniwersytet Medyczny. Polish.

19. Tee JC, Klingbiel JF, Collins R, Lambert M, Coopoo Y. [2016] Preseason Functional Movement Screen component tests predict severe contact injuries in professional rugby union players. Journal of Strength and Conditioning Research; 2016 Mar 12. DOI: 10.1519/JSC.0000000000001422.

20. Teyhen DS, Shaffer SW, Lorenson CL. [2012] The functional movement screen: a reliability study. Journal of Orthopaedic and Sports Physical Therapy; 42(6), 530-540.