



# Comparison of dynamic balance indicators using the Star Excursion Balance Test method in men of various types of martial arts with left- and right-sided motor asymmetry

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## Abstract

**Purpose:** to perform a comparison of the Star Excursion Balance Test indicators in men of various types of martial arts with left- and right-sided motor asymmetry.

**Material and methods.** The results of the study were obtained at the Ivan Bobersky Lviv State University of Physical Culture at the Department of Fencing, Boxing and National Martial Arts in the period October-December 2023. Qualified male martial artists aged 18-22 in the number of 84 participated in the collection of experimental material: 11 representatives WKF karate (including 1 left-hander), 12 members of fencing (including 2 left-handers), 9 representatives of hopak hand-to-hand combat (including 1 left-hander), 31 representatives of boxing (including 12 left-handers), 21 representatives of Kyokushinkai karate (among whom there was 1 left-handed person). Research methods: analysis of literary sources and materials from the Internet; survey (questionnaire); measurement of anthropometric indicators of athletes (height, body weight, length of arms and legs); measurement of Star Excursion Balance Test (SEBT); methods of mathematical statistics.

**Results:** right-handed martial artists ( $n=67$ ) had an anthropometric advantage over left-handed martial artists ( $n=17$ ): height – 178.1 cm versus 177.5 cm, respectively, body weight – 70.9 kg versus 66.8 kg, length arms – 76.7 cm vs. 73.9 cm ( $P<0,05$ ), leg length – 95.0 cm vs. 91.8 cm. Comparison of SEBT indicators revealed: left-handed group has better SEBT indicators in almost all positions, as on the left side of the body, as well as on the right. When comparing indicators of all 8 positions of SEBT of the left leg in right-handed and left-handed players, it was found that left-handed players had significantly ( $P<0,05$ ) better indicators in positions 6 and 7. Left-handed martial artists demonstrated significantly ( $P<0,05$ ) the best SEBT indicators in positions 6, 7, 8 of the right leg than right-handed martial artists. SEBT indicators of both right and left arms showed that positions 7, 8 of both left and right arms were significantly ( $P<0,05$ ) better than those of right-handers. A separate phenomenal result is the specificity of passing the SEBT test by left-handed athletes: their results are significantly ( $P<0,05$ ) better in the most difficult positions – 6, 7, 8, and in each of the four limbs of the body, regardless of motor asymmetry.

**Conclusions.** The results of the work demonstrated phenomenal SEBT indicators in left-handed martial artists, compared to right-handed martial artists. This phenomenon is observed in all SEBT indicators of the lower and upper limbs of the left and right sides of the body: indicators of all SEBT positions in left-handed athletes are better than in right-handed athletes. Lefties reliably dominate in the most difficult positions of the test – 6, 7, 8, both in the girdle of the upper limbs and in the balance and flexibility of the lower limbs, regardless of asymmetry. This phenomenon is observed against the background of left-handed athletes lagging behind right-handed athletes according to anthropometric indicators. In view of the above, we assume that left-handed athletes have special properties of neuromuscular activity that require special in-depth research.

**Keywords:** left-handed, right-handed, functional asymmetry, motor asymmetry, Star Excursion Balance Test, martial arts.

## Анотація

**Порівняння показників динамічної рівноваги за методикою Star Excursion Balance Test у чоловіків різних видів одноборств з ліво- та правосторонньою руховою асиметрією**

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**Мета:** здійснити порівняння показників Star Excursion Balance Test у чоловіків різних видів одноборств з ліво- та правосторонньою руховою асиметрією.

