ARCHIVES OF BUDO
Journal of Innovative Agonology

e-ISSN: 1643-8698

Section: *HEALTH THROUGH COMBAT SPORT & SURVIVAL EXERCISES* *Original Paper*

Does hand preference affect the accuracy in fencing? The pilot study

Magdalena Krzykała[1] A-D *, Mateusz Witkowski[2] A-D, Karolina Perz[2] A-D, Bartosz Hekiert[2] A,D

[1] Department of Recreation, Poznań University of Physical Education, Poznań, Poland;
2 Department of Physical Education and Sport, Adam Mickiewicz University, Poznań, Poland;
*** Corresponding author:** Magdalena Krzykała, Department of Recreation, Poznań University of Physical Education, Poznań, email address: krzykala@awf.poznan.pl;

Authors' Contribution:

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

Received: date
Accepted: date 20.12.2024
Published: date 20.12.2024

Dictionary:

Handedness: the preference for using one hand rather than the other [2].

Hit precision: the accurate hit of a weapon into a well-defined field [29].

Abstract:

Background and Study Aim: Handedness has been studied for years in different contexts. Several connections with sports results have been obtained, especially highlighting the advantage of left-handed players. However, the relationship of handedness with precision in sports has not been clarified. The aim of present study was to identify the relationship between handedness and hit precision in fencing.

Material and Methods: The research participants were 58 female foil fencers aged 14–17 years (junior category). The Edinburgh Inventory Handedness Questionnaire was used to measure hand preference and for dividing the athletes into three subgroups (right-handed, left-handed, ambidextrous). Hit precision was determined using the Favero EFT-1 electronic board. Handedness differentiated the participants' performance in hit precision.

Results: The hit precision of left-handed participants was greater than right-handed and ambidextrous participants, but only when using the left hand. The smallest differences in the hit precision score were observed between right-handed and ambidextrous fencers; left-handers stood out significantly. Moreover, the left-handed and ambidextrous fencers displayed smaller differences in their use of both hands during hitting compared to right-handed fencers.

Conclusions: More and newer solutions are needed to make player scoring easier. A focus is also needed on the precision of movement execution in fencing, which can be crucial to success.

Keywords: fencing, female, foil, hit precision, handedness

1. Introduction

Lateralisation is one aspect of motor development that manifests in functional asymmetry. It most often involves upper limb activities. The preference for using one hand rather than the other is called handedness. This trait is associated with complex brain asymmetries influenced by genetics, environment and neurodevelopment [1, 2]. Considering the preference for performing various daily activities distinguishes the left-handed, right-handed and those who can use both hands, the so-called ambidextrous (no clear preference). The ambidextrous make up only around 1–2% of the total population, according to various sources [3]. The proportion of right-handed to left-handed people in the population appears to have remained unchanged for several thousand years [4]. Depending on what activity is observed (for example, throwing or using a hammer) left-handed people comprise around 10–13% of the population [5-7].

Healthy right-handed individuals tend to prefer the right hand for complex tasks that involve the use of tools, such as writing with a pen, slicing with a knife or cutting with scissors. This preference is often an indicator of the dominant hand as assessed by standardised questionnaires [8, 9]. A tendency to use tools more often with the right hand is shown by more than 85% of the total population, indicating left hemisphere dominance to control hand movements [10-12]. Being left-handed has been shown to confer some advantage in sports. Top-level athletes show an overrepresentation of left-handers. Left-handers have been characterised as more common among trained and elite athletes in various sports, including tennis, rock climbing, handball, boxing and wrestling, in contrast to the non-sporting population [13-16]. These observations apply mostly to interactive sports, where two or more players play or compete against each other in direct contact (e.g. tennis, cricket, boxing, fencing), but less so in non-interactive or individual sports (e.g. golf, swimming) [6, 17]. A higher proportion of left-handers can also be confirmed in baseball [18], cricket [19, 20] and fencing [21]. Fencing, in particular, shows a significant overrepresentation of left-handed athletes. In a study that analysed functional asymmetry among female fencing athletes with a master class in the sport, a very high left-handed dominance of 40% was observed [22]. This is usually explained by the fact that, being in the minority, they are used to confronting right-handed players. As a result, they develop more effective fighting strategies [23, 24]. On the other hand, theories exist about the neurofunctional advantage of left-handers. Explaining them requires further research [25].

