ORIGINAL ARTICLE

Influence of traditional karate training on the stability and symmetry of the load on lower limbs

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A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
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Abstract

Background & Study Aim: Systematic traditional karate training leads primarily to changes in the kinaesthetic system of a sportsperson. The aim of the research is the influence of traditional karate training on the stability and symmetry of the load on lower limbs.

Material & Methods: A questionnaire was used and body stability was tested with the stabilometric platform Alfa, with its biofeedback switched off. The experimental group was 64 people practicing traditional karate, consisting of 48 boys and 16 girls. The age span was 9–19 years old. The control group was 118 randomly selected people from primary school and lower secondary school, who did not declare any organized physical activity. The control group included 59 boys and 59 girls, aged 10–16 years old.

Results: Sports people practicing traditional karate showed lower values of all the tested variables than those in the control group. This proves better stability in body posture for the sports people. Two positive correlations were registered indicating the influence of the length of training on the increase in maximum bend to the left, as well as average bend X. A negative correlation was found between the length of training and the length of the path, as well as the decrease in the average speed X.

Conclusions: Karate is the right form of physical activity influencing the posture stability revealing itself in the decrease of the path length projection of the center of gravity depending on the age and training experience.

Key words: martial arts • postural balance • psychomotor performance • proprioception

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Background

One of the problems of modern society is the limited activity and movement typical of young people. Asian culture has long fascinated Europeans due to its uniqueness. Interest in Asian culture is revealed in different forms of physical activity, including Asian martial arts such as aikido, judo, kung fu, taekwondo and karate. Systematic karate training causes changes not only in the motor system of the sportsperson, but also influences a subject's mental state and emotions. It leads to the acquisition of a state of mental balance and improved ability to control one's body [1–3].

Systematic training leads to improvement of motor patterns and more efficient application of different techniques in karate. The attack and defence techniques during a fight demand taking up unstable body posture such as standing on one leg. Staying in this posture is only possible due to a perfectly functioning system of balance control [4].

The studies of the influence of Asian martial arts on the biological development and motoric potential of both children and infants [5–8], as well as adults [9–11], have highlighted the following properties: speed, muscle strength, endurance, flexibility, physical efficiency. In the recent years, there have been reports about better coordination abilities among people training Asian martial arts [12], including the study of body balance [3,13–15].

Karate, as one of the martial arts, has a potential influence on improving the general fitness, symmetrical and balanced development of the muscle system, body posture correction, motor coordination and spatial orientation, endurance, strength, agility and flexibility.

Karate training incorporates elements of exercises used in kinesitherapy: exercises in open and closed sequences, patterns taken from **PNF** therapy, balancing exercises crucial for deep sensory development and body perception (which is essential in the prevention of potential falls), exercises influencing the fluidity of movements, integration of cerebral hemispheres and coordination of movement, breathing exercises, exercises of alternate straining and relaxation of the muscles, exercises stabilizing body posture and steadiness of the position and movement, exercises of isotonic muscle performance (concentric and exocentric) [16,17].

PNF – Prorioceptive Neuromuscular Facilitation.

COP – centre of foot pressure.

Body posture stability, balance and neuromuscular coordination determine the physical fitness of a sportsperson. The postural stability is supported by the coordination of three systems: proprioception, sight and the vestibular system [18,19]. At the same time, intensive training schemes, frequent injuries and falls as well as overloads in the motor system caused by physical factors, are likely to violate balance, neuromuscular coordination and proprioception [1,20]. Optimal amplitude of the projection of feet pressure on the floor helps to keep balance, progress in training and improve performance in fights [3]. Evaluation of balance is currently possible with a stabilometric platform. Posturography with stabilometric platforms is a simple and safe method of research [21].

Purpose of research

The aim of the research is the influence of traditional karate training on the stability and symmetry of the load on lower limbs.

Research questions:

1. Does karate training significantly influence the stability and symmetry of load in the lower limbs?
2. Are there any correlations between the studied indicators of stability as well as indicators of load symmetry in lower limbs and age, gender, place of residence, frequency of training, training experience, injuries received?

Material and Methods

Questionnaire and body posture stability test. The questionnaire was used to obtain the demographic data (age, gender, place of residence, frequency of weekly training, training experience) as well as medical data (injuries of lower limbs within three years before the test).

