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Brain dominance of competitive fencers by weapon, gender and sport performance

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Abstract

Background & Study Aims: Fencing was investigated in the specialised literature as being part of striking combat sports. The purpose of this study is knowledge about the dominant areas of the brain of fencing athletes according to weapon, gender, and sports performances.

Material & Methods: Forty-one competitive Romanian fencers, 23 female and 18 male athletes (Mage = 23.2), took part in the study. The Brain Dominance Questionnaire was used, adapted by Roco (2004) after the Herrmann Brain Dominance Instrument (HBDI). The questionnaire items are arranged in four sections corresponding to the four brain quadrants proposed by Herrmann (who pioneered the Whole Brain Thinking approach): upper and lower left quadrants of the brain (ULQ and LLQ), respectively upper and lower right sectors (URQ and LRQ).

Results: Fencers with international results use less the upper right quadrant of the brain than fencers having local/regional results, being, therefore, less involved in risky activities, and operating less outside the rules/norms. After applying the Kruskal-Wallis test no significant differences were found between the three groups of athletes, according to the weapon used: foil, épée or sabre. However, regardless of the weapon, fencers are organised, planned individuals who establish procedures and take preventive measures (aspects specific to LLQ), are better at analytical activities and prefer to solve problems through reasoning and logic (aspects specific to ULQ), using more the left hemisphere. Also, fencers in foil are using more the upper right quadrant of the brain (URQ), comparing to fencers who use sabre or épée, using thus imagination more to solve game situations. Gender-related findings were discussed, female fencers using more the lower right quadrant, being more sensitive persons, who like more to be supportive in social interactions.

Conclusions: Fencers, having both high level performances and without outstanding sport results use (slightly more) the left hemisphere (compared to the right hemisphere). Fencers, whether they use the sabre, épée or foil, predominantly use the upper left quadrant of the brain and the lower left sector. Considering the differences by gender, a more integrated use of both cerebral hemispheres was observed in female fencers.

Keywords: cerebral preferences • fencing • sports performance • Whole Brain Model

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INTRODUCTION

Fencing originally had a military and utilitarian purpose, at some point acquiring a purely sporting dimension [1]. In 1896, during the inaugural edition of the Modern Olympic Games (held in Athens), fencing became a recognised sport. But fencing was included by the Greeks, also, in the first Olympic Games (776 BC) 'as hoplomachia (one-to-one fight with weapons)' [2]. Fencing was investigated in the literature as being part of striking combat sports [3]. As Kalina underlined: "every combat sport is martial arts but not vice versa" [4, p. 18].

With respect to the type of weapons, in fencing, we emphasize: épée, sabre and foil. Researchers found that left-handers were occasionally observed in sabre, while consistently overrepresented in foil and épée [5]. Information on the functions of the three weapons and how to score in competitions are found in the literature [6, 7]. Figure 1 is clarifying as to where fencers are allowed to strike, depending on the weapon [8, 7].

In Romania, fencing is very popular, Romania being a constant presence at the highest level, in international competitions – see Dințică for the distribution of Romanian medals at the Olympic Games [9]. The total number of medals (fencing) at World, European and Olympic championships sum up 141 (by May 2023).

Each athlete (and person) has a particular way of processing and interpreting data, hemispheric dominance playing a very important role [10]. Complementing the differences between the right and left hemisphere with the differences between the cortical system and the limbic system, Ned Herrmann (who pioneered the *Whole Brain Thinking* approach) mentions that left limbic (lower left quadrant of the brain) prevails when the left brain is dominant, the one that plans and organizes, while the right limbic (lower right quadrant of the brain) is the source of emotional and affective activity, activating (mainly) when we interact with others [11]. The metaphorical whole brain model supposes the existence of four

Fencing – *noun* 'the art or practice of fighting with slender swords formerly in combat, now as a competitive sport' [34].

Épée – is the heaviest of the three modern fencing weapons (foil, épée, and sabre), each a separate event, épée is the only one in which the entire body is the valid target area. Épée is the heaviest of the three modern fencing weapons [35].