Many factors affect success in sports, such as genetic potential, occupation, physical environment, daily nutrition, quality of sleep, training, injury, coach–athlete relationship, body structure and body composition [26]. In fencing, as in many other sports, success is connected with extremely important skills: the precision of performing certain specific actions, which can guarantee success or contribute to failure [27, 28]. In studies of motor (functional) asymmetry, precision of movement is understood as the speed and accuracy of performing a movement task [29]. In this paper, precision is understood as the accurate thrust of a weapon into a well-defined hitting area.

Precision is influenced by several factors, such as the type of uncertainty an athlete has with a guided weapon, fatigue after exercise and the athlete’s lateralisation type [30]. Witkowski et al. attempted to determine the relationships between the ability to maintain precision and control movements and fatigue in fencing. The study included 20 fencers, who were divided into two groups based on their level of sporting prowess. The first group consisted of Poland’s top athletes, members of Olympic teams. The second group consisted of players on the Polish fencing team who were not members of the Olympic team. The results allowed for observing similar physiological reactions of the body to an increase in fatigue in both groups of athletes. According to the authors, in competitive fencers, physical exercise did not significantly affect the ability to maintain precision and control of movements. Additionally, competitive fencers were characterised by greater precision during various stages of exercise compared to less fit athletes [31].

Fencing requires a high level of coordination to achieve speed and accuracy [32]. So-called coordination endurance provides athletes with greater accuracy of movement, which is understood in sports as the precise control of an object, and in fencing, a weapon, at any time during a sports fight [33]. According to Stein, each person manifests the so-called speed–accuracy trade-off: the shorter the movement time, the lower the accuracy [30]. In the case of elite fencers, the interaction manifests itself in a different way of handling the weapon, which is characterised by high hit accuracy.

According to research, the precision of movement in fencing, as well as reaction time, the timing of the entire fencing action and spatial orientation, determine the highest level of an athlete's performance [34]. Despite ongoing research on female fencing athletes, many questions remain. To date, not all the factors determining the precision of inflicting hits in this sport have been identified. This is very important because the most thoughtful and precise movements are necessary for high results and sporting success. The hand is the most specialised organ in fencing, especially important in the acquisition of technical skills. Hence, the aim of the study was to identify the relationship between the type of handedness and hit precision.

2. Materials and Methods

Participants

A total of 58 female athletes aged 14–17 (14.43 ±1.36) years practising foil fencing in the junior (under 17) category, representing at least an intermediate level of specialised preparation, participated in this study. Their average experience was 5–12 years. The variation in training experience in the study was due to the different sports levels of the female athletes studied. The age of starting fencing training and specializing in the sport varied. Some female athletes start as early as age 5, giving them up to 12 years of experience. Others, on the other hand, start specialized training only at the age of 12, with about 5 years of experience.

The inclusion factor for the study was the athletes' participation in the European Cup of Cadet Women in Fencing, which took place in Poznań, January 12–13, 2019. Finally, all athletes had to have the right age, skills and ranking in the Polish Fencing Association.

All participants were chosen so as to represent similar fencing skills, so neither age nor training age should have affected the results. All participants were healthy. They were informed and instructed on the study procedure prior to the study.

The research was carried out during the starting period, on the eve of the 2019/2020 season competition. In the annual training cycle, training is constructed for the participation of athletes in eight World Cups, which are held on five continents. Depending on the date, preparation for the Cup lasts from 4 to 6 weeks and is designed to determine the strongest team for the European and World Championships, which take place in late June and early July, followed by a period of de-training. A general preparation period begins in September, followed by a specialised preparation period in October, and then the season begins in November. Under-17 athletes have control starts in World Cups to verify their sports level.