A stability test was performed on all subjects (both research and control groups) with a stabilometric platform Alfa, with its biofeedback off. A stabilometric platform is an appliance used for testing balance on a stable surface. In the study we used the following indicators: imprint of the centre of foot pressure (**COP**), average bend of COP in the frontal plane, average bend of COP in the sagittal plane, length of the COP path in cm, area of the middle foot pressure surface in cm^2 imprinted on the platform, average COP speed in cm per second in the frontal plane, average COP speed in cm per second in the sagittal plane, average load on the right and left side (percentage), and time of the dominating load of the right and left side (percentage).

Each test lasted 2 minutes. The subject had to stand bare feet on the platform in an upright position, with the upper limbs alongside the body, eyes looking straight forward.

The Alfa platform was used to perform a stabilometric test objectively showing balance with open eyes. The Alfa platform complies with the European Union directive 2007/47/EC as a class I unit; it complies with the European standard EN 60601-1 (IEC 62-5) as a class II unit, Type B; and it complies with European standard EN 60601-1-2 "Electromagnetically safe".

The tested karate fighters practiced 2 or 3 times a week at the Academy of Movement with a world champion in traditional karate. Each training session lasted 1.5 hours.

The data was statistically processed with the use of descriptive statistics: non-parametric Mann-Whitney test and Spearman's rank correlation coefficient [22,23]. The test results of the lower limb load in two compared test groups were introduced in the form of an average, median value (median) and standard deviation.

The study was carried out between 1 and 15 April 2012. The research group was a total of 64 people practicing traditional karate, including 48 (75%) male, and 16 (25%) female. The average age was 15.1 years old (in the range 9–19 years old).

Table 1. Place of residence of the subjects.

Place of residence	Group (p=0.0081**)		Total (n=182)
	Research (n=64)	Control (n=118)	
City	48 (75.0%↓)	106 (89.8%↓)	154
Country	16 (25.0%↓)	12 (10.2%↓)	28

Table 2. Frequency of training (weekly) for karate fighters (n=64).

Frequency of training (weekly)	Number of people	Percentage
1	1	1.6%
2	30	46.9%
3	23	35.9%
4	5	7.8%
5	3	4.7%
6	1	1.6%
7	1	1.6%

The control group was 118 randomly selected people from primary school No 13 and lower secondary school No 7 in Rzeszow who did not declare any organized physical activity. The control group included 59 (50%) boys and 59 (50%) girls. Average age was 12.9 years old (aged 10–16 years old). The subjects' age in both groups is similar.

In both groups (research and control) most subjects live in a city. The difference is larger in the control group (Table 1). Among the karate fighters the dominant group are the people practicing 2 or 3 times a week (Table 2).

The experience in training was extremely varied and determined by the subject's age. The average experience was 3.9 years. The number of people who in the past had some injuries to the lower limbs is similar in both groups: in the research group 12 people (18.8%), in the control group 26 people (22%). These were ankle sprain, damage to the ligaments of the knee and haemorrhages into the calf muscles. Eight subjects had their lower left limb injured.

Results

In the majority of empirical variables the median significantly differs from the average value, which means that the spread of the studied features was asymmetrical and was characterized by the presence of outlying observations.

People practicing karate showed lower values of all the tested variables than those from the control group. They are not of high statistical significance, but this fact proves karate fighters' better stability. A statistically significant difference is observed in the plantar pressure, which was smaller in the group of karate fighters, which demonstrates their more stable posture. A slightly lower difference, of a statistically marginal degree, was also found in the maximum bend to the right. Considering the rest of the results we can conclude that people practicing karate have a more stable posture, the load on lower limbs calculated from the percentage difference of dominating time is more even (Table 3, Figures 1 and 2).

The diagram shows values of centile 50 (median), centiles 25 and 75 as well as 10 and 90. It is noticeable that the level of plantar pressure median is lower in the karate fighters group.

Factors affecting lower limb load

Age and test values

Average speed X, average speed Y, path length and plantar pressure have decreased with age, both in the research group and in the control one. This is a statistically valid result (Table 4, Figures 3 and 4).

Also, there has been noticed that with age maximum bend left and maximum bend right decrease, which proves symmetricalization of the body posture (Table 4, Figures 5 and 6).

Frequency and time of training and test results

We registered two positive correlations proving the connection between the period of training with an increase

Table 3. Tested variables of postural stability and load on lower limbs.