Performance – *noun* the level at which a player or athlete is carrying out their activity, either in relation to others or in relation to personal goals or standards [34].

Neuroscience Whole Brain Theory – *noun* integrating the MacLean' triune brain theory and the Sperry's brain hemispheres, Ned Herrmann proposes that the brain consists of four quadrants that influence the thinking styles [36].

Cerebral dominance – *noun* from a biochemical point of view, right hemispheric dominant persons had '(i) increased HMG CoA reductase activity, (ii) elevated serum digoxin levels, (iii) reduced serum ubiquinone levels, (iv) increased serum tryptophan and reduced tyrosine, (v) increased serum dolichol levels, and (vi) decreased RBC membrane Na(+)-K+ ATPase activity and serum magnesium levels. Left hemispheric dominant individuals had the opposite patterns' [37].

Cohen's d – is frequently used in estimating sample sizes for statistical testing (a lower Cohen's d indicates the necessity of larger sample sizes, and vice versa); the strength of the effect d: 0.2 weak, 0.5 average, 0.8 strong.

Figure 1. (a) sabre; (b) foil; (c) épée

specialized parts of the brain: upper left, lower left, upper right and lower right [12], each operating mode having its own way of being (its own perceptions and language). No brain preference is better than other [13]. These quadrants work together, interact, Roco emphasizing that about 50% of people (regardless of age) predominantly use three brain sectors, while approximately 40% use (predominantly) two brain quadrants. In her book from 2004 [11], Mihaela Roco (also Senior scientific researcher at the Institute of Psychology of the Romanian Academy) clearly described the characteristics of the four brain sectors proposed by Ned Herrmann (see also [13]). Therefore:

1. Upper left quadrant of the brain (ULQ): when this sector is activated people appreciate things or ideas by their components, ignoring the whole (analytical approach). They prefer logical reasoning, easily understand technical and scientific concepts, manipulate figures with ease (mathematical approach). They have a predilection for rigorous and precise reflection, gather facts before making a decision and analyse possibilities.

2. Upper right quadrant (URQ): the person thinks by visualising the facts and solves situations through intuition and imagination. People in whom this brain sector dominates perceives things, ideas holistically, without reducing them to individual components, accept ambiguity and are not afraid to overturn established rules. Has ideas and invents innovative solutions, sees things in a broader perspective. This area is associated with artistic activities such as music, painting and sculpture.

3. Lower right quadrant (LRQ): activating this sector makes the person want to connect with others and feel good in a group. The person easily perceives nonverbal signs of interpersonal problems, feels the reactions and desires of others, intuitively understanding their emotions and feelings. He/she likes to communicate and is not afraid of his/her own emotions.

4. Lower left quadrant (LLQ): activating this sector causes a person to manage their emotions and want to control them. The person is concerned with maintaining control over one's own emotional state, pays attention to detail, establishes procedures and lives according to a precise timetable and schedule (doesn't like change). He/she tends to follow habits to feel safe, otherwise would be disoriented. Therefore, the person plans and organizes things to make them as coherent as possible. The more hidden flaws he/she finds, the more anxious he/she becomes.

Herrmann [14] underlined, also, from a thinking perspective, four different selves:

- rational self (ULQ): analyses, is critical, logical, likes numbers.
- safekeeping self (LLQ): timely, plans, established procedures, takes preventive actions.
- feeling self (LRQ): is expressive, sensitive to others, is emotional, feels, is supportive.
- experimental self (URQ): imagines, takes risks, likes surprises, breaks rules.

Cerebral preferences can be modified/can evolve according to occupation, life circumstances, education, or training [15]. There are professions in which the left-brain mode of operation dominates (e.g., engineers, lawyers, computer scientists, economists, historians); in highly creative people (regardless of profession) all four brain quadrants are activated according to the specific moments of problem solving [11].

In sports field, researchers explored the dominant cognitive functions in different sports disciplines, being aware that 'athletes possess the ability to read the game, which is known as *the sports brain*' [16].