Participation in this study was voluntary, and qualification was purposeful. No participant had medical contraindications to participate. Approval to conduct the study was obtained from the Bioethics Committee at the Karol Marcinkowski Medical University in Poznań (Resolution No. 255/19).

The theoretical model connected with factors that can determine hit precision in fencing has been proposed: somatic factor, functional factor and handedness [35]. In present paper relationship between the type of handedness and hit precision was identified. All measurements were completed in 1 day.

Hand preference measurement

The strength of hand preference was determined by the Edinburgh Inventory Handedness Questionnaire [8]. It contains questions about the preference for using the right or left hand in performing a range of everyday activities such as writing, drawing, cutting, throwing, using a knife alone, brushing teeth and lighting a match. Participants are asked to describe and demonstrate how to perform each activity. Some tasks require the use of both hands. The preference for using hands is marked by the researcher by writing '1' in the appropriate hand column and '0' in the other. If the preference for using the right or left hand is dominant and the respondent would not use the other hand in the activity performed, the researcher marks '2' and '0' in the columns, respectively. On the other hand, if the use of one or the other hand is indifferent, then in turn the researcher writes '1' in one column and '1' in the other. Based on the observations and the participant's answers, the lateralisation coefficient is determined, the value of which reflects to what extent the person is right- or left-handed. The following scale was used in the study: always right 2 points, usually right 1 point, no preference 0 points, always left 2 points, usually left 1 point. Scores were then counted by analogy, following the methodology of Gonzales [36].

Hit precision measurement

To assess the precision of hits, all athletes took a test which was performed using the Favero EFT-1 electronic board (Favero Electronics Srl Arcade [TV], Italy) according to methodology used in Witkowski et al. study [31].

Three of the nine tests described in the procedure were used. Each participant was informed what actions were to be carried out and which sequence. The athlete's task was to perform in the shortest possible time a series of embeddings of the end of the weapon (punts) into randomly appearing, red-lit targets. The tests allowed for accurately determining the precision of inflicting hits in different variations. Test 1 consisted of hitting two randomly appearing targets, which were illuminated in red in 10 cycles. Each cycle began with the illumination of the first target. A correct, accurate hit on the first target was followed by the illumination of the second target. During the execution of the task, the participants were in a fencing stance at a distance suitable for performing a straight push. In the event of not hitting the target or not performing the hit sequence correctly, a time of 2.50 seconds was added to the test and counted towards the overall average performance of the given programme. Test 2 consisted of hitting three randomly appearing targets that illuminated red in 10 cycles. Each cycle began with the illumination of the first target. A correct, precise hit on the first target was followed by the illumination of the second target. A correct, accurate hit on the second target was followed by the illumination of the third target. In case of not hitting the target or not correctly performing the hit sequence, the participant was credited with a time of 2.70 seconds, counted towards the overall task performance average. Test 3 consisted of hitting three red-lit targets simultaneously in three cycles. In case of not hitting the target or not correctly executing the hit sequence, the participant was credited with a time of 3.00 seconds, counted towards the overall task execution average. The tests were performed twice, using both the dominant and non-dominant hand. The averaged time from the all three tests for each hand separately, to the nearest 0.01 second, was used for analysis.

Statistical analysis

Basic descriptive statistics were calculated, and means were compared, using Student's t-test for two groups with equal variance or the non-parametric Mann–Whitney U test for variables without normal distribution. The strength of the effect (r) made it possible to determine the size of the differences between the two groups. One-way ANOVA or Kruskal-Wallis H analysis was done for three groups. Tukey's least significant difference post-hoc test was used to assess which of the groups differed. The eta squared (E2), was used as the measure of the Kruskal-Wallis test effect size.

