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THE INFLUENCE OF THREE-YEAR SYMMETRICAL TRAINING ON THE PRECISION AND FREQUENCY OF THE FENCERS' MOVEMENT

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Abstract Introduction: The assessment and comparison of the precision and frequency of movement in épée fencers representing various sport classes, and the determination of the influence of three-year symmetrical and unilateral training on dynamic asymmetry. Material and Methods: The research was conducted in 60 female épée fencers, who were divided into four groups according to the sport class they represent (n = 15). In group I there were medalists of the World and European Championships, in group II – medalist of the Polish Championships. Group III and IV consisted of players who achieved successes at the Warsaw Championships. After three years of symmetrical training, the tests were repeated in groups III and IV.
The tests were carried out using the Vienna Test System with the aid of the Motor Performance Series device (S2 test), which allows the assessment of coordination skills in terms of fine motor skills. Results: In the conducted research, significant differences in the asymmetry of the upper limbs in the aiming and tapping tests were found in all data groups. The differences in the tests obtained with the dominant and non-dominant upper limb confirm the greatest dynamic asymmetry in the female fencers from the Masters Class. After three years of symmetrical training in the experimental group and unilateral training in the control group, statistically significant differences were observed in all the trials performed with the dominant and non-dominant upper limb. However, in the experimental group of épée fencers, the dynamic asymmetry in the aiming indicators was lower than in the control group. Conclusions: Dynamic asymmetry in terms of the precision and frequency of movement was recorded in all studied groups. High-class épée fencers were characterized by the most significant difference between the results obtained with the dominant and non-dominant upper limbs, which is the result of long-term unilateral training. The three-year symmetrical training conducted in the experimental group had a positive effect on the precision and frequency of movement, however, it did not prevent the occurrence of dynamic asymmetry in the participants. The unilateral training used in the control group further increased the asymmetry of movement in the sportswomen.

Key words movement precision, movement frequency, training symmetrization, fencing

Introduction

In fencing, coordination skills play a very important role in improving technical actions. High-level neuromuscular coordination shortens the time needed to learn and acquire motor skills and improves the economy of performing a motor task (El-Sayed, 2006). In competition, quick, decisive actions characterized by the precision of movement result in hitting the opponent (Rodineau & Bouvard, 1999; Taddei et al., 2011; Tsokalis & Vagenas, 2010).

The accuracy and frequency of movement are the abilities that play a special role when using the most popular weapon, i.e., the épée, where the entire body is the valid target area. This means that a hit can be made on the foot or the hand just behind the bell guard.

In the course of changing situations in a fencing duel between high-class players, it is decisive to execute the action with precision, at the right time and economically. A high level of such ability will be manifested in the expression of actions less visible to the opponent and therefore more surprising. The high frequency of movement is an ability that enables the making of the maximum number of movements with a selected part or the body per time unit. The ability to perform movements with maximum frequency depends on the performance of the nerve centers that govern the antagonistic muscle groups. This results in a quick transition from the state of excitation to the state of inhibition and vice versa (Maeda & Yajima, 2017). In fencing, the frequency of movement plays a crucial role in the preparation of the proper action, which is preceded by preparatory complex actions aimed at concealing the proper action.

Therefore, the development of the precision and frequency of movement should play a key role in the training of fencers. One of the methods of increasing the level of these coordination skills is the symmetrization of training, which is needed to enhance the sports potential of a sportsperson (Starosta, 2003). This method is based on bilateral transfer, which consists of changes in the brain that occur as a result of the formation of new specific neural networks that control the training of effectors (Duque et al., 2008; Muellbacher et al.2000; Obayashi, 2004). It has been proven by many authors that training of one side of the body will improve the performance of the other (Hardt et al.,2009; Ruddy & Carson, 2013; Sanchis-Moysi et al., 2010; Sannicandro et al., 2010; Trautmann et al., 2012). Learning and perfecting motor skills in sports should be based on transfer training, i.e., the two-way flow of nerve impulses between the brain hemispheres (Starosta, 2003). Another advantage of symmetrical training is the relief brought to the dominant side exposed in unilateral disciplines to many years of training overload, which may result in a premature end of the sports career. Among fencers, especially those with long training experience, morphological and dynamic asymmetry was observed (Johne et al., 2013; Johne et al., 2006; Tsolakis & Tsiganos, 2008). Guan et al. (2021), in their research on fencers and taekwondo practitioners, proved that training in these sports disciplines contributes to greater asymmetry in the strength of the lower limbs and body balance, which is associated with a high risk of injury.