Variables	Group						p
	Research (n=64)			Control (n=118)			
	$\bar{\chi}$	Me	s	$\bar{\chi}$	Me	s	
Maximum bend left [cm]	–2.74	–2.56	3.40	–2.31	–2.00	3.67	0.237
Maximum bend right [cm]	3.06	2.64	2.87	4.05	3.09	3.74	0.091
Maximum bend back [cm]	–7.0	–7.8	4.4	–8.1	–8.5	4.0	0.122
Maximum bend front [cm]	–0.3	–0.7	4.5	–0.1	–0.4	4.5	0.909
Average bend X [cm]	0.27	0.29	2.22	0.89	0.53	2.60	0.232
Average bend Y [cm]	–3.55	–3.73	4.16	–4.19	–4.75	3.97	0.322
Average speed X [cm/s]	1.84	1.71	0.65	1.97	1.81	1.02	0.467
Average speed Y [cm/s]	2.18	2.03	0.79	2.36	2.23	0.82	0.117
Path length [cm]	186.5	172.2	64.2	201.4	186.9	83.5	0.184
Plantar pressure [cm^2]	49.2	27.4	84.7	62.2	38.8	105.7	0.046*
Average load on the left [%]	49.2	50.0	3.7	48.4	49.0	4.2	0.385
Average load on the right [%]	50.8	50.0	3.7	51.6	51.0	4.2	0.374
Bend difference on both sides [%]**	5.8	6.0	5.0	6.5	5.0	5.8	0.629
Time of dominant load on the left side [%]	45.1	47.5	39.9	37.9	25.0	38.6	0.310
Time of dominant load on the right side [%]	54.9	52.5	39.9	62.0	75.0	38.5	0.316
Dominant time difference [%]**	72.1	95.0	34.4	74.4	89.0	30.8	0.990

* $p<0.05$. ** The additional variable introduced here indicates absolute difference between the load on both lower limbs.

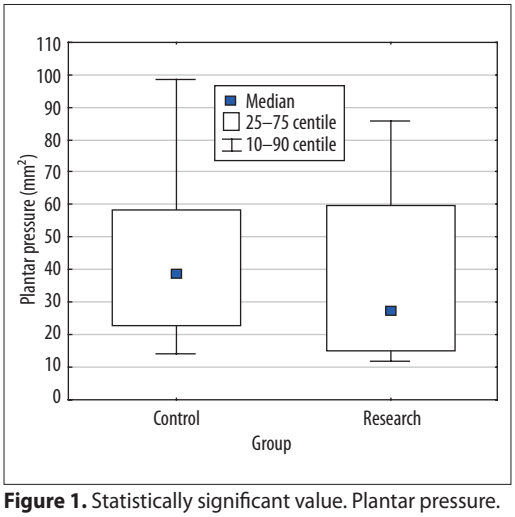

Figure 1. Statistically significant value. Plantar pressure.

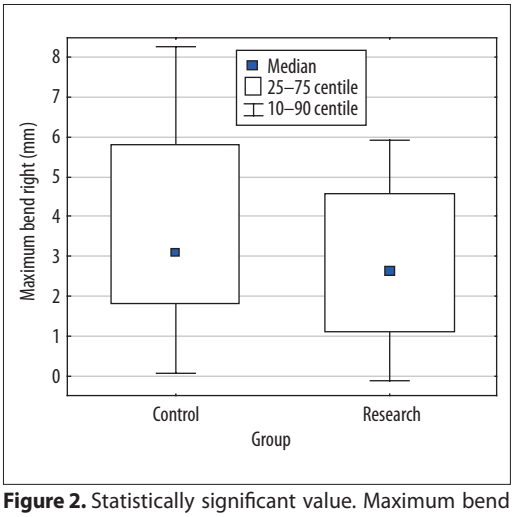

Figure 2. Statistically significant value. Maximum bend right.

in maximum bend to the left and average bend X (Figures 7 and 8). A negative correlation was registered between the period of training and length of the path, as well as decrease in average speed X, which is a good result. No correlation was found between the period of training and variables related to the lower limb load. The obtained results of the stability and load on lower limb variables are not correlated with the number of training days per week (Table 5).

Gender and the results of testing

Gender does not have any influence on the results of lower limb testing. No statistically significant differences were found between test results of boys and girls (Table 6).