**Матеріал і методи.** Дослідження проведено у Львівському державному університеті фізичної культури імені Івана Боберського на кафедрі фехтування, боксу та національних одноборств у період жовтень-грудень 2023. У зборі експериментального матеріалу брали участь кваліфіковані одноборці чоловічої статі віком 18-22 років у кількості 84 особи: 11 представників карате за версією WKF (серед яких був 1 лівша), 12 представників фехтування (серед яких



було 2 лівші), 9 представників рукопашу гопак (серед яких був 1 лівша), 31 представник боксу (серед яких було 12 лівшів), 21 представник Кіокушинкай карате (серед яких був 1 лівша). Методи дослідження: аналіз літературних джерел та матеріалів з мережі Інтернет; опитування (анкетування); вимірювання антропометричних показників спортсменів (зросту, маси тіла, довжини рук та ніг); вимірювання показників Star Excursion Balance Test (SEBT); методи математичної статистики.

**Результати:** одноборці-правші ( $n=67$ ) мали перевагу по антропометричним показникам ніж одноборці-лівші ( $n=17$ ): зріст – 178,1 см проти 177,5 см відповідно, маса тіла – 70,9 кг проти 66,8 кг, довжина руки – 76,7 см проти 73,9 см ( $p<0,05$ ), довжина ноги – 95,0 см проти 91,8 см. Порівняння показників SEBT виявило: група лівшів мають кращі показники SEBT практично по всіх позиціях, як по лівій стороні тіла, так і по правій. При порівнянні показників всіх 8 позицій SEBT лівої ноги у правшів та лівшів, виявлено вірогідно кращі ( $p<0,05$ ) показники в лівшів у позиціях 6 та 7. Одноборці-лівші продемонстрували вірогідно найкращі ( $p<0,05$ ) показники SEBT в позиціях 6, 7, 8 правої ноги, ніж одноборці-правші. Показники SEBT обох правої та лівої рук показали, що позиції 7, 8 як лівої, так і правої руки у лівшів вірогідно кращі ( $p<0,05$ ), ніж у правшів. Окремим феноменальним результатом є специфіка проходження тесту SEBT лівшами: їхні результати вірогідно кращі ( $p<0,05$ ) в найскладніших позиціях – 6, 7, 8, у кожній з чотирьох кінцівок тіла, незалежно від рухової асиметрії.

**Висновки.** Результати роботи продемонстрували феноменальні показники SEBT в одноборців-лівшів, у порівнянні із одноборцями-правшами. Дане явище спостерігається в усіх показниках SEBT нижніх та верхніх кінцівок лівої та правої сторони тіла: показники всіх позицій SEBT у лівшів є кращими, ніж у правшів. Лівші вірогідно домінують в найскладніших позиціях тесту – 6, 7, 8 як в поясі верхніх кінцівок, так і в балансі та гнучкості нижніх кінцівок, незалежно від асиметрії. Дане явище спостерігається на фоні відставання лівшів від правшів за показниками антропометрії. З огляду на вищевказане, ми припускаємо те, що лівші мають особливі властивості нервово-м'язової діяльності, які потребують спеціальних поглиблених досліджень.

**Ключові слова:** лівша, правша, функціональна асиметрія, рухова асиметрія, Star Excursion Balance Test, одноборства.

## Introduction

Left-handedness remains an understudied phenomenon in several sports. In 40-50 % of cases, experienced coaches are wrong in predicting the success of individual athletes (Shynkaruk, & Ulan, 2016a). According to the authors, in the modern conditions of the development of sports, the genetic predispositions of young athletes are particularly relevant for study, among which an important place is occupied by functional asymmetry, which is of particular interest for certain groups of sports, the phenomenon of left-handedness.

The above-mentioned scientists note the tendency to increase the number of left-handed fencers in sports and emphasize the need to take into account functional asymmetry in the process of selecting athletes. According to the researchers (Shynkaruk, & Ulan, 2016a), the definition of functional asymmetry can serve as a marker of the effectiveness of actions in sports and is necessary to take into account during the organization of events for the sports selection of children for classes in one or another sport, as well as the orientation of their training, to choose the most effective means and methods for further organization of the training process. According to scientists, the need to orient sports training taking into account the dominant hemisphere is because the leading part of the body can work out faster and recover after loads, master complex coordination movements, and form motor skills. In highly qualified athletes, optimal adaptation is observed when applying loads aimed at the maximum development of genetically determined individual endowments (Moskvin, & Moskvina, 2010).