Athletes' brain dominance (when talking about Herrmann's model) was less investigated, and much less in fencing. For example, in the case of female senior artistic gymnasts (members of the Romanian Olympic team), the left-brain mode of operation dominates [17]. Similar results were observed when researchers investigated twenty of the best chess players in Romania [18]. On the other hand, Roco et al. [19] found that the right brain modality dominates in the case of junior female handball players. In 2023, Predoiu et al. [20] examined, also, sports managers, finding that experienced sports managers use significantly more the upper left quadrant (ULQ) and,

also, the lower right sector of the brain (LRQ), while future sports managers predominantly use the lower left quadrant.

The aim of this study is knowledge about the dominant areas of the brain of fencing athletes according to gender, weapon and sports performance achieved.

The following research questions were put forward in the study:

1. What are the differences between top level fencers and other athletes in terms of activation of different brain sectors?

2. Which brain quadrant and which brain hemisphere do fencers predominantly use, depending on the weapon used – épée, sabre and foil?

3. What are the differences between male and female performance fencers in terms of the brain sectors used, and in terms of hemispheric dominance?

MATERIAL AND METHODS

Participants

Forty-one competitive Romanian fencers (23 female and 18 male athletes), aged between 18 and 38 (M_{age} = 23.2), took part in the study, distributed as follows: 22 obtained international performances (at European or World level), being, also, members of the Romanian national teams (épée, sabre and foil); 10 male and 12 female; 19 fencers without outstanding sport results (at regional/ local level) 8 male and 11 female athletes; with respect to the weapon used: 15 fencers in foil (6 male and 9 female); 10 fencers in épée (3 male and 7 female), and 16 in sabre (9 male and 7 female).

Fencers were classified as elite/experts (with international or national level performances), and the second group of athletes registered regional/local performances, as in previous studies [21, 22].

Measurements

The Brain Dominance Questionnaire was used, adapted by Roco [11] after the Herrmann Brain Dominance Instrument (HBDI) and after consulting Chalvin's work [23] on the assessment of brain dominance. The questionnaire has 72 items arranged in four sections corresponding to the four brain quadrants (ULQ, URQ, LLQ and LRQ). Items examples: 'Did you like algebra in school?' (ULQ), 'Do you like or are you gifted in the areas of: painting, drawing, sculpture, music?' (URQ), 'Are you an orderly, organised person?' (LLQ), 'Do you like to give advice to others?' (LRQ). Ways of answering: 1 = very little; 2 = a little; 3 = moderately; 4 = a lot; 5 = very much. Left hemisphere result is the sum for ULQ and LLQ, while right hemisphere result: URQ + LRQ.

By means of the HBDI questionnaire (and, also, using the Romanian version of HBDI, adapted by Roco) a person can determine which brain hemisphere is used more, and it can give a general picture of the weight of the four brain quadrants. Schkade, Potvin and Herrmann (see [11]) established a correlation between the answers to the questionnaire and the activation of the brain hemispheres (with the help of EEG). Thus, the type of answers to the questionnaire provides the same information as the EEG, being possible to just give the questionnaire, without doing the EEG, to see which hemisphere dominates.

Procedure

The study was conducted between November 2022 and February 2023. The questionnaire in this study was administered online via google forms. Authors equally contributed to the study. Following the completion of The Brain Dominance Questionnaire, the confidentiality of personal data was ensured. Participants had the possibility to withdraw from the research at any time.

Ex post factor design

The dependent variables are represented by the fencers' results considering the four brain sectors (ULQ, URQ, LLQ and LRQ), as well as considering the two cerebral hemispheres (left and right). The independent variable (plays the role of the independent variable) is the membership of the fencers in one of the groups (top level fencers vs. fencers without outstanding results, male athletes vs. female athletes, respectively foil, épée or sabre fencers).

Statistical analyses

As a first step, we checked the differences between top fencers and athletes without outstanding performances in terms of activation of different brain sectors. To test whether there are significant differences between top fencers

and other athletes in the activation of different brain quadrants, a t-test for independent samples was used (Shapiro-Wilk test, p>0.05), as well as the homogeneity of the variances (Levene's test, p>0.05). Next, we investigated which brain sector and which brain hemisphere fencers predominantly use, taking into account the weapon used: foil, épée or sabre (Kruskal-Wallis nonparametric test was applied). Statistical analysis was performed regardless of gender and sports performance recorded. As the last step we investigated which are the differences between male and female fencers in terms of the brain quadrants used, as well as in terms of hemispheric dominance. The names of statistical indicators are explained under the Tables.