Table 4. Age and values of stability and tested variables of lower limbs load.

Variables	Age [years old]		
	Research group (n=64)	Control group (n=118)	Total
Maximum bend left [cm]	0.27*	–0.05	0.08
Maximum bend right [cm]	0.04	–0.25*	–0.14
Maximum bend back [cm]	0.20	0.00	0.07
Maximum bend front[cm]	0.10	–0.10	0.00
Average bend X [cm]	0.16	–0.16	–0.04
Average bend Y [cm]	0.22	–0.02	0.07
Average speed X [cm/s]	–0.40*	–0.43*	–0.41*
Average speed Y [cm/s]	–0.27*	–0.24*	–0.24*
Path length [cm]	–0.34*	–0.35*	–0.33*
Plantar pressure [cm^2]	–0.27*	–0.19*	–0.21*
Average load of the left side [%]	–0.12	0.11	0.03
Average load of the right side [%]	0.12	–0.12	–0.03
Difference of bend on both sides [%]	0.04	–0.16	–0.08
Time of dominant load on left side [%]	–0.16	0.07	–0.01
Time of dominant load on right side [%]	0.16	–0.06	0.01
Dominant time difference [%]	0.07	–0.02	0.02

* $p<0.05$.

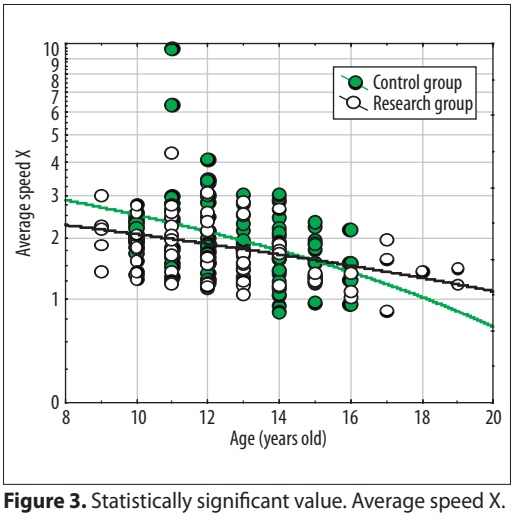

Figure 3. Statistically significant value. Average speed X.

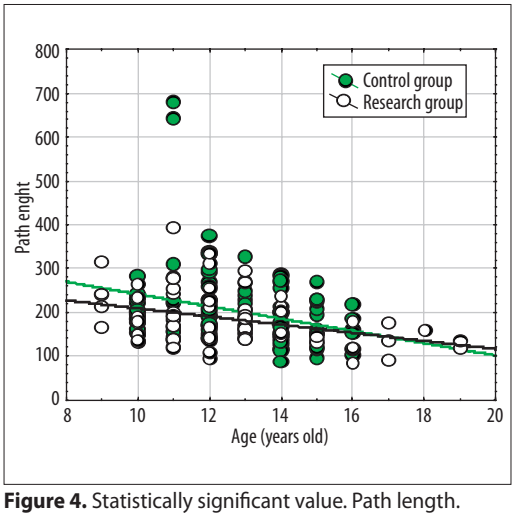

Figure 4. Statistically significant value. Path length.

Injuries and test results

Lower limb injuries influenced in a statistically significant way the time of the dominating load and average load on the limbs (for this variable the difference is close to statistically significant: $p=0.072$). These correlations refer only to the group of karate fighters. Among the group with injuries the average load time on the left side is very low; the average load on this side is also lower.

Statistically significant differences in the research group also referred to the maximum bend to the left and average bend X (Table 7).

Statistically significant correlations are represented in the figures below (research group only). The diagram shows the average value with the information about a typical range of variability and 95% confidence interval in the compared groups (Figures 9 and 10).

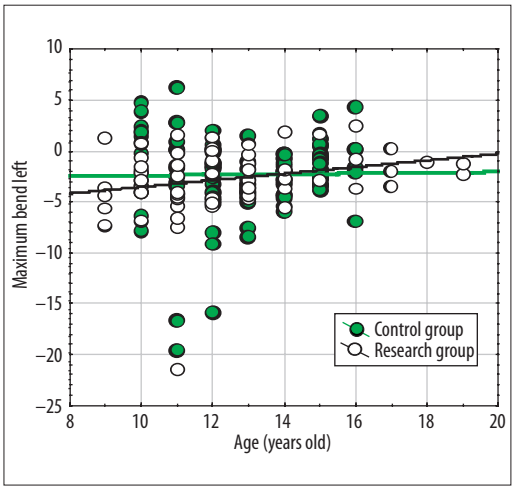

Figure 5. Statistically significant value. Maximum bend left.