Special interest in the «left-handed phenomenon» arises in martial arts (wrestling, boxing, karate, fencing, etc.) and game sports - tennis, football, basketball, etc. Researchers claim that the athletic success of left-handers is determined by their faster

reaction, compared to right-handers (Klein, Moskvin, & Chuprikov, 1986). The German scientist Loffing F. (2017) studied left-handedness and the effect of the time limit on players in elite interactive ball games (badminton, squash, table tennis, cricket, baseball). Referring to data on interactive ball sports, the scientist suggested that the left-handed advantage is related to the time limit in such a sport. The prevalence of left-handedness listed in the elite rankings increased from low (8,7 %) to high (30,39 %) in time-limited sports, and clear left-handed representation was found in only a few (i.e., baseball, cricket, and table tennis).

The division of athletes into right-handed and left-handed athletes in science is related to such concepts as «functional asymmetry» and «motor asymmetry». Motor asymmetry is a component of the functional asymmetry of the human brain (Lazurenko, Kucherenko, & Morgun, 2009). It is related to the specifics of a particular type of sport, and the dynamics of its manifestation depend on the athlete's experience and level of preparation (Moskvin, & Moskvina, 2010).

Regarding motor asymmetry, researchers note the advantage of left-handed athletes in several sports activities, which is especially clearly manifested in contact sports (Ulan, 2016). A trend towards the selection of left-handed athletes, who are uncomfortable opponents for a one-on-one fighter, has been observed. The left-handed asymmetry profile of fencers makes them uncomfortable opponents for right-handed players, thereby determining the effectiveness of competitive matches (Ulan, 2016b).

Peculiarities of motor asymmetry in humanities students were investigated using pushing and throwing exercises with balls of different weights (Nikitenko, Kukurudziak, & Nykytenko, 2015). Scientists have established that one of the infor-



mative tests for determining a person's motor asymmetry is to use the impact of balls of different masses on the range. It is also determined that a high level of development of power contributes to better accuracy in throwing the ball at the target. According to the authors, the effectiveness of throwing a weighted ball for accuracy with the dominant hand is related to the functional properties of the human nervous system and the imperfection of coordination when performing throwing movements for accuracy with balls with the non-dominant hand of a person is compensated by its strength capabilities. In their next study, scientists examined the features of motor asymmetry in boxers. Manual motor asymmetry is not the basis for determining the fighting stance of a beginner boxer (Nikitenko, & Nykytenko, 2016). The push of weighted balls at a distance is an informative test for determining the motor asymmetry of beginner boxers – on its basis; it is advisable to identify an adequate (left- or right-sided) combat stance at the beginning of training in boxing technique. The hand dynamometry method is not very informative for determining manual motor asymmetry in boxers. The tapping test is narrowly focused and can be used in boxers to diagnose fine motility of hand muscles and manual motor asymmetry. Qualified boxers probably have a better-developed non-dominant hand (the one in front of them in the fighting stance) than beginners in boxing.

Scientists from many countries of the World have been using the Star Excursion Balance Test method in their research for more than two decades, aimed at studying the dynamic balance of a person. This method is used mainly in research of a medical and rehabilitation nature and is considered sufficiently reliable according to the testimony of scientists (Kinzey, & Armstrong, 1998). Scientists have conducted several studies of injuries of the lower extremities and asymmetry in representatives of game sports – basketball, handball, and football (Plisky, et. al., 2006; Gonell, et. al., 2015; Smith, et. al., 2015; Stiffler, et. al., 2017). The relationship between the age of young teenage soccer players and the index of limb symmetry and the standards of the modified mSEBT test was also investigated (Philp, et. al., 2019). Scientists (Chang, et. al., 2020) studied the relationship between functional motor screening (FMS), the SEBT test, the agility T-test, the results of the vertical jump test, and the risk of sports injuries in 32 young athletes (11 volleyball players, 12 basketball players, and 9 handball players). According to their findings, junior athletes at high risk of sports injury did not show differences in FMS, SEBT, and physical fitness tests.