To determine the relationships between variables, a series of correlation analyses were performed using Pearson's (r) and Spearman's (rho) coefficients.

A value of p = 0.05 was taken as the level of statistical significance. The statistical analyses used the IBM SPSS statistics package version 25.

3. Results

Indicators First, we decided to test whether handedness was a differentiating factor among the study group in terms of hit precision. Competitors, depending on their handedness, were com-pared with each other using the non-parametric Kruskal–Wallis test (right-handed vs. left-handed vs. ambidextrous). The results indicated that all three groups of fencers differed significantly in terms of hit precision, however, the effects of the differences were weak (Table 1).

Table 1. Differences in right and left hands precision between three groups of fencers and their significance.

Functional characteristic	Right-handers (n = 21)		Left-handers (n = 10)		Ambidextrous (n = 27)				
	M	*SD*	*M*	*SD*	*M*	*SD*	*H*	*p*	E^2
Right hand precision	0.78	0.13	0.98	0.15	0.79	0.17	9.18	**0.010**	0.16
Left hand precision	0.99	0.17	0.81	0.14	0.96	0.17	8.28	**0.016**	0.14

Hit precision was measured as an averaged time from the all three test trials for each hand separately using the Favero EFT-1 electronic board. **Legend:** M: mean; SD: standard deviation; **H**: result of Kruskal–Wallis test of significance of differences; **p**: p-value; **E2**: eta-square – effect size

The analysis resulted in a statistically significant effect of the handedness variable (F (2, 26.6) = 5.386, p = 0.011). It also showed statistically significant differences between all groups (p = 0.001). Left-handed individuals had lower scores in left-handed precision than right-handed and ambidextrous individuals (F (2, 26.6) = 5.386, p = 0.011). On the other hand, they had higher scores in right-handed precision than right-handed and ambidextrous fencers (F (2, 25) = 6.275, p = 0.006).

Right-handed fencers averaged 0.210 points better in right-handed precision, while left-handed athletes averaged 0.170 points better in left-handed precision. Ambidextrous players also achieved different results in the precision of hits between hands (0.170 points), with better results obtained with the right hand.

To determine statistically significant differences between groups in the precision of the right and left hands, the Mann–Whitney U test was conducted. The results obtained are included in Table 2.

Table 2. Significance of differences in right and left hands precision according to handedness.

Functional characteristic	Handedness	*U*	*p*	*r*
Right hand precision	Right-handed vs left-handed individuals	37.50	**0.004**	−0.64
	Right-handed vs ambidextrous	280.00	0.941	−0.01
	Left-handed vs ambidextrous	55.50	**0.007**	0.59
Left hand precision	Right-handed vs left-handed individuals	39.50	**0.006**	0.62
	Right-handed vs ambidextrous	250.00	0.622	0.08
	Left-handed vs ambidextrous	60.50	**0.014**	−0.53

Hit precision was measured as an averaged time from the all three test trials for each hand separately using the Favero EFT-1 electronic board**. Legend:** U: non-parametric Mann–Whitney test; p: p-value; r: strength of effect.

It was observed that left-handed individuals differed from right-handed and ambidextrous people in terms of right-hand ($p = 0.004$, $p = 0.007$, respectively) and left-hand precision ($p = 0.006$, $p = 0.014$, respectively). The strength of the effect of these differences was moderate. Between right-handed and ambidextrous participants, no significant differences existed in the precision of right- ($p = 0.941$) and left-handed hits ($p = 0.622$).

4. Discussion

The aim of our study was to identify the relationship between the type of handedness and hit precision. The athletes studied were characterised by different handedness. In a group of 58 girls, 36% were right-handed, 15% were left-handed and 49% were ambidextrous. The literature on upper limb lateralisation is disparate, which, among other things, may be due to the use of different research methods to distinguish individuals with different handedness types. In a study by Bescos et al. [37], out of 87 fencers from 32 countries, 21% were left-handed. According to the results of a study by Vorack et al. [38], out of 99 fencers, 11.1% had a dominant left hand. The present study confirms that in some sports, including fencing, an overrepresentation of left-handed individuals exists [31].

