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The assessment of movement patterns of children practicing karate using the Functional Movement Screen test

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Summary

Introduction. Functional limitations can be a cause and a consequence of injuries. The purpose of this work was to diagnose functional limitations of children engaged in Oyama Karate aged 10-12.

Materials and methods. 62 children (17 girls and 45 boys) participates in the study, of which 23 were engaged in karate. All participants took part in the Functional Movement Screen (FMS) test consisting of seven tasks assessed according to a scale assigning 0-3 points. An original survey regarding training and past injuries constituted an additional research tool. In the statistical analysis the U Mann-Whitney test and the Pearson's correlations were used. The minimal significance level was $p<0.05$.

Results. The girls practicing karate obtained a significantly higher ($p=0.005$) results in FMS test than the girls from the control group. Similar tendencies were observed in case of the boys – karatekas obtained a higher result in than the boys in the control group ($p=0.001$). In the case of boys the highest result was obtained in the shoulder mobility, and the lowest – in the trunk stability push-up. No significant differences between the dominant and non-dominant sides were noted for any of the groups and for any exercises.

Conclusions. 1. Higher result in the FMS test was obtained by sportsmen, which can indicate smaller functional limitations, which may be caused by rational training. 2. Dependency between the result of the FMS test and the age concerned the control group more significantly which may indicate an acceleration of motor development of children engaged in martial arts.

Introduction

Karate is a sports discipline and a close combat art which comes from a Japanese island – Okinawa [1]. Currently it combines traditional elements, which are self-defence, and modern elements, i.e. sports competition. One of the purposes of traditional karate is perfecting oneself. In sports karate the score constitutes the purpose [1,2]. Karate as a sports discipline must fulfil two conditions: safety of the fighters and respecting techniques of "the fist art". Complex karate training must include elements of kumite (shai) and kata, as well as general development exercises, which create the basis for specialized training. At the beginning the basics and kata constitute the main elements. Correctly performed kata exercises improve speed, balance, posture, technique and coordination. They include blocking, kicking and punching [1]. The starting point for all correct techniques of this discipline includes stretching exercises. They ensure appropriate flexibility of muscle and ligament apparatus, preventing – among others – postural deformities [3,4]. Key muscle groups which should be strengthened include abdominal and lower limb rim areas [5-7]. They ensure stable posture during movements and fighting [4]. Karate training requires time, patience and consistency. However, as with all sports disciplines, training may cause overload or injuries [8-10]. In order to minimalize the risk it is necessary to conduct reliable assessment of physical fitness and functional condition, individually adjusted load and adequate biological regeneration supporting exertional restitution, as well as alleviating negative effects of movement apparatus overload.

The main purpose of the study was to assess functional limitations, quality and symmetry of movement, using the FMS test of children practicing Oyama Karate.

Material and methods

The study involved 62 children (17 girls and 45 boys), aged 10-12, divided into two groups. Group 1 (the study group) included children engaged in Oyama Karate (6 girls and 17 boys); Group 2 (the control group) – children physically inactive (11 girls and 28 boys). The age of the participants was 10.9 years ±0.78 on average. The study group included children engaged in karate for at least two years, with at least an 8 kyu degree. Healthy children with no chronic diseases were qualified for the study; they had not had any serious injuries in the past six months (preventing physical activity for more than a week). All children had their parents' written consent to participate in the study. The biometric characteristics of the participants are presented in Table 1.

The Functional Movement Screen (FMS) test was used to conduct functional assessment. It was developed in order to detect functional limitations, asymmetry and predisposition to injury of individual elements of the musculoskeletal system. Performing physical tasks in relation to the FMS test requires an optimal fitness level, strength, balance and flexibility [11-13]. The Functional Movement Screen test consists of seven physical tasks assessed according to a scale assigning 0-3 points, where 3 means a correct implementation of the pattern; 2 means implementation of the pattern with compensation; 1 means the lack of possibility to implement the pattern; and 0 means pain which prevents movement. The FMS test consists of seven tasks: Deep Squat, Hurdle Step, In-Line Lunge, Shoulder Mobility, Active Straight Leg Raise, Trunk Stability Push-Up, Rotary Stability [12, 13].

Deep Squat test. Correct performance: torso upright, hip joints below thigh level, knee joints and the dowel rod over the feet. Deep squat is applied to assess both sides, functional mobility of the hips, knees and ankles. The dowel rod above the head indicates symmetrical cooperation in the shoulders, as well as mobility in the joints and the thoracic spine. A low result of this test can result from numerous factors. Limited ability to move the upper part of the torso can be attributed to a weak range of motion in the shoulder girdle, as well as a weakened mobility in the thoracic spine. Limited range of motion of the lower kinematic chain (dorsiflexion of the ankle joints, limited bend in the hip and knee joints) can also cause low testing ability [12,13].