Japanese scientists (Endo, & Miura, 2021) determined the relationship between distance measurements in the SEBT test and posture and leg muscle strength in 9 students. At the same time, the force of flexion and extension of the lower limbs in the hip and knee joints was measured using an isokinetic platform, as well as the angles of limb flexion in the hip, knee, and ankle joints. As a result of testing, the associated factors differed for dominant and non-dominant legs even in the same SEBT position.

Several studies have also been conducted in single combats using the SEBT technique. Thus, postural and neuromuscular indicators were investigated in healthy men (n=12) engaged in taekwondo in comparison with children (n=17) of the control group (Jlid, M. et. al., 2016). Taekwondo practitioners

had better SEBT scores than non-practitioners. According to the authors, taekwondo exercises stimulate the sensory input and motor output of the postural system, which increases its efficiency. In addition, the dynamic nature of taekwondo allows you to develop the strength of the muscles of the lower limbs. According to the authors, taekwondo improves postural and neuromuscular functions in a sample of healthy men even before puberty.

A group of other scientists (Guan, et. al., 2020) studied bilateral lower limb strength asymmetry and dynamic balance in child athletes: 28 fencers (19 boys and 9 girls) and 28 taekwondo players (19 boys and 9 girls) were examined in one leg jump and SEBT indicators. This study found that child athletes in both laterally dominant and non-laterally dominant sports demonstrated interlimb asymmetry in leg strength and dynamic balance. According to these scientists, gender should be an important factor in assessing the bilateral difference in leg strength and dynamic balance for child athletes. In another study, the same authors (Guan, et. al., 2021) examined one-legged jumping performance, SEBT test scores, and hamstring and calf muscle flexibility in 13 male children who are qualified taekwondo athletes. Asymmetry between the limbs was studied in the state of rest and fatigue. As a result of the work, the scientists concluded that fatigue significantly affects the asymmetry between the limbs during jumping and dynamic balance in child athletes, while the variation of the asymmetry between the limbs after fatigue may differ in different tests. According to the recommendation of the scientists, to prevent injuries, practitioners should consider the assessment of asymmetry between the limbs in children both in the recovery state and in the state of fatigue, and remember the fatigue response of each leg in functional tests.

We previously conducted a study using the SEBT method in Yoshinkan aikido, boxing, and Kyokushinkai karate athletes (Kindzer, & Nikitenko, 2023). The results of the work revealed significant differences in SEBT indicators among the representatives of the above-mentioned martial arts. When comparing the SEBT indicators of the left and right arms separately in representatives of different martial arts, a probable difference between the results of Kyokushin karate and Yoshinkan aikido athletes was revealed in favour of Kyokushin karate athletes. As a result, the comparison of the SEBT indicators of the left and right legs between the representatives of the specified martial arts did not reveal any significant differences.

In another study of ours using the SEBT test (Kindzer, Nikitenko, & Vyshnevetskyi, 2024), it was established that its indicators may be related to the level of qualification of the athletes: in representatives of male Kyokushin karate and level 1 DAN, the amplitude of SEBT indicators turned out to be greater, than in Kyokushin karateka with level 1 KYU.

The results of our next study using this technique (Kindzer, et. al., 2024) showed better results in fencers, compared to representatives of the karate version of the WKF and hand-to-hand hopak, in particular in SEBT indicators of the lower extremities. This is due to the specificity of many years of training in fencing, where the result depends precisely on the development of the muscles of the athletes' lower limbs. At the same time, SEBT indicators of the upper limbs in fencers do not have the same bright manifestation. Karate fighters have

some advantage in the SEBT indicators of the upper and lower limb belt, compared to the SEBT indicators of hopak hand-to-hand combatants. As a result of the study, we reasonably confirmed the fact that long-term practice of a certain type of martial arts has an impact on anthropometric indicators and SEBT.