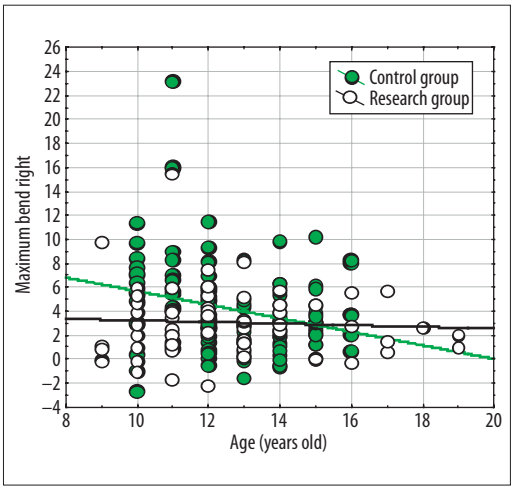

Figure 6. Statistically significant value. Maximum bend right.

Table 5. Period and frequency of training and tested variables of lower limb stability and load.

Variables	Training period [in years]	Frequency of trainings [weekly]
Maximum bend left [cm]	0.37*	0.24
Maximum bend right [cm]	0.11	0.11
Maximum bend back [cm]	0.11	0.15
Maximum bend front [cm]	0.05	0.09
Average bend X [cm]	0.29*	0.18
Average bend Y [cm]	0.13	0.13
Average speed X [cm/s]	–0.29*	–0.13
Average speed Y [cm/s]	–0.17	–0.09
Path length [cm]	–0.26*	–0.15
Plantar pressure [cm^2]	–0.24	–0.22
Average load of the left side [%]	–0.24	–0.08
Average load of the right side [%]	0.24	0.08
Bend difference on both sides [%]**	–0.06	–0.08
Time of dominant load on the left side [%]	–0.23	–0.09
Time of dominant load on the right side [%]	0.23	0.09
Dominant time difference [%]**	0.00	0.00

* $p<0.05$. ** The additional variable introduced here indicates absolute difference between the load on both lower limbs.

Discussion

Karate can be considered to offer almost perfect and harmonious development of the whole body (the empirical proofs can be found in *The complete Encyclopaedia of Exercises* published in Britain) [24]. While practicing different techniques the equal load on both sides plays a crucial role, whether they are blocks with both arms alternatively or simultaneously, or also foot techniques done in a standing position, in half-turn, turn or jump, but with the other leg being a support [25,26].

The authors of the publication *The comparison of the role of vision on static postural stability in athletes and non-athletes*[18] point out that balance control is inseparably linked to stability. Stability is a broader term meaning the ability to regain a state of balance. In the case of a human being it is the ability to actively regain the typical position of the body in space which was lost due to destabilizing

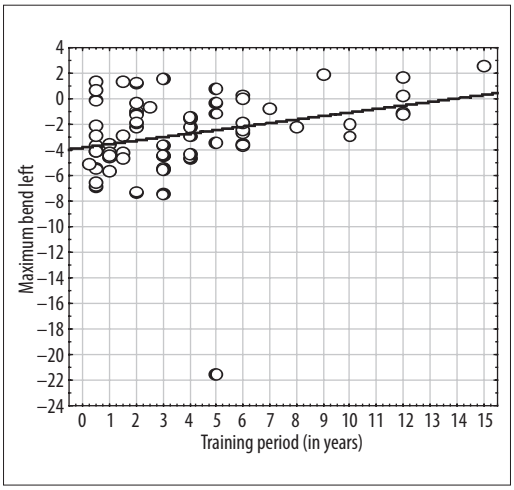

Figure 7. Statistically significant value. Maximum bend left.