It can be assumed that symmetrical training will prevent the occurrence of asymmetry and will affect the development of selected coordination abilities for the dominant and non-dominant limb.

Sports training should not impede the development of the organism, but contribute to the enhancement of the body, hence the need to pursue training symmetrization (Starosta, 2003). Many authors dealing with the issue of asymmetry and symmetry focus mainly on particular types of asymmetry and symmetry, and not on multi-faceted assessment and influence on selected coordination abilities. Only a few publications propose a modification of the current theory of shaping the movements and the training methods used are short-term (Johne, 2021).

Therefore, the present research is an attempt to assess and compare the precision and frequency of movement in épée fencers of various sport classes, and to determine the influence of the three-year symmetrical and unilateral training on dynamic asymmetry.

Materials and Methods

The research was conducted in 60 female épée fencers, who were divided into four groups according to the sport class they represent (n = 15). The characteristics of the studied groups are presented in Table 1.

All players and their parents were informed about benefits and dangers of the research. An informed form approved by the authorization or parents of minors, approved by the University's ethics committee, was provided. All procedures followed the Helsinki Declaration.

The first group consisted of the most experienced players who won medals at the World and European Championships. The second group included 1st class sportswomen (medalists of the Polish championships). Group III (control) and IV (experimental) consisted of fencers with the shortest training experience and representing the 2nd class. These are players who have been successful in the Warsaw Championships. They trained with two different methods in two sports clubs. One-sided training was performed in the control group. This training consisted of using exercises that mainly focused on one side of the body. Two-hour classes were held 4 times a week. The following loads were applied in symmetrization exercises: 20% during the performance of all-round exercises, 5% of targeted exercises. Movement symmetrization was not used during the specialized exercises.

Among the athletes of the experimental group, symmetrical training was conducted for three years, focusing on both sides of the body. The following loads were used in symmetrical exercises: 50% in whole body training, 30% in targeted exercises and 20% in specialized exercises (fencing duels, training with weapons). In order to determine the effect of symmetrical training on the precision and frequency of movement as well as dynamic asymmetry, the tests were repeated after three years in the control and experimental group.

Table 1. Characteristics of the groups (mean ± SD)

Indicators	Group I	Group II	Group III (control)		Group IV (experimental)	
			Assessment 1	Assessment 2	Assessment 1	Assessment 2
Age (years)	21.7 ±3.4	17.9 ±2.2	15.9 ±1.7	18.9 ±1.7	15.3 ±1,6	18.3 ±1.6
Body height (cm)	175 ±6.4	174 ±5.4	169.1 ±5.1	173.4 ±5.7	170.1 ±5.9	175.8 ±7.8
Body mass (kg)	65.3 ±7.3	61.1 ±6.5	56.9 ±6.2	64.5 ±6,7	57.4 ±7.9	65.3 ±6.6
Training experience (years)	11.2 ±3.7	7.6 ±2.1	3.6 ±1.4	6.6 ±1.4	3.2 ±0.6	6.2 ±0.6
Sports class	C. i IC.	I	II		II	

Note: C. – champion class, IC. – international champion class

The tests were carried out using the Vienna Test System. It is a measuring system very popular in the diagnosis of neuropsychophysical abilities as well as neurophysiological predispositions. In order to assess the precision and the frequency of movement, the Motor Performance Series device was used (S2 test), which allows the assessment of coordination skills in terms of fine motor skills. Taking advantage of the setup of the device, an aiming test was carried out, which consisted in touching 20 sensors on the device plate with a pen as quickly and precisely as possible. The study was conducted for the dominant and non-dominant upper limb, and the following indicators were assessed: error number and error time [ms]. The tapping test, used to assess the maximum frequency of movement, consisted in tapping a pen as quickly as possible, while holding it in a position perpendicular to a square plate with a side of 4 cm. The test was also performed for the right and left hands, and the number of taps was assessed during the first and the second sixteen seconds of the test.