Ethics

The study was conducted with respect to the recommendations of the Declaration of Helsinki. Written informed consent was obtained from all athletes, and the anonymity and data confidentiality were ensured. Also, the research was approved by the local Ethics Committee – National University of Physical Education and Sports, Bucharest, Romania (ID: 747/SG).

RESULTS

Top fencers use more the upper left sector of the brain and less the upper right cortical area. The left hemisphere is also used slightly more by top level athletes (compared to the right hemisphere). Fencers without outstanding athletic performance use more the upper left and the lower left quadrants of the brain and less the lower right sector. The left hemisphere is also used more by these athletes (compared to the right hemisphere), as is the case of high level fencers (Table 1).

There are no significant differences between the two groups of fencers (top and other athletes) in terms of the use of a particular brain quadrant. However, in the case of URQ, the alpha threshold is very close to 0.05 (p = 0.066), with fencers having high level performances using this brain area less than fencers without such results (Table 2).

There are no significant differences (p> 0.05) between the results of the three groups of athletes, according to the weapon used: foil, épée, sabre respectively, in terms of the brain quadrants used (Table 3).

Fencers (regardless of the weapon) predominantly use the upper left quadrant of the brain (ULQ) and the lower left area (LLQ). At the same time, athletes use the left hemisphere more (Table 4). In other words, fencers, whether they use the sabre, épée or foil, are organised, structured, controlled, planned individuals who establish procedures and take preventive measures (aspects specific to the LLQ), are better at analytical activities, use critical thinking and prefer to solve problems through reasoning and logic (aspects specific to ULQ). Moreover, data in Figure 2 emphasize that fencers in épée are using (a little more) ULQ, LLQ and LRQ (comparing to other fencers), while fencers in foil are using more the upper right quadrant of the brain (URQ).

Table 1. Descriptive statistics – brain quadrants and hemispheric dominance.

Brain sectors	Min		Max		Range		Mean		SD		SE		CV	
	A	T	A	T	A	T	A	T	A	T	A	T	A	T
ULQ	51	56	78	72	27	16	65.94	63.72	7.59	5.45	1.74	1.16	0.11	1.16
URQ	48	41	81	76	33	35	63.63	58.22	9.97	8.3	2.28	1.77	0.15	1.77
LLQ	46	52	79	77	33	25	65.47	62.95	9	6.32	2.06	1.34	0.13	1.34
LRQ	44	50	76	79	32	29	62.57	62.36	9.34	8.46	2.14	1.8	0.14	1.8
LH	97	108	153	144	56	36	131.4	126.6	15.23	9.57	3.49	2.04	0.11	2.04
RH	97	91	151	152	54	61	126.2	120.5	16.94	15.7	3.88	3.36	0.13	3.36

A fencers without outstanding performances; **T** fencers with international performances; **ULQ** upper left quadrant of the brain; **URQ** upper right quadrant; **LLQ** lower left quadrant; **LRQ** lower right quadrant; **LH** left hemisphere; **RH** right hemisphere; **SE** standard error; **CV** coefficient of variation.

Table 2. Fencers without outstanding results vs. top fencers.

Brain sectors	t	p	d Cohen
ULQ	−1.0855	0.284	−0.3400
URQ	−1.8931	0.066	−0.5929
LLQ	−1.0470	0.302	−0.3279
LRQ	−0.0774	0.939	−0.0242
LH	−1.2092	0.234	−0.3787
RH	−1.0996	0.278	−0.3444

ULQ upper left quadrant of the brain; **URQ** upper right quadrant; **LLQ** lower left quadrant; **LRQ** lower right quadrant; **LH** left hemisphere; **RH** right hemisphere; **t** Student's *t*-distribution; **p** probability; **d** (see glossary)

Table 3. Brain dominance results – fencers (by weapon used).