We also conducted a study (Kindzer, et. al., & Cynarski, 2024), where right-handed female university students aged 18-22 participated: 10 representatives from Kyokushinkai karate, 6 from boxing, 8 from fencing (epee), and 7 from WKF karate. The results of the correlations of SEBT indicators in boxing and fencing representatives indirectly indicate the asymmetric impact of these single combats on the arms and legs of a person's body. The SEBT results of Kyokushinkai karate representatives indicate the symmetry and uniform development of the left and right parts of the body. The indicators of the WKF karate representatives occupy an intermediate place in this comparison: the peculiarities of their SEBT indicators show that along with symmetrical manifestations, asymmetric ones are also observed.

Thus, summarizing the above review of scientific research, we can claim that this work is novel and relevant. What is new and relevant is that until now no comparisons of upper and lower extremity SEBT indicators have been made in left- and right-handed martial artists. A promising direction in sports orientation and selection can be the application of the SEBT technique, in particular, when looking for differences in dynamic balance (equilibrium) between right-handed and left-handed athletes.

**Connection of research with important scientific programs or practical tasks.** The work was performed following topic 2.3. Research Summary plan of the Ivan Bobersky Lviv State University of Physical Culture for the years 2021-2025: «Individualization of the training of athletes in martial arts at the stages of multi-year improvement».

**The purpose** – of the study is to perform a comparison of the Star Excursion Balance Test indicators in men of various types of martial arts with left- and right-sided motor asymmetry.

## Material and methods

The results of the study were obtained at the Ivan Bobersky Lviv State University of Physical Culture at the Department of Fencing, Boxing, and National Martial Arts in the period October-December 2023. Qualified male martial artists

aged 18-22 years participated in the collection of experimental material in the number of 84 individuals, among whom were:

- 11 representatives of karate according to the WKF version (among whom there was 1 left-hander), including candidates for Masters of sports, and Masters of sports of Ukraine;
- 12 representatives of fencing (among whom there were 2 left-handers), including candidates for Masters of sports, and Masters of sports of Ukraine;
- 9 representatives of Hopak hand-to-hand combat (among whom there was 1 left-hander), including candidates for Masters of sports, and Masters of sports of Ukraine;
- 31 representatives of boxing (among whom there were 12 left-handers), including first-class athletes, candidates for Masters of sports, and Masters of sports of Ukraine;
- 21 representatives of Kyokushinkai karate (among whom there was 1 left-hander), including from 1 Kyu to 2 Dan.

Because the number of left-handers in most martial arts was limited, we decided to create mixed groups of representatives of various martial arts. Thus, in total, we formed two groups of athletes from different martial arts – 67 right-handed and 17 left-handed.

Among the research participants are champions and prize-winners of national and international competitions in the specified martial arts. The absolute majority of athletes under investigation are students of the Department of Fencing, Boxing, and National Martial Arts of Ivan Bobersky Lviv State University of Physical Culture.

The following research methods were used in the work:

- analysis of literary sources and materials from the Internet;
- survey (questionnaire);
- measurement of the Star Excursion Balance Test (SEBT) indicators of the girdle of the upper and lower limbs of martial artists both sides of the body (Fig. 1) in a restored state of the organism;
- measurement of athletes' anthropometric indicators (height, body weight, arm and leg length), which always preceded the SEBT measurement procedure;
- methods of mathematical statistics using the applied standard program Statistica – 7.