Hurdle Step. Correct performance: foot, knee, hip in line, slight movement of the groin, the dowel rod and the hurdle parallel with one another. The hurdle step is applied to assess the mechanics and length of step. The movement requires good coordination, as well as stability between hips and torso during the jump. This task assesses bilateral functional stability and mobility of the hip, knee and ankle. On the other hand the sportsman had to show a relevant level of balance, as the test requires dynamic stability. A low score of this test can result from weak stability of the loaded leg (in the support phase) or insufficient mobility of the stepping leg. Flexing of the hip joint in one leg while simultaneously maintaining the joint in a straightened position requires bilateral asymmetrical mobility of the hip joint [12,13].

In-Line Lunge. Correct performance: torso perpendicular to the floor, one foot behind the other, knee and heal in contact with the floor. The test assesses mobility of hip joints and knee joints, as well as flexibility of the quadriceps which is responsible for knee stability. The participant has to have a relevant level of balance due to lateral imbalance. A low score in this test can result from improper motion in the hip joint (stride forward and back), the lack of stability for the knee and ankle. Finally the lack of balance caused by weakening of the abductors and adductors in one or both hip joints can cause a low testing ability. Limitations can also occur in the thoracic spine segment [12,13].

Shoulder Mobility. Correct performance: hands should be a palm width apart. Bilateral assessment of shoulder mobility. The range of shoulder mobility consists of: internal and external rotation. The test also requires physiological mobility of the thoracic spine, scapula and chest. A low test score can be caused by increased internal rotation, performed at the cost of external rotation. This happens as a result of excessive shortening of the latissimus dorsi and the pectoralis major. Weakening of the scapula stabilizing muscles can lead to loss or impairment of mobility, as well as scapula stability, which translates into the range of shoulder mobility [12,13].

Active Straight Leg Raise. Correct performance: ankle between hip joint and middle of the thigh. Performing active straightening via raising of the leg. It requires flexibility of the hamstring, which functional flexibility is necessary during trainings and competitions. It is different from passive flexibility, which is subject to common assessment. The sportsman has to show relevant mobility in the hip joint of the opposing leg, as well as stability of lower part of the torso. A low score may indicate low flexibility of hamstring, improper mobility of the opposing hip, resulting from low flexibility of the iliopsoas muscle [12,13].

Tab. 1. Characteristics of the research group

Groups	Sex	Number of people [n]	Age [years]	Body mass [kg]	Body height [cm]	Training experience [lata]
Group 1 (karatekas)	girls	6	11.33 ±0.81	41.5 ±5.99	154.5 ±6.47	2.83 ±0.75
	boys	17	10.88 ±0.78	37.94 ±8.85	158.16 ±14.42	3.47 ±1.23
Group 2 (non-active)	girls	11	10.82 ±0.75	40.36 ±5.29	151.82 ±8.86	-
	boys	28	10.86 ±0.81	41.43 ±6.95	160.11 ±13.47	-

Trunk Stability Push-Up. Correct performance: men – one repetition with thumbs above the head, women – one repetition with thumbs at cheek level. Torso stability during the test is assessed regarding the ability to stabilize the spine in the sagittal plane during movement in the closed kinematic chain. If the torso does not have proper stability, kinetic energy will be lost and it may lead to poor functional efficiency and an increased risk of micro-injuries. Unsatisfactory results of the test can be caused by weakening of torso stabilizers [12,13].

Rotary Stability. Correct performance: one unilateral repetition, straight torso, elbow and knee are in contact above the board. This task assesses the complex movement requiring proper neuromuscular coordination and transfer of energy from one body segment to another via the torso. Rotary stability test assesses complex torso stability during alternating limb movement. A condition to perform this task is the ability to asymmetrically stabilize the torso in the transverse and sagittal planes. Numerous functional activities in sport requires 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. A low score of the test can be caused by low bilateral stability of torso stabilizers [12,13].

The participants also completed the survey regarding among others the nature of trainings, the type and number of injuries related to and not related to sport.

Standard statistical analysis methods were used in the development of empirical data. The results were presented using arithmetic means (), taking standard deviations (SD) into account. Dependencies were determined using the Pearson's correlation, while the significance of differences between the pairs of variables was assessed using the U Mann-Whitney test. The minimal significance level was $p<0.05$.

Results

In the FMS test the girls engaged in karate obtained a significantly ($p=0.005$) higher result (17.17 on average) than the girls from the control group (14.27) (Tab. 2). The highest results were noted during the shoulder mobility task during which all the girls obtained the maximum result. Significant differences ($p<0.05$) were observed in case of the third exercise – in line lunge, but in all tasks the girls from Group 1 obtained higher results (Fig. 1).