Brain sectors	Kruskal-Wallis test			
	χ^2	df	p	ε^2
ULQ	2.00991	2	0.366	0.05025
URQ	0.41950	2	0.811	0.01049
LLQ	0.47016	2	0.791	0.01175
LRQ	0.00675	2	0.997	0.00016
LH	1.42025	2	0.492	0.03551
RH	0.18997	2	0.909	0.00475

ULQ upper left quadrant of the brain; **URQ** upper right quadrant; **LLQ** lower left quadrant; **LRQ** lower right quadrant; **LH** left hemisphere; **RH** right hemisphere; **χ^2** sampling distribution of χ^2; **df** degrees of freedom; **p** probability; **ε^2** effect size (epsilon squared)

The differences between male and female fencers in terms of the brain quadrants used, as well as in terms of hemispheric dominance are presented by descriptive statistical indicators for the two groups of fencers. Male and female fencers use more the upper left quadrant of the brain (cortical sector) and the lower left quadrant (limbic sector), the left cerebral hemisphere being, implicitly, used more. However, when talking about female fencers, the difference between the results for the two brain hemispheres (LH – RH = 4.6) is smaller, when compared to male fencers (the difference is 7.1) – see Table 5. Therefore, in the case of female athletes we can conclude about a more integrated use of both cerebral hemispheres.

Table 4. Brain dominance (depending on weapon used) – descriptive level.

Statistical indicator	Weapon	ULQ	URQ	LLQ	LRQ	LH	RH
N	foil	15	15	15	15	15	15
	épée	10	10	10	10	10	10
	sabre	16	16	16	16	16	16
Mean	foil	65.3	62.3	63.3	61.6	129	124
	épée	66.7	59.5	66.2	63.2	133	123
	sabre	63.1	60.0	63.6	62.8	127	123
SE	foil	1.99	2.60	2.17	2.28	3.92	4.44
	épée	1.67	3.74	2.73	3.02	3.57	6.03
	sabre	1.51	1.82	1.64	2.19	2.68	3.69
SD	foil	7.69	10.1	8.41	8.81	15.2	17.2
	épée	5.27	11.8	8.63	9.55	11.3	19.1
	sabre	6.04	7.28	6.57	8.75	10.7	14.8
Skewness	foil	−0.372	0.103	−0.447	−0.556	−0.557	−0.172
	épée	−0.819	0.200	0.313	−0.118	0.458	−0.601
	sabre	−0.274	0.811	0.289	0.575	0.0120	0.845

ULQ upper left quadrant of the brain; **URQ** upper right quadrant; **LLQ** lower left quadrant; **LRQ** lower right quadrant; **LH** left hemisphere; **RH** right hemisphere; **SE** standard error; **SD** standard deviation

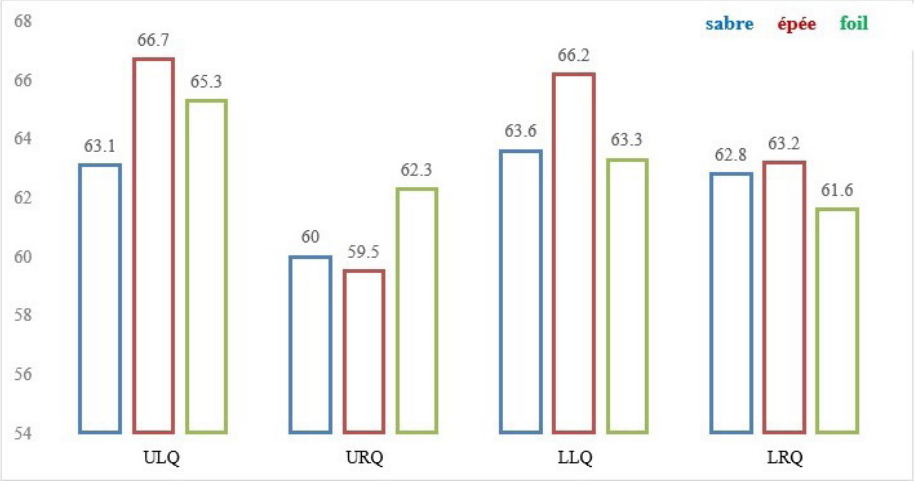

Figure 2. Brain quadrants used by fencers according to the weapon used (average results).