The survey in the form of a questionnaire preceded the measurement of SEBT indicators, and was aimed at detecting left- or right-sided motor asymmetry in each martial artist. The studied athletes had to subjectively, based on their own life

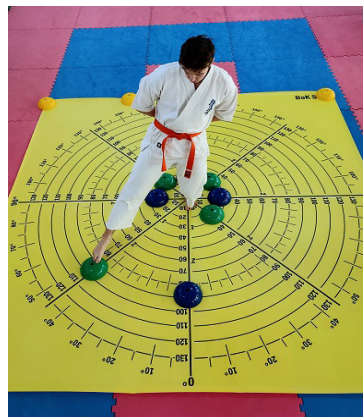


Figure 1. Star Excursion Balance Test measurements



experience, determine to whom they belong – left-handed or right-handed.

SEBT testing took place in compliance with the requirements that we have already described in previous publications using this method (Kindzer, Nikitenko, & Vyshnevetskyi, 2024).

In this work, as in previous studies (Kindzer, et. al., 2024), we calculated indicators of the arithmetic mean value (Mean), the standard deviation of the arithmetic mean (Std.Dev.), and also used the Mann-Whitney U-test statistical method, because the SEBT indicators obtained in different groups with a non-normal distribution of indicators and (or) with a small number of individuals were compared. The left-handed group is

small (n=17), and their SEBT indicators do not show signs of a normal distribution. The group of right-handed people (n=67) has a distribution of SEBT indicators, which, according to the Kolmogorov-Smirnov test and Shapiro-Wilk's W-test, is also not normal to use the Student's T-test.

### Research results and their discussion

Anthropometric indicators of male martial artists who participated in the study are presented in Table 1.

As can be seen from the table, compared to left-handers, right-handers have a slight (unreliable) advantage in height, body weight, and legs length according to average group indicators. The average arm length of right-handed athletes was re-

**Table 1. Anthropometric indicators of the studied representatives of martial arts**

Group	Height, cm		Body weight, kg		Arm length, cm		Leg length, cm	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Left-handed (n = 17)	177,5	5,197	66,8	7,540	73,9	3,782	91,8	5,768
Right-handed (n = 67)	<b>178,1</b>	5,035	<b>70,9</b>	8,751	<b>76,7</b>	4,638	<b>95,0</b>	5,858
Mann-Whitney U-test	U=506,0; P>0,05		U=395,0; P>0,05		<b>U=363,0;</b> <b>P&lt;0,05</b>		U=417,0; P>0,05	