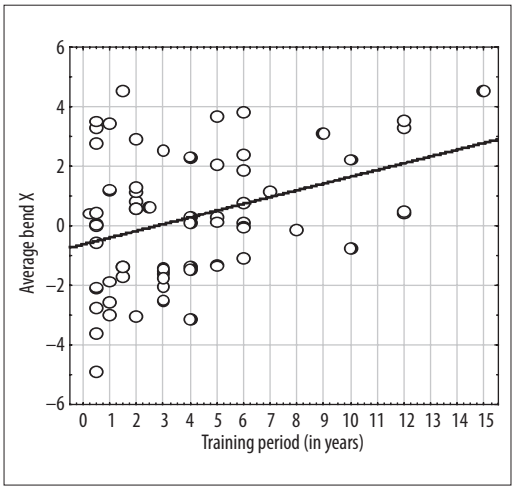

Figure 8. Statistically significant value. Average bend X.

Table 6. Gender and variables of lower limbs stability and load.

Variables	Research group (n=64)			Control group (n=118)		
	Gender		p	Gender		p
	Male (n=48)	Fem (n=16)		Male (n=59)	Fem (n=59)	
Maximum bend left [cm]	–3.19	–2.07	0.203	–1.95	–2.11	0.965
Maximum bend right [cm]	2.64	2.64	0.812	3.51	3.05	0.580
Maximum bend back [cm]	–7.4	–10.0	0.484	–9.7	–7.9	0.149
Maximum bend front [cm]	0.3	–2.1	0.320	–0.5	–0.3	0.530
Average bend X [cm]	0.20	0.43	0.812	0.52	0.54	0.759
Average bend Y [cm]	–3.27	–5.39	0.401	–5.57	–4.55	0.228
Average speed X [cm/s]	1.75	1.64	0.232	1.88	1.71	0.222
Average speed Y [cm/s]	2.20	1.77	0.135	2.34	2.05	0.222
Path length [cm]	181.3	148.2	0.116	195.1	169.4	0.226
Plantar pressure [cm^2]	30.4	22.0	0.351	46.4	34.1	0.266
Average load of the left side [%]	50.0	50.0	0.788	49.0	49.0	0.584
Average load of the right side [%]	50.0	50.0	0.788	51.0	51.0	0.610
Bend difference on both sides [%]*	6.0	3.0	0.384	4.0	6.0	0.569
Time of dominant load on the left side [%]	49.5	46.0	0.484	25.0	26.0	0.621
Time of dominant load on the right side [%]	50.5	54.0	0.484	75.0	74.0	0.606
Dominant time difference [%]*	95.0	89.0	0.419	86.0	92.0	0.703

* The additional variable introduced here indicates absolute difference between the load on both lower limbs.

factors. Balance is one of the most important motor skills in both everyday life and sports activities [18].

In the work *Coupling between punch efficacy and body stability for elite karate* [4] the authors draw our attention to the fact that balance is of great importance for karate fighters, as it predetermines the proper execution of all the techniques, which can be performed exclusively upon taking and keeping a definite and, most important, stable position [4].

It is worthy of note that, to ensure the proper training process for beginner fighters of different martial arts, simplified *kata* were designed, known as *seitei, pinan (heian)*, which include the most basic positions and techniques (*waza*) helpful in understanding the key elements

Table 7. Injuries and tested variables of stability and load of lower limbs.

Variables	Research group (n=64)			Control group (n=118)		
	Injuries		p	Injuries		p
	No (n=52)	Yes (n=12)		No (n=92)	Yes (n=26)	
Maximum bend left [cm]	–2.92	–0.71	0.090	–2.12	–1.52	0.340
Maximum bend right [cm]	2.38	3.65	0.185	3.02	3.58	0.607
Maximum bend back [cm]	–8.1	–7.6	0.858	–8.2	–8.9	0.961
Maximum bend front [cm]	–0.1	–2.7	0.766	–0.3	–1.4	0.554
Average bend X [cm]	0.09	1.05	0.077	0.46	0.69	0.961
Average bend Y [cm]	–3.56	–4.90	0.753	–4.57	–5.46	0.686
Average speed X [cm/s]	1.75	1.53	0.792	1.83	1.75	0.572
Average speed Y [cm/s]	2.11	1.83	0.580	2.19	2.37	0.849
Path length [cm]	177.6	140.0	0.380	186.9	187.4	0.889
Plantar pressure [cm^2]	30.4	23.9	0.952	37.0	41.3	0.951
Average load of the left side [%]	50.0	47.5	0.072	49.0	48.5	0.992
Average load of the right side [%]	50.0	52.5	0.072	51.0	51.5	0.930
Bend difference on both sides [%]*	6.0	5.0	0.818	5.0	5.0	0.607
Time of dominant load on the left side [%]	56.5	6.0	0.040*	26.0	16.0	0.475
Time of dominant load on the right side [%]	43.5	94.0	0.040*	74.0	84.0	0.508
Dominant time difference [%]*	95.0	88.0	0.966	91.0	84.0	0.428

* The additional variable introduced here indicates absolute difference between the load on both lower limbs.