The STATISTICA software package (StatSoft, Inc. 2018) was used to statistically analyze the research results. The compliance of statistical distributions with the normal distribution was checked using the Shapiro-Wilk test. The analysis of variance (ANOVA) for repeated measures was performed to compare the results in the four tested groups of sportswomen, and after three years of training – in the experimental and control group. The year of the study and the side of the body were repeating factors. The level of significance assumed was $p < 0,05$.

Results

In the conducted research, significant differences in the asymmetry of the upper limbs in the aiming and tapping tests were found in all groups of data. The differences in the tests obtained with the dominant and non-dominant upper limb confirm the greatest dynamic asymmetry in the female fencers of the Masters Class. In addition, among the épée fencers in group II, and the control and experimental groups, there was a significant difference in the number of errors and error time in the aiming test, and in the number of taps in the first and the second 16 seconds of the tapping test performed with the dominant and non-dominant upper limb. Comparing the results obtained in the first study by the sportswomen in groups III and IV, lower asymmetry was observed in the control group in the aiming indicators. After three years of symmetrical training, in the second study, differences were found among the participants in the control and experimental groups in all the trials performed with the dominant and non-dominant upper limb. However, in the experimental group of épée fencers, the dynamic asymmetry in the aiming indicators was lower than in the control group (Table 2). This proves the beneficial effect of symmetrical training on reducing dynamic asymmetry.

Table 2. Mean values ±SD of index values: aiming – number of errors aiming – aiming error time – number of strokes in the first 16 seconds, and knocking - number of knocks in the second 16 seconds for individual groups in the first and second for the dominant and non-dominant hands in individual groups in the first and second study and the significance (p) for the dominant and non-dominant hand

	Assessment 1								Assessment 2			
Index	Group I	p	Group II	p	Group III (control)	p	Group IV (experimental)	p	Group III (control)	p	Group IV (experimental)	p
AEN DH	0.93 ± 1.03		1.13 ± 0.92		1.27 ± 1.1		1.33 ± 1.54		1.13 ± 0.88		0.93 ± 0.74	
AEN NDH	3.07 ± 2.15	0.0001	2.73 ± 1.75	0.01	4.93 ± 1.79	0.01	4 ± 2.07	0.001	3.78 ± 1.08	0.0001	2.8 ± 1.36	0.0005
AET DH [ms]	0.03 ± 0.04		0.04 ± 0.04		0.04 ± 0.04		0.05 ± 0.08		0.04 ± 0.04		0.03 ± 0.04	
AET NDH [ms]	0.13 ± 0.13	0.0001	0.1 ± 0.06	0.003	0.25 ± 0.12	0.003	0.18 ± 0.12	0.0001	0.22 ± 0.12	0.0001	0.16 ± 0.1	0.001
TNTF 16 DH	110.73 ± 6.57		114.87 ± 7.61		99.93 ± 6.33		107.53 ± 9.36		103.8 ± 6.81		109.4 ± 9.27	
TNTF 16 NDH	99.2 ± 7.41	0.001	99.73 ± 12.52	0.005	89 ± 9.43	0.01	91.47 ± 7.53	0.01	92.07 ± 10.02	0.001	96.2 ± 6.65	0.001
TNTS 16 DH	101.07 ± 7.53		105 ± 7.65		90.13 ± 6.7		93.67 ± 7.81		95.6 ± 7.27		97.4 ± 5.18	
TNTS 16 NDH	88.2 ± 6.85	0.001	87.27 ± 9.67	0.001	78.2 ± 9.14	0.003	82.13 ± 4.72	0.003	81.13 ± 6.36	0.001	87.8 ± 4.72	0.001