In the FMS test the boys engaged in karate obtained a higher result (16.12 on average) than the boys from the control group (13.89 on average). The difference was statistically significant $p=0.001$ (Tab. 2). In case of boys in both groups the highest result was achieved in the shoulder mobility test, and the lowest – in the trunk stability – push up test. In all tasks the highest result was obtained by the boys from the study group, however significant differences were observed in case of three exercises: *deep squat* ($p=0.013$), *shoulder mobility* ($p=0.049$) and *trunk stability – push up* ($p=0.004$) (Fig. 2).

No significant differences between the dominant and non-dominant sides were noted for any of the groups and for any exercises. Differences which were nearly significant (Group 1: $p=0.083$; Group 2: $p=0.081$) were observed among the boys in the shoulder mobility test (Tab. 3).

Tab. 2. Overall results of FMS test

		mean value	standard deviation	min	max	difference
girls	karatekas	17.17	1.47	15	19	p=0.005
	non-active	14.27	2.1	11	18	
boys	karatekas	16.12	1.96	13	20	p=0.001
	non-active	13.89	2.26	9	18	

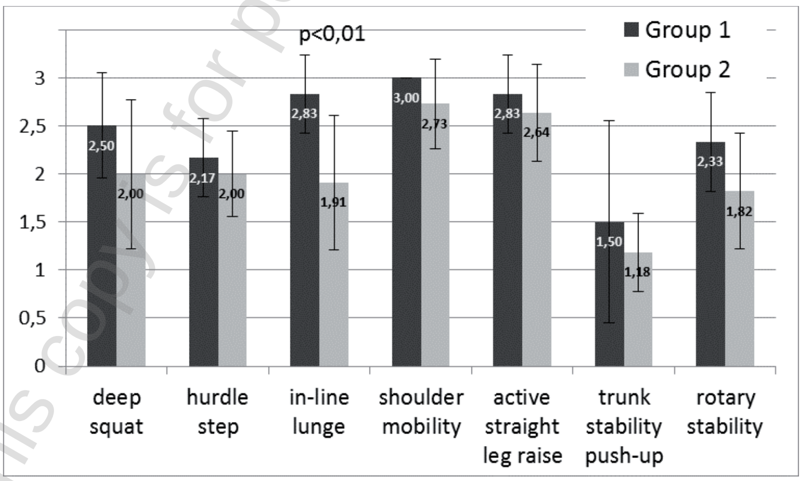

Fig. 1. Results of FMS test in girls

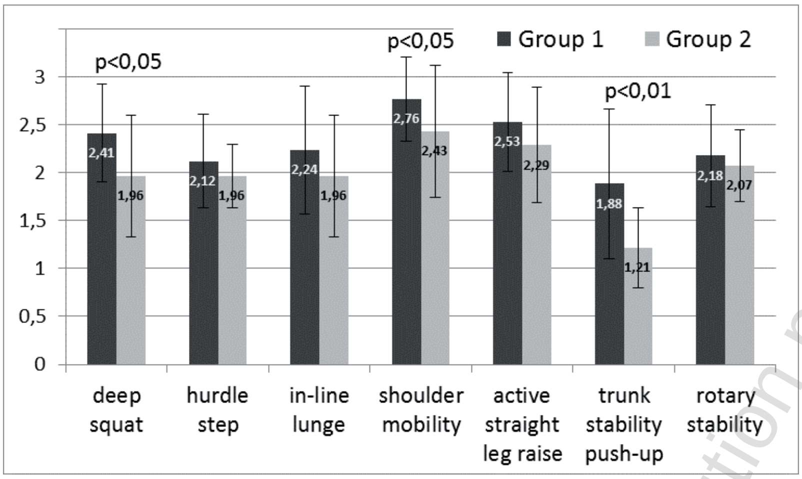

Fig. 2. Results of FMS test in boys

Tab. 3. Results of bilateral exercises

groups		hurdle step		in-line lunge		shoulder mobility		active straight leg raise		rotary stability	
		non-domi-nant	domi-nant	non-domi-nant	domi-nant	non-domi-nant	domi-nant	non-domi-nant	domi-nant	non-domi-nant	domi-nant
girls	karatekas	2.17	2.17	2.83	2.83	3.00	3.00	2.83	2.83	2.33	2.33
	non-active	2.00	2.00	1.91	2.00	2.73	2.73	2.64	2.64	1.91	1.82
boys	karatekas	2.12	2.18	2.35	2.29	2.76	2.94	2.53	2.53	2.18	2.18
	non-active	1.96	2.00	2.04	2.07	2.50	2.71	2.32	2.29	2.14	2.07