**Table 2. Star Excursion Balance Test indicators of representatives of martial arts, cm**

Limb	SEBT position	Left-handed (n = 17)		Right-handed (n = 67)		Mann-Whitney U-test	
		Mean	Std.Dev.	Mean	Std.Dev.	U	P
Left leg	1	<b>80,51</b>	12,855	78,82	8,676	544,5	> 0,05
	2	<b>83,36</b>	15,765	80,54	8,238	563,5	> 0,05
	3	<b>83,82</b>	16,046	79,14	9,687	497,5	> 0,05
	4	<b>91,73</b>	19,559	83,43	12,443	435,0	> 0,05
	5	<b>89,64</b>	15,894	83,17	13,350	431,0	> 0,05
	6	<b>88,95</b>	15,100	78,84	12,412	345,5	<b>&lt; 0,05</b>
	7	<b>76,65</b>	13,015	69,00	12,888	390,5	<b>&lt; 0,05</b>
	8	<b>79,26</b>	13,261	73,37	8,579	415,0	> 0,05
Right leg	1	<b>83,94</b>	13,604	77,97	7,869	447,0	> 0,05
	2	<b>85,21</b>	14,474	79,82	8,259	461,5	> 0,05
	3	<b>86,56</b>	15,692	79,72	10,551	423,0	> 0,05
	4	<b>92,24</b>	15,151	85,33	12,877	417,5	> 0,05
	5	<b>89,47</b>	12,373	85,37	12,782	448,0	> 0,05
	6	<b>89,02</b>	14,477	80,25	15,314	390,5	<b>&lt; 0,05</b>
	7	<b>79,94</b>	16,634	69,95	12,730	366,0	<b>&lt; 0,05</b>
	8	<b>80,20</b>	12,463	73,07	9,709	354,5	<b>&lt; 0,05</b>
Left arm	1	<b>75,64</b>	11,943	70,04	9,459	452,5	> 0,05
	2	<b>82,77</b>	10,728	78,94	7,597	471,5	> 0,05
	3	<b>91,56</b>	12,617	88,47	8,841	482,5	> 0,05
	4	<b>102,25</b>	17,486	99,11	12,457	546,0	> 0,05
	5	<b>97,35</b>	18,011	92,32	14,084	482,5	> 0,05
	6	<b>77,48</b>	12,470	73,12	11,440	467,5	> 0,05
	7	<b>60,52</b>	7,157	56,11	7,462	382,5	<b>&lt; 0,05</b>
	8	<b>68,79</b>	11,483	62,13	9,904	388,0	<b>&lt; 0,05</b>
Right arm	1	<b>76,98</b>	12,703	69,04	10,898	392,0	<b>&lt; 0,05</b>
	2	<b>83,21</b>	11,598	77,08	9,505	422,5	> 0,05
	3	<b>90,75</b>	13,400	88,08	9,890	504,0	> 0,05
	4	<b>104,56</b>	19,895	99,76	13,920	503,0	> 0,05
	5	<b>98,49</b>	21,116	93,35	16,116	506,0	> 0,05
	6	<b>81,47</b>	15,615	73,20	12,393	394,5	> 0,05
	7	<b>62,82</b>	9,351	55,78	10,135	291,0	<b>&lt; 0,05</b>
	8	<b>68,80</b>	10,829	61,67	10,569	368,0	<b>&lt; 0,05</b>

liably 2,8 cm longer ( $p < 0,05$ ) than that of left-handed athletes.

That is, the group of right-handed martial artists ( $n=67$ ) had an advantage in almost all basic anthropometric indicators (height, body weight, arm length, leg length) compared to left-handed martial artists ( $n=17$ ). As you can see, there are almost 4 times more right-handed athletes than left-handed athletes.

Before starting the testing, we assumed that the differences between left-handed and right-handed athletes would be asymmetrical: the difference between them would be on a certain side of the body – on the left or the right. The results of the experiment turned out to be phenomenal. A comparison of SEBT indicators of all positions on all four limbs of representatives of both groups (Table 2) revealed a very interesting phenomenon: the group of left-handed athletes has better SEBT indicators in almost all positions, both on the left side of the body and on the right. This is even though left-handed athletes lag behind right-handed athletes in anthropometric indicators (see Table 1).

Thus, when comparing the indicators of all 8 positions of SEBT of the left leg in right-handed and left-handed athletes, it was found that left-handed athletes performed significantly better ( $p < 0,05$ ) in positions 6 and 7. These are the most difficult positions, as they require balancing on the left leg simultaneously with rotation and twisting the body in its direction and with a cross movement of the right leg (Figure 2).

Left-handed martial artists demonstrated significantly better ( $p < 0,05$ ) SEBT indicators in positions 6, 7, and 8 of the right leg (see Table 2) than right-handed martial artists: similarly, mirror to the left leg (see Figure 2) while balancing on their right leg, performed best with their left leg on the indicated SEBT positions. These positions are the most difficult in this test.

The indicators of SEBT of both right and left arms in left-handed martial artists are also better than in right-handed martial artists (see Table 2). Again, positions 7, and 8 of both left and right hands are significantly better ( $p < 0,05$ ) than right-handed. These are the most difficult positions, requiring twisting of the torso while balancing on one arm (similar to SEBT positions for legs). Left-handers also had significantly better ( $p < 0,05$ ) SEBT scores in position 1 of the right balancing arm: this suggests that left-handers have a greater range of motion with their left arm when balancing on their right arm.