In our study the right- and left-handed participants as well as ambidextrous performed the same task with using both hands. They had to perform a series of gun tip embeddings in randomly appearing targets in the shortest possible time, which made it possible to accurately determine the precision of inflicting hits in different variants. It is very important for fencers to respond quickly and accurately to attacks from either side, and they should anticipate the opponent's moves, including lateral shifts in position [39]. We hence decided to choose the three most diverse test trials, which were averaged separately for each hand which made it possible to assess the hits precision.

Compared with athletes from other sports, fencers are generally not faster in reaction-time tests but are more accurate, with left-handers performing the best. Left-handers have the advantage in many sports, but this may be particularly evident in interactive sports that are characterized by high spatiotemporal pressure (e.g. table tennis, fencing) as opposed to slower interactive sports (e.g. tennis, squash) [39]. Our study is the first to examine a potential interaction between handedness and hit precision among female foil fencers. We revealed differences regarding the hit precision depending on handedness. First, we stated, that handedness differentiates three groups of fencers in terms of the hit precision with both right and left hands. Significant differences were shown between right-handed and left-handed athletes, as well as between left-handed and ambidextrous athletes. Left-handers had significantly lower right-hand precision and significantly higher left-hand precision compared to the other groups. The smallest differences in the hit precision were observed between right-handed and ambidextrous fencers, with left-handers standing out. Left-handers are less strongly lateralized than right-handers [8]. One reason could be that almost all tools and facilities (e.g., scissors, notebooks, spiral staircases) in daily life are designed for right-handed people. People who are not right-handed have often been made to use their right hand for many occupational tasks [5] so the difference between hands in some activities could be diminished.

We also observed that the left-handers and ambidextrous fencers displayed smaller differences than their right-handed counterparts in their use of both hands during hitting so they were less lateralized. In other study similar observation was done where left-handers fencers were less lateralized, which was connected with superior motor performance [34]. Fencers demonstrated more symmetric patterns of arm performance that were associated with substantially better accuracy and quality of movement in the left arm. They had greater symmetry in arm performance than non-fencers [40]. Additionally, left-handers tend to demonstrate more symmetric arm movements then right-handed individuals [41].

We stated, that left-handers were slightly better than right-handers in this activity at using their non-preferred hands, but the difference was small. Overall, little difference existed between right- and left-handers in using their preferred hand, but left-handers were considerably better than right-handers in using their non-preferred hands.

Generally, scoring a point in fencing requires accuracy, among other things, and precision in the use of the blade is extremely important. The idea is to ensure that the move made is exactly as planned. Our results confirm previous findings in other research evidencing the important role of handedness and fencing performance.

The analyses carried out undoubtedly have their limitations. One is certain ambiguities arising, such as from the commonly adopted method of assessing hand dominance, which makes it difficult to compare the results of studies by different authors, as well as to interpret the data obtained. Additionally, the size of the group is too small to be able to make definite conclusions about the effect of handedness on hit precision in female foil fencers.

Fencing requires more and newer solutions to make scoring easier. Fagan et al. [42] suggested that in the recruitment process, selectors at all levels should be encouraged to pay special attention to left-handed players. They may show some performance advantage over peers with other types of handedness. In the context of the available literature and our analysis, it also seems important to focus on the precision of movement execution in fencing, which can be crucial to success.

5. Conclusions

Handedness differentiated the participants' performance in hit precision. The smallest differences in the hit precision score were observed between right-handed and ambidextrous fencers; left-handed athletes stood out significantly. Moreover, the left-handed and ambidextrous fencers displayed smaller differences in their use of both hands during hitting than their right-handed counterparts, indicating that they were more symmetrical in hit precision. Applying these findings to athletes in sports that require movement precision could provide valuable information on the potential relationship between handedness and precision in performing a given movement task. However, this requires further research.