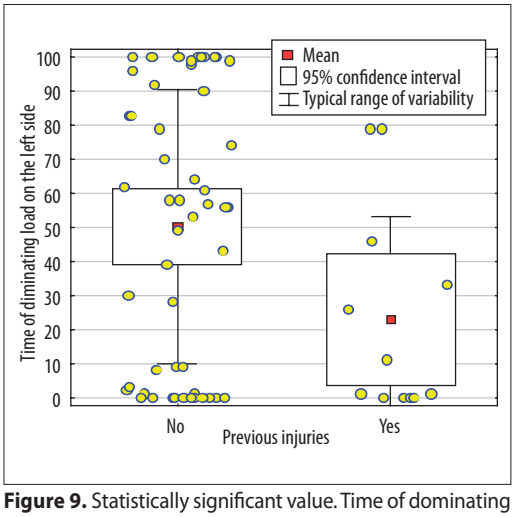

Figure 9. Statistically significant value. Time of dominating load on the left side.

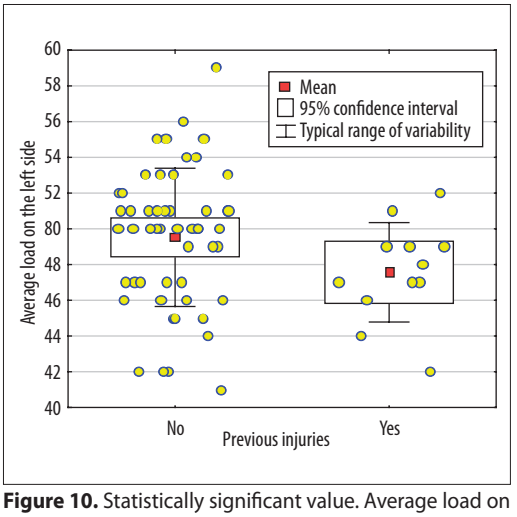

Figure 10. Statistically significant value. Average load on the left side.

(keeping the balance, body posture, proper distance and timing). Only after mastering the basic *kata* can the beginners study more advanced *kata,* which are taught according to the ancient martial arts.

Bajorek et al. [3] claim that in situations when stability is lost, e.g. when bending forward (which can be forced by an attack or defence) in order to get a longer reach of the fighters' limbs, balance determines the ergonomic workout of karate fighters. Of major importance in this case is finding the golden mean between stability, width of the position and projection of the centre of gravity [3].

Fong et al. [27] tested children practicing taekwondo. The researchers consider that children affected by developmental coordination disorder (**DCD**) have weaker postural control and are more prone to falls and injuries than their healthy peers. The tests by Shirley were done on 44 children with coordination disorder (DCD). Out of the group of 44 children with developmental coordination disorder (DCD) 21 children were randomly chosen to be were given daily **TKD** (taekwondo) training for three months (1 hour a day).

The remaining 23 children out of the DCD group, as well as 18 children developing properly, were the control group. Sensory efficiency and ability to keep an upright position were evaluated with a sensory organization test (SOT) and unipedal stance time (**UST**). Analysis of the results indicated an improvement in the research using both SOT test (p=0.003) and UST test (p=0.007). The results were better and statistically significant in the group of 21 children with developmental coordination disorder (DCD) who practiced taekwondo, than in the control group of 23 children with DCD. The researchers stated that three-month daily TKD training improves sensory organization and sense of balance evaluated in the upright position [27].

In our research, comparing the study of the research and control groups we obtained statistically significant results concerning maximum bend to the right (3.06 mm *vs.* 4.05 mm), as well as the size of the centre area of foot pressure imprint on the platform (plantar pressure) (49.2 mm^2 *vs.* 62.2 mm^2). At the same time, the acquired results prove better stability and balance in people practicing karate. These results were affected by such factors as age of the subjects, training experience and injuries to the lower limbs within the last three years.