Thus, the above results of the comparison of SEBT in-

dicators in representatives of martial arts (boxing, Kyokushinkai karate, WKF karate, fencing, and Hopak hand-to-hand combat), when dividing them into two groups based on motor asymmetry, revealed the phenomenon of the superiority of left-handed martial artists over right-handed martial artists. This phenomenon needs a scientific explanation and further study. Left-handed martial artists prevail over right-handed martial artists in almost all SEBT positions. Interestingly, the dominance occurs not only on the left side of the body but also on the right side – it turned out to be total in our experiment. At the same time, left-handed athletes have lower anthropometric indicators than right-handed athletes. That is, a conclusion is suggested about the quality of test performance by left-handed athletes: it is higher than that of right-handed athletes. It can be assumed that left-handed athletes possess certain properties of neuromuscular activity and the central nervous system in general, which require special research.

A separate phenomenal result is the specificity of passing the SEBT test by left-handed athletes: their results are probably better in the most difficult positions – 6, 7, 8, and in each of the four limbs of the body, regardless of motor asymmetry.

## Conclusions

The results of the study showed phenomenal SEBT indicators in left-handed martial artists ( $n=17$ ) compared to right-handed martial artists ( $n=67$ ). This phenomenon is observed in all SEBT indicators of the lower and upper limbs of the left and right sides of the body: indicators of all SEBT positions in left-handed athletes are better than in right-handed athletes. Left-handed athletes significantly dominate in the most difficult positions of the test – 6, 7, 8, both in the girdle of the upper limbs and in the balance and flexibility of the lower limbs, regardless of their functional asymmetry. This phenomenon is observed against the background of left-handed athletes lagging behind right-handed athletes according to anthropometric indicators.

Given the above, we assume that left-handed athletes have special properties of neuromuscular activity that require special in-depth studies.

**Prospects for further research in this direction.** A perspective in this direction is to conduct in-depth research in martial arts and other sports regarding the so far little-studied capabilities of left-handed athletes, and their comparison with right-handed athletes.

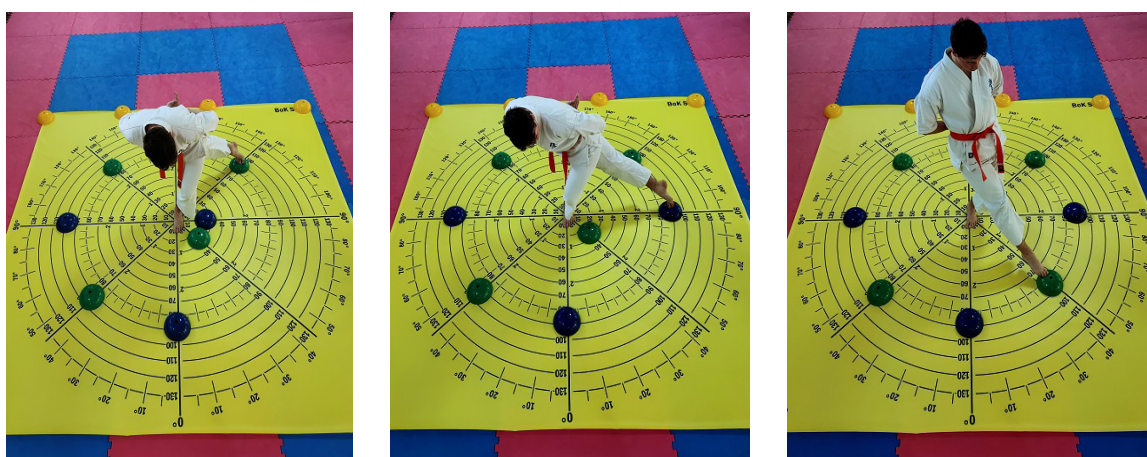


Figure 2. SEBT positions sequentially from left to right: 6, 7, 8



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