Data Availability Statement: The data supporting this study's findings are available from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declared no conflict of interest.

References

1. Toga AW, Thompson PM. Mapping brain asymmetry. Nat Rev Neurosci 2003; 4: 37-48
2. Sun T, Walsh C.A. Molecular approaches to brain asymmetry and handedness. Nat Rev Neurosci 2006; 7: 655-662
3. de Kovel CGF, Carrión-Castillo A, Francks C. A large-scale population study of early life factors influencing left-handedness. Sci Rep 2019; 24;9(1): 584
4. Faurie C, Raymond M. Handedness frequency over more than ten thousand years. Proc Biol Sci 2004; 27;3: 43-45
5. Gilbert AN, Wysocki CJ. Hand preference and age in the United States. Neuropsychologia 1992; 30(7): 601-608
6. Raymond M, Pontier D, Dufour AB et al. Frequency-dependent maintenance of left handedness in humans. Proc Biol Sci 1996; 22;263(1377): 1627-1633
7. Sha Z, Pepe A, Schijven D et al. Handedness and its genetic influences are associated with structural asymmetries of the cerebral cortex in 31,864 individuals. Proc Natl Acad Sci USA. 2021; 23; 118(47): e2113095118
8. Oldfield RC. The assessment and analysis of handedness: the Edinburgh inventory. Neuropsychologia 1971; 9(1): 97-113
9. McFarland K, Anderson J. Factor stability of the Edinburgh Handedness Inventory as a function of test-retest performance, age and sex. Br J Psychol 1980; 71(1): 135-142
10. Chapman JA, Henneberg M. Switching the handedness of adults: results of 10 weeks training of the non-dominant hand. Persp Hum Biol 1999; 4(1): 211-217
11. Peters M, Reimers S, Manning JT. Hand preference for writing and associations with selected demographic and behavioral variables in 255,100 subjects: the BBC internet study. Brain Cognition 2006; 62: 177-189
12. Raymond M, Pontier D. Is there geographical variation in human handedness? Laterality 2004; 9(1): 35-51
13. Margonato V, Roi GS, Cerizza C et al. Maximal isometric force and muscle cross-sectional area of the forearm in fencers. J Sports Sci 1994; 12(6): 567-572
14. Holtzen DW. Handedness and professional tennis. Int J Neurosci 2000; 105(1-4): 101-119
15. Leyk D, Gorges W, Ridder D et al. Hand-grip strength of young men, women and highly trained female athletes. Eur J Appl Physiol 2007; 99(4): 415-421
16. Ziyagil MA, Gursoy R, Dane Ş et al. Left-handed wrestlers are more successful. Percept Mot Skills 2010; 111(1): 65-70
17. Grouios G. Motoric dominance and sporting excellence: training versus heredity. Percept Mot Skills 2004; 98(1): 53-66