Table 5. Brain quadrants and hemispheric dominance by gender.

Brain sectors	Min		Max		Range		Mean		SD		SE		CV	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
ULQ	51	51	78	74	27	23	65.33	64.3	6.57	6.63	1.54	1.38	0.1	0.1
URQ	48	41	81	77	33	36	61.94	59.78	10.26	8.78	2.42	1.83	0.16	0.14
LLQ	46	52	79	79	33	27	65.05	63.39	8.08	7.46	1.9	1.55	0.12	0.11
LRQ	44	50	76	79	32	29	61.33	63.34	9.31	8.42	2.19	1.75	0.15	0.13
LH	97	107	153	151	56	44	130.4	127.7	13.2	12.2	3.11	2.55	0.1	0.09
RH	97	91	152	151	55	60	123.3	123.1	17.79	15.5	4.19	3.24	0.14	0.12

M male fencers; **F** female fencers; **Min** minimum; **Max** maximum; **SD** standard deviation; **SE** standard error; **CV** coefficient of variation; **ULQ** upper left quadrant of the brain; **URQ** upper right quadrant; **LLQ** lower left quadrant; **LRQ** lower right quadrant; **LH** left hemisphere; **RH** right hemisphere

There are no significant differences between fencers by gender in terms of the use (predominantly) of a particular brain quadrant ($p>0.05$). However, we highlight the following (nuanced) differences based on the results obtained at the descriptive level. Male fencers use a little more the upper right sector of the brain (URQ), the lower left quadrant (LLQ), and, also, the left cerebral hemisphere, while female fencers use more the lower right quadrant of the brain (LRQ), being more emotional and sensitive persons, who like more to express themselves and to be supportive in interpersonal relationships. In the case of the right brain hemisphere (RH), gender differences are almost non-existent. A very small difference (of only one point) could also be found in the use of the upper left quadrant (ULQ) – Table 6.

Table 6. Male fencers vs. female fencers

Brain sectors	t	p	d Cohen
ULQ	−0.4948	0.623	−0.15572
URQ	−0.7261	0.472	−0.22850
LLQ	−0.6830	0.499	−0.21493
LRQ	0.7256	0.472	0.22835
LH	−0.6753	0.503	−0.21253
RH	−0.0283	0.978	−0.00889

ULQ upper left quadrant of the brain; **URQ** upper right quadrant; **LLQ** lower left quadrant; **t** Student's *t*-distribution; **p** probability; **d** (see glossary)

DISCUSSION

The current study explores brain preferences of competitive fencing athletes according to sports performance achieved, weapon used and gender. Statistical data processing highlighted that top level fencers use more the upper left area of the brain (cortical quadrant) and less the upper right quadrant. The left hemisphere is used slightly more by fencers, having both high level performances and, also, without outstanding sport results (compared to the right hemisphere).

Even if there are no significant differences between the two groups of athletes (top level fencers and other athletes) in terms of the use of a particular brain quadrant, one can observe that fencers with international results use less the upper right quadrant than fencers without such performances. In other words, high level fencers are less involved in risky activities, operate less outside the rules /norms, and, also, like surprises less, compared to fencers with regional/local results.

In a next phase we investigated which brain sector and which brain hemisphere is used more by fencers, taking into account the weapon used: foil, épée or sabre. Fencers, whether they use the sabre, épée or foil, are organised, structured, controlled, planned individuals who establish procedures and take preventive measures (aspects specific to LLQ), are better at analytical activities, use critical thinking and prefer to solve problems through reasoning and logic (aspects specific to ULQ). Therefore, regardless of the weapon, fencers predominantly use the upper left quadrant of the brain (ULQ) and the lower left area (LLQ), using more (implicitly) the left hemisphere – compared to the right hemisphere. The data analysis revealed, also, that fencers in épée are using (a little more) ULQ, LLQ and LRQ (comparing to other fencers), while fencers in foil are using more the upper right quadrant of the brain (URQ), comparing to fencers who use sabre and épée. This can be explain taking into account the specifics of the sport discipline, in foil, the target area being only the torso, and not all upper half of the body (as in sabre), or the entire body (as in épée). Therefore, fencers in foil, activating more URQ are in a position to generate more innovative solutions and solve more the game situations through imagination (having the smallest target area for scoring). This is supported by the literature [24-27], authors resorting to small-sided games (the playing surface being thus reduced) in order to develop divergent thinking in athletes. It should be noted, however, that the differences between fencers – by weapon, were not statistically significant.