The logical continuation of the research in this area seems to be an analysis of the tendencies seen in the process of training which concerns the correction of maximal deviation differences between the right and left side presumably rooted in the multiple repetition of sequences of movements made reciprocally in karate training.

Our research has shown that with age, which indirectly relates to the period of training, the path length and plantar pressure decrease, and it proves better balance in the subjects practicing karate which, in its turn, results from better coordination of muscle activity. Undoubtedly, this is directly influenced by the methodology of martial arts training.

An important factor influencing our research of selected variables was injuries, or lack thereof, within the last three years. In view of the fact that the number of injuries was comparable in the control group and in the group practicing karate, and the statistically significant results were obtained only in the research group, they referred only to the influence of the injury on the time of dominant load on the left side, maximum bend to the left, average bend on the X axis and the average load on the left side. The overall results indicate the influence of injuries on the stability and load on lower limbs, as well as pinpoint the fact that the injury factor demands continuation of the research using a larger sample.

DCD – developmental Coordination Disorder.

TKD – taekwondo.

UST – unipedal stance time.

It should be mentioned that results similar to ours were obtained by other researchers [4,28]. Blazević et al. studied the motor skills of people practicing karate and confirmed a radical influence of karate training on the ability to maintain balance [28].

Ludivine et al. [29] draw our attention to the fact that ageing should not be necessarily associated with a decline in physical activity and, respectively, the quality of life. They proved that long-lasting practice of martial arts can prevent these processes. Their pilot research was to study the effects of a karate training programme in the spheres of quality of life and motor skills. Fifteen people at the age of 50 participated in a one-year experiment. The participants practiced specially adapted karate for 90 minutes three times a week. They showed improvements in the time of reaction and balance variables in the position with eyes closed (p=0.01) [29].

Cesari et al. [4] tested different techniques of karate hits comparing advanced fighters and beginners. The research was a dynamic test done on a stabilometric platform. The study analysed the variables of the centre of pressure (COP) shift of the fighter, as well as the movement and kinematics of the upper limbs. The study suggested the conclusion that the period of training is crucial for an increase in the stability of dynamic posture while making a hit in karate, which concurs with our results [4].

The results obtained by Mohammad Akbari et al. [2] also agree with ours. They concern the influence of ankle injuries on posture stability and load symmetry on lower limbs. Marie-Ludivine et al. (following Mohammad Akbari et al.) [29] studied 30 people with ankle injuries. The researchers measured the index of bending and the limit of balance stability in different conditions (with eyes closed and open). Symmetry of the limbs load did not differ in either case, while the load of a lower limb after an ankle injury was significantly lower in the test with eyes closed. The researchers associate it with the lack of proprioception in the test with eyes closed [2].

In the process of karate training one more important aspect should be mentioned. The process of training of

young karate fighters is a well-defined process of long-term transformation where good performance is achieved through introducing the proper training forms of exercises for the given level as well as a range and intensiveness of load in accordance with individual characteristics of the fighters. The coach should manage the process of training in such a way that optimal training forms are chosen and a permanent control over this process is sustained. The trainer is also responsible for monitoring the development of the children's motor skills. It is essential to observe the posture, symmetry of movements, proper load of the limbs, to adjust the positions taken during the training (to prevent possible overloads in the motor system), as well as to introduce the necessary corrections into the training programme.

The value of karate training is its potential influence on: improvement of the sensomotoric system, the control of balance and prevention of clumsiness, improvement of general physical skills, symmetrical and well-balanced development of musculature, motor coordination and spatial orientation [27,30,31].

In karate training, we can find some elements used in rehabilitation exercises, including exercises in open and closed chains, movement patterns of PNF treatment, balanced exercises playing an important role in proprioception development, exercises affecting motion smoothness, integration of cerebral hemispheres, movement coordination, breathing exercises, exercises of alternate muscle contraction and relaxation, exercises stabilizing posture and steadiness of position and movement, exercises of isotonic muscle action (concentric and eccentric, *'chou tui'* exercises) [5].

All this is essential for the long-term effects of exercise and fighting effectiveness, but also for the state of the musculoskeletal system in older age [32].

Conclusions

1. Karate is the right form of physical activity influencing the posture stability revealing itself in the decrease of the path length projection of the center of gravity depending on the age and training experience.
2. Karate does not give satisfactory results of lower limb symmetry load with people who have suffered injuries of lower limbs, despite a completed treatment.

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