18. Chance DM, Maymin PZ. A new look at the left-handed advantage in baseball. Int J Perform Anal Sport 2023; 23(6): 458-488
19. Aggleton JP, Wood CJ. Is there a left-handed advantage in "ballistic" sports? Int J Sport Psychol 1990; 21(1): 46-57
20. Edwards S, Beaton A. Why is there an over-representation of left-handed bowlers in professional cricket in the UK? Laterality 1996; 1(1): 45-50
21. Bisiacchi PS, Ripoll H, Stein J et al. Left-handedness in fencers: an attentional advantage? Percept Mot Skills 1985; 61(2): 507-513
22. Poliszczuk T, Lampkowska M. Asymetria funkcjonalna i dynamiczna czasu reakcji prostej u zawodniczek trenujących szermierkę. Pediatr Endocrinol Diabetes Metab 2007; 13(4): 206-209; Polish
23. Voracek M, Reimer B, Ertl C. Digit ratio (2D: 4D), lateral preferences, and performance in fencing. Percept Mot Skills 2006; 103(2): 427-446
24. Witkowski M, Tomczak M, Bronikowski M et al. Visual perception strategies of foil fencers facing right-versus left-handed opponents. Percept Mot Skills 2018; 125(3): 612-625
25. Roi GS, Bianchedi D. The science of fencing. Sports Med 2008; 38(6): 465-481
26. Stone MH, Stone M, Sands WA. Principles and practice of resistance training, Publisher: Human Kinetics, Champaign IL, 2007.
27. Michaluk T. Sport of the disabled in the semiotic and philosophical research perspective. Physiother 2011; 19(1): 41-48
28. Nowak I. Rajdy samochodowe-logistyczne wyzwanie dla całego zespołu. Logistyka 2017; (3): 14-19; Polish
29. Olex-Zarychta D. Lateralizacja funkcjonalna kończyn człowieka i jej uwarunkowania w zakresie koordynacji motorycznej. Publisher: AWF Katowice, Poland, 2010; Polish
30. Stein JF. Factors influencing the initiation, performance and precision of the hit in fencing. In Proceedings of the 1st International Congress on Science and Technology in Fencing, Barcelona, Spain 15-17.02.2008
31. Witkowski M, Tomczak M, Karpowicz K et al. Effects of fencing training on motor performance and asymmetry vary with handedness. J Mot Behav 2019; 52(1): 50-57
32. Sorel A, Plantard P, Bideau N et al. Studying fencing lunge accuracy and response time in uncertain conditions with an innovative simulator. Plos One 2019: 14(7): e0218959
33. Starosta W. Symetryzacja ruchów – metoda rozwijania koordynacji u początkujących i zaawansowanych zawodników. Sport Wyczynowy 1996; 7;8: 36-46; Polish
34. Rokita A, Bronikowski M, Popowczyk M et al. Precision and coordination parameters of Polish elite cadet fencers. Med Dello Sport 2014; 67: 369-381
35. Krzykała M, Perz K, Witkowski M et al. Somatic determinants of hit precision in female foil fencers. Arch Budo 2023; 19: 247-255
36. Gonzalez CL, Goodale MA. Hand preference for precision grasping predicts language lateralization. Neuropsychologia 2009; 47(14): 3182-3189
37. Bescós R, Esteve M, Porta J et al. Prenatal programming of sporting success: associations of digit ratio (2D:4D), a putative marker for prenatal androgen action, with world rankings in female fencers. J Sports Sci 2009; 27(6): 625-632
38. Voracek M, Reimer B, Dressler G. Digit ratio (2D:4D) predicts sporting success among female fencers independent from physical, experience, and personality factors. Scand J Med Sci Sports 2010; 20(6): 853-860
39. Loffing F, Hagemann N, Strauss B et al. Laterality in sports: theories and applications. San Diego: Academic Press, 2016
40. Akpinar S, Sainburg RL, Kirazci S et al. Motor asymmetry in elite fencers. J Mot Behav. 2015; 47(4): 302-11
41. Przybyla A, Coelho CJ, Akpinar S, et al. Sensorimotor performance asymmetries predict hand selection. Neuroscience. 2013; 228: 349-360
42. Fagan F, Haugh M, Cooper H. The advantage of lefties in one-on-one sports. J Quant Anal Sports 2019; 15(1): 1-25

Authors:
Krzykała Magdalena: https://orcid.org/0000-0001-8373-1869
Witkowski Mateusz: https://orcid.org/0000-0002-0334-7865
Perz Karolina: https://orcid.org/0000-0002-1235-2981
Hekiert Bartosz: https://orcid.org/0000-0003-4210-9592

Citation: Krzykała M, Witkowski M, Perz K et al. Does hand preference affect the accuracy in fencing? The pilot study. Arch Budo J Inn Agon 2024, 20: 90-99