AEN DH – aiming – error number of the dominant hand, AEN NDH – aiming – error number of the non-dominant hand, AET DH – aiming – error time of the dominant hand, AET NDH – aiming – error time of the non-dominant hand, TNTF 16 DH – tapping – number of taps in the first 16 seconds with the dominant hand, TNTF 16 NDH – tapping – number of taps in the first 16 seconds with the non-dominant hand, TNTS 16 DH – tapping – number of taps in the second 16 seconds with the dominant hand, TNTS 16 NDH – tapping – number of taps in the second 16 seconds with the non-dominant hand.

There were significant differences in the number of errors and error time in the aiming test for the non-dominant hand between the studied groups. There were no statistically significant differences between the study groups in the trials performed with the dominant upper limb. In the studies regarding the frequency of movement,

there were significant differences between sportswomen of different sport classes in the trials performed with the dominant and non-dominant upper limb. Only in the most experienced female épée fencers from groups I and II no such difference was found. In the control and experimental groups, a statistically significant difference between the studied indicators occurred only in the number of taps in the first 16 seconds of the tapping test (Table 3).

Table 3. The level of significance between the dominant and non-dominant limb in the indicators: targeting-error number, targeting-error time, knocking-number of knocks in the first 16 seconds in the first study

Index	Group I	p	Group II	p	Group III	p	Group IV	Group II	p	Group IV	p	Group I	p	Group III
AEN DH		—		—		—			—		—		—	
AEN NDH		0.05		0.05		—			0.03		—		—	
AET DH [ms]		—		—		—			—		—		—	
AET NDH [ms]		0.05		0.05		—			0.03		—		—	
TNTF 16 DH		—		0.0001		0.01			0.05		—		0.0001	
TNTF 16 NDH		—		0.01		—			0.03		0.01		0.005	
TNTS 16 DH		—		0.0001		—			0.0005		0.01		0.001	
TNTS 16 NDH		—		0.03		—			—		0.05		0.001	

AEN DH – aiming – error number of the dominant hand, AEN NDH – aiming – error number of the non-dominant hand, AET DH – aiming – error time of the dominant hand, AET NDH – aiming – error time of the non-dominant hand, TNTF 16 DH – tapping – number of taps in the first 16 seconds with the dominant hand, TNTF 16 NDH – tapping – number of taps in the first 16 seconds with the non-dominant hand, TNTS 16 DH – tapping – number of taps in the second 16 seconds with the dominant hand, TNTS 16 NDH – tapping – number of taps in the second 16 seconds with the non-dominant hand.

In the second study, carried out after three years of using symmetrical training in the experimental group and unilateral training in the control group, significant differences were recorded between the groups in terms of the number of errors in the aiming test performed with a non-dominant hand and the number of taps in the first 16 seconds of the tapping test with the dominant hand and the number of taps in the second 16 seconds of the tapping test with the non-dominant hand. When comparing the results between the first and the second test in groups III and IV, only in the indicators of the error number and error time in the aiming test with the dominant hand no significant difference was found (Table 4).

Table 4. Significance of differences between the control and experimental groups in the indicators: the error number and error time in the aiming test, the number of taps in the first 16 seconds and the number of taps in the second 16 seconds in the tapping test obtained with the dominant and non-dominant upper limb in the second test, and between the first and the second test in group III and IV

	Assessment 2			Group III (control)			Group IV (experimental)		
Index	Group III (control)	p	Group IV (experimental)	Assessment 1	p	Assessment 2	Assessment 1	p	Assessment 2
AEN DH		—			—			—	
AEN NDH		0.03			0.005			0.03	
AET DH [ms]		—			—			—	
AET NDH [ms]		—			0.05			—	
TNTF 16 DH		0.05			0.01			0.05	
TNTF 16 NDH		—			0.05			0.01	
TNTS 16 DH		—			0.001			0.05	
TNTS 16 NDH		0.001			0.05			0.005	