In the last part of the study, we wanted to investigate which are the differences between male and female fencers in terms of the brain quadrants used, as well as in terms of hemispheric dominance. No significant differences were found between fencers by gender (in terms of the use of a particular brain quadrant or cerebral hemisphere). Both male and female fencers use more the upper left quadrant of the brain (cortical sector) and the lower left quadrant (limbic sector), the left cerebral hemisphere being, therefore, used more. However, when talking about female fencers, the difference between the results for the two brain hemispheres is smaller, when compared to male fencers, being able to discuss (in the case of female athletes) about a more integrated use of both cerebral hemispheres. In 2014, researchers underlined that women have greater interhemispheric connectivity [28]. We mention, also, that male fencers use a little more the upper right sector of the brain (URQ), the lower left quadrant (LLQ), and, also, the left cerebral hemisphere (compared to female athletes), while female fencers use more the lower right quadrant of the brain (LRQ), being more sensitive and emotional persons, who like more to express themselves and to be supportive in interpersonal relationships. In the case of the right brain hemisphere (RH) and for ULQ, gender differences (in the case of the investigated fencers) are almost non-existent. In this context, we present Xin et al. study [29] who emphasized: 'using the designed 3D PCNN algorithm, we confirmed that the gender-related differences exist in the whole brain (…) as well as in each specific brain regions' and might be related to 'gender differences in cognition, emotional control as well as neurological disorders'. However, other researchers suggested that more investigation is needed to determine whether women and men really have different brain structures [30].

As Evans and Brewer [31] asserted 'areas of science in which policy and practice lag behind research evidence are known as *valleys of death*', being necessary to advance the application of psychology in working with athletes, in this case, considering the way of interacting with competitive fencers according to their brain dominance

(a less addressed topic). The differences between athletes and specialists with different brain preferences can be used to form groups of persons, who complement each other and are not in a destructive position. On the other hand, coaches, sport psychologists, physical trainers, can communicate with athletes according to hemispheric dominance, the information being more easily decoded by the cortex – see Roco [11] and Predoiu [18] for ways to communicate with athletes according to brain dominance.

The findings of the current study offer valuable information to coaches, athletes, parents, sport psychologists, in terms of fencers' brain dominance. If a person understands better his/her own thinking preferences, then communication, productivity, learning and development, the subjective well-being and problem solving can be facilitated [32].

The study has some limitations. First, the research should be carried out on a larger number of fencers, taking into account the weapon used. Data could be different if junior fencers would be investigated, athletes from other countries, only male or female fencers using a certain weapon (foil, épée or sabre) or only male (or female) top level fencers. Future investigation needs to shed light considering these research directions. We also bring into discussion the limitations related to explicit measurements (the possible desirable answers), a questionnaire being used (see [33]).

CONCLUSIONS

Fencers, having both high level performances and without outstanding sport results use (slightly more) the left-brain hemisphere, compared to the right hemisphere. Athletes with international results use less the upper right quadrant of the brain than fencers without such performances, being less involved in risky activities and operating less outside the norms. Fencers, whether they use the sabre, épée or foil, predominantly use the upper left quadrant of the brain and the lower left sector, using more the left-brain hemisphere. Also, fencers in foil are using more the upper right quadrant of the brain (using more imagination to solve the game situations), comparing to fencers who use sabre or épée. Considering the differences by gender (in terms of using a particular brain quadrant), it was found that female fencers use more the lower right quadrant, being more sensitive persons, who like more to be supportive in social interactions.

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