Tab. 4. Correlations (Pearson [r]) between age, BMI and results of FMS

		deep squat	hurdle step	in-line lunge	shoulder mobility	active straight leg raise	trunk stability push-up	rotary stability	sum
age	karatekas	0.279	0.225	0.303	0.025	0.264	0.144	0.296	0.392*
	non-active	0.485**	0.079	0.297	0.214	0.304	0.514**	0.442**	0.583***
BMI	karatekas	-0.132	0.012	0.327	-0.497*	0.053	0.098	0.220	0.052
	non-active	-0.034	-0.039	-0.198	-0.384*	-0.321*	0.073	0.098	-0.278

* p<0.05, ** p<0.01, *** p<0.001

A positive correlation was noted between the age and the general result of the FMS test in both groups. Among the inactive girls and boys the age correlated also with the result of the first, sixth and seventh exercise. A significant negative correlation was observed also between the result of the shoulder mobility test and the BMI index – in both groups. In the control group a similar tendency was observed for the active straight leg raise test (Tab. 4).

Discussion

The FMS test is a simple screening test which allows functional deficits and asymmetry of the participants to be determined [14-16]. Currently it is applied not only in professional and amateur sports, but also in case of numerous occupational groups, such as soldiers or firefighters [17].

High repeatability is an advantage of the test. It constitutes a basis to plan strictly function-oriented rehabilitation. Therefore, it is possible to reduce the risk of injuries and eliminate the risk factors for the occurrence of injuries [18-20].

The majority of studies using the FMS test include adults, and only few focus on young people and children. One of them is a research project by Parenteau et al., during which 30 hockey players aged 12-17 were tested. The average result obtained by the participants was 12.64 (± 3.65). The highest result was obtained during the second task – hurdle step (2.46 ±0.69 on average). While the lowest result was achieved during the push-up test (1.21±1.37 on average). First of all, each player was assessed on the spot and then twice using video materials. Statistical analysis indicated significant compliance of all evaluators for five of seven main tests. It can be concluded that the FMS test is a reliable test for young hockey players and it can be used by physiotherapists and trainers as a tool to prevent injuries [21].

There are not too many studies of movement patterns conducted among adepts of martial arts. The Functional Movement Screen test was used to study – among others – highly skilled aikido contestants. They obtained a result of 17.75 points on average. The highest and the lowest results were obtained during the push-up test and the rotary stability test respectively – similarly to the above mentioned studies. A positive correlation was observed between the age and the number of years during which a given person was engaged in trainings, and the general result of the FMS test. A negative correlation was noted between the total number of points obtained in the test and the number of past injuries [18].

In his studies Aptowicz et al. used a possibility to assess symmetry of a sportsman. The study group included men engaged in Olympic taekwondo. It was proven that the most problematic exercise was the rotary stability test (1.2 on average). The least problematic was the push-up test (2.6 on average). All bilateral exercises, apart from in line lunge, indicated movement asymmetry [22].

Muscle strength and muscle activity can be assessed in numerous ways. The most frequently used methods include: torque measurement, ultrasound or electromyographic testing. They are precise, but clinically inappropriate due to high costs and necessity of equipment. From the clinical point of view the standardized tests, such as the Front Abdominal Power Test, the Double Leg Lowering Maneuver (DLLM) or the FMS test, are more reliable. The first two are used to assess abdominal muscle endurance, but despite high repeatability they are not as precise as the EMG test. The FMS test is efficient due to low costs and high repeatability [23, 24]. Moreover, unlike the majority of studies, which focus on single features and motor elements, the FMS test allows to assess and shape quality of movement [14].

In his research project Paterno et al. indicated that injuries occurring among children engaged in sports of athletics in 30-50% include injuries resulting from overload. Severe injuries occur only in 15% of all cases and they are caused mainly by contact with the opponent. Children engaged in running the most frequently occurring pathologies involve knee joints, i.e. inflammation of the patellofemoral joint, the iliotibial band syndrome and the tibial stress syndrome [25].

Despite numerous social, psychological and health advantages of physical activity started in childhood, it is important to remember about an increased risk of injures and pain among young people engaged in trainings [26, 27].

It is necessary to continue studies using the FMS test among young sportsmen engaged in various disciplines. It will allow trainers to plan trainings more efficiently in order to prevent injuries which at a young age are often career ending. Low costs of the test and a possibility to comprehensively assess movement instead of single elements of physical activity constitute an advantage of the test.

Conclusions

1. Sportsmen obtained a higher (statistically significant) result in the FMS test which may indicate smaller functional limitations and higher movement quality possibly resulting from rational (comprehensive, symmetric) training.
2. Dependency between the result of the FMS test and the age involved inactive people to a greater extent which may indicate acceleration of motor development of the adepts of martial arts.
3. Conducting functional assessment using the FMS test allows implementation of an individual training, which may impact increased movement quality, therefore studies using the above mentioned tool should be continued on broader and more diverse groups.

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