AEN DH – aiming – error number of the dominant hand, AEN NDH – aiming – error number of the non-dominant hand, AET DH – aiming – error time of the dominant hand, AET NDH – aiming – error time of the non-dominant hand, TNTF 16 DH – tapping – number of taps in the first 16 seconds with the dominant hand, TNTF 16 NDH – tapping – number of taps in the first 16 seconds with the non-dominant hand, TNTS 16 DH – tapping – number of taps in the second 16 seconds with the dominant hand, TNTS 16 NDH – tapping – number of taps in the second 16 seconds with the non-dominant hand.

Discussion

Training dedicated to the non-dominant side of the body can be a great way to increase the sportsperson's versatility and prevent overloading the dominant side. Thanks to the bilateral transfer, it is possible to develop motor coordination by forcing the other hemisphere of the brain to be active (Starosta, 2003). In typically unilateral disciplines, symmetrical training is often overlooked and underestimated by coaches, despite many studies proving the beneficial effect of such transfer.

Similar conclusions were also reached by other authors who observed a considerable morphological asymmetry, especially in fencers with the longest training experience (Johne et al., 2003). The positive effect of symmetrical training was also recorded in the studies on the influence of the symmetrization of training on coordination abilities. After several years of training, better results of simple reaction time were found for the non-dominant limb, but also for the dominant limb in the female épée fencers using symmetrical training, in comparison to the sportswomen who focus only on the dominant side. Moreover, owing to such training, it was possible to prevent dynamic asymmetry (Johne, 2021).

In the conducted research, despite three years of symmetrical training, asymmetry was recorded in all trials performed with the dominant and non-dominant upper limb. However, in the sportswomen from the experimental group, the dynamic asymmetry in terms of the precision of movement was smaller than in the fencers using asymmetrical training. This proves the beneficial effect of symmetrical training on reducing dynamic asymmetry. The positive impact of such training was also noted in the sports results achieved by the players of the experimental

group. The three-year symmetrical training also had a positive effect on the sports results achieved by the players of the experimental group in comparison with the competitors of the control group.

The precision of movement plays a very important role in the execution of an effective action in fencing combat. It is often the case that the ability is decisive in terms of scoring a hit and winning a fencing match. The great importance of the precision of movement in achieving high results in the épée can be demonstrated by the fact that in the research conducted, successful competitors representing Masters Class competitors were characterized by the highest level of the precision of movement.

Moreover, in the research conducted in fencers by Witkowski et al. (2019) more experienced sportsmen were characterized by a high level of the precision of movement at various stages of the training, in comparison with the less experienced fencers.

The experiment carried out in foil fencers by Witkowski et al. (2020) proved that a six-week transfer training has a positive effect on the accuracy of hits made with the dominant hand. However, this was a short-term effect as in the tests repeated after a month, it was undetectable. Like in the conducted research, the authors found a significant improvement in the indicators of the precision and frequency of movement in the participants of the control group, who also trained using the traditional method, and in the participants of the experimental group training with the symmetrical method. The authors conclude that systematic symmetrical training may influence the stabilization of sensory and motor habits.

The positive effects of interhemispheric training based on special coordination training were also observed in studies of young fencers. The obtained results of the accuracy of movement of both the dominant and non-dominant hand have significantly improved, which leads to the conclusion that symmetrical training can be very effective and may produce positive results at an early stage of training (Witkowski et al., 2019).

Conclusions

High-class female épée fencers were characterized by the greatest dynamic asymmetry in terms of the precision and frequency of movement obtained using the dominant and non-dominant upper limbs. This is the result of high specialization and many years of unilateral training.

The three-year symmetrical training conducted in the experimental group had a positive effect on the level of the precision and frequency of movement. However, it did not prevent the dynamic asymmetry in the studied sportswomen. The unilateral training conducted in the control group further increased the asymmetry of movement in the examined épée fencers. Therefore, it can be concluded that the use of symmetrical training can result in greater effectiveness of training.

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