IOSR Journal of Sports and Physical Education (IOSR-JSPE)
e-ISSN: 2347-6737, p-ISSN: 2347-6745, Volume 4, Issue 5, (Sep - Oct 2017), PP 01-08
www.iosrjournals.org

Analysis of the Relationship between Cerebral Lateralization and Grip Strength in Elite Fencing Athletes

Mustafa Gümüş*
Physical Education and Sports Department, Bülent Ecevit University, Turkey
Corresponding Author: Mustafa Gümüş

Abstract: *The goal of this study is to examine the relationship between cerebral lateralization, hand preference and grip strength in fencing, which provides health, speed, agility, flexibility, balance, reflexes, coordination, intuition, timing ability, quick thinking and decision-making for your body. 117 elite fencing athletes whose ages range from 18 to 25 and attended Interuniversity Fencing Championship voluntarily participated in the study. Hand preference was confirmed by Oldfield Survey. Foot, eye and ear preference was also experimented by three items. Handgrip strength was measured by Jamar hydraulic dynamometer. Of the total subjects attended to our study, 48,1% were dominantly right-handed, 40,3% were right-handed, 10,2% were left-handed and 1,4% were dominantly left-handed. Dominant handgrip strength was 44.2 kg for the right-handed and 43.9 kg for the left-handed subject athletes. When we compared the dominance of hands, feet, eyes and ears together, 86,41% of the subjects dominantly preferred right hand, foot, eye and ear and the left hemisphere was dominant. This functional laterality may be due to dominance of the left hemisphere. It is significant to make similar evaluations intended for hand and hand preference on more subjects at different ages and competition categories in which hand preference is improved by active use.*

Keywords: *Cerebral lateralization, grip strength, fencing, hemisphere, hemispheric asymmetry*

Date of Submission: 26-08-2017 Date of acceptance: 06-10-2017

I. Introduction

The role of the laterality in sports has recently been studied by scientists in a variety of disciplines including neuropsychology, evolutionary biology and psychology, kinesiology, sports psychology, anthropology and etc [1, 2, 3, 4, 5, 6].

Hemispheric variations (cerebral lateralization) are the different abilities that cerebral hemispheres demonstrate in acquiring, implementing, and controlling of a number of specific neurological functions [7]. The cerebral dominance; however, refers to the predominance of cerebral hemispheres in the performance and control of some neurological functions. In humans, the verbal functions are dominant in the left hemisphere and spatial functions are more dominant in the right hemisphere [8]. In the binary classification of the human brain in the form of right and left hemispheres; it was identified that while the right side of the brain controls and regulates the left side of the body, the left side of the brain has taken the role of controlling and regulating the right side of the human body. This idea suggests that the left hemisphere plays a major role in complex events; however, the right hemisphere has only a small fraction of role as a silent section [9].

Nowadays, the idea that the two cerebral hemispheres are complementary but with very different specializations has gained acceptance. As a result of researches in the theories of hemispheric specializations, the left hemisphere was found to be rational and analytical and the right hemisphere was related to intuitive and holistic features [10].

Studying of hand, foot, eye and ear preferences was found to play an important role in evaluating the cerebral lateralization, which was described as anatomical and functional differentiation between the right and left hemispheres of the human brain [11, 12].

Since hand preference may be an artificial choice gained by environmental influences and may not provide accurate information about the natural lateralization of brain, researchers indicated that the eye dominance, which was unaffectable from any environmental influences in no sense, is more important in determining the natural lateralization [13]. Similarly, Elias and Bryden (1998) stated that the cerebral biasness might be more related to footedness rather than the other side preferences, and it was culturally and environmentally less influenced than handedness [14]. Therefore, hand, foot, ear and eye preferences should be studied together in determination of the cerebral lateralization.

About 90% of the people prefers to be right-handed, 80% right-footed, 70% right-eyed and 60% right-eared [15, 16, 17, 18]. Annett (1985) stated that the right-eyed ratio of the right-handed persons was higher than that of left-handed ones to be right-eyed. It was identified that 72% of the right-handed persons preferred the

right foot, 1.5% left foot, and 26.5% both feet; however, 54.8% of the left-handed individuals preferred the left foot, 18.7% right foot, and 26.5% both feet [19].

In fencing, the ability level of each individual depends on several variables. These are high level of hand, foot, eye coordination combined with quality of vision, perception, thinking quickly with reflex, balance and agility. We can say that the most important issue is the visual variables. As in all other sports branches, using lateral functions in fencing sport, in other words, using one side of the body separately or in combination provide motion enrichment.

Attention is of great significance for fencers. Mental abilities such as attention, perception, intelligence, reaction and expectation are considered to be the most important factors that must be managed. Mental abilities play a major role in motor behavior, as well as emotions and responses during participation in physical activity in sports. Using mental abilities and emotional factors at the highest limits enhances the effort of athletes during training and competitions [20].

In this direction, it was aimed to determine the hemispheric differences and the hand grip strength, which is considered as an indication of the individual's muscle strength and upper extremity functional integrity, and the relationship between these two issues in the fencing sport that gives health, strength, speed, power, agility, flexibility, balance, reflex, coordination, intuition, timing ability, quick thinking and gained decision making ability to the human body.

II. Method

The Subjects

As 63 were at national level, a total of 117 elite fencing athletes, competed in the intercollegiate fencing championship and aged from 18 to 22 (22.07±2.29) years old, participated in this study.

Protocol

Hand preference was assessed using the Edinburgh Handedness Inventory, and the Geschwind Scores[21] were calculated. Ten questions were asked to each subject regarding their hand preferences for writing, drawing, throwing, using various implementations such as scissors, toothbrush, knife without fork, spoon, striking matches, and jar opening. They were asked to put "+" in the column associated with the hand they used to carry out these activities. They were asked to put "++" in the associated column if their preferences for one hand was very strong; and to put a "+" in both columns if they were using both hands equally. A "++" in the right column was assigned plus 10 points, a "+" in the right column plus 5 points, whereas a "++" in the left column minus (–) 10 points (minus) and a "+" in the left column minus (–) 5 points. The sum of these points was used to determine the Geschwind Score (GS), as an indicator of the direction and degree of hand preferences of the subjects. Hand preference was evaluated in 5 groups depending on the GS values, as consistent right-handers: $+80<GS<+100$, weak right-handers: $+20<GS<+75$, ambidexters: $-15<GS<+15$, weak left-handers: $-75<GS<-20$, and strong left-handers: $-100<GS<-80$ [21, 22].

The foot preference was analyzed based on the three items (kicking a ball, picking up a pebble, stepping onto a chair), eye preference was assessed by three items (looking through a keyhole, looking into a bottle, and looking through a telescope), and ear preference was also assessed by three items (listening to a door, listening to a heartbeat, and using an earphone). The items were scored on a three-point scale of left, mixed and right, scored as – 1, 0, and +1 [23].

The hand grip strength measurements were made via the Jamar hydraulic hand dynamometer (Sammons Preston, USA). The dominant side was given priority. The measurement was made when a subject was in a sitting position while the forearm was in a 90 – degree flex (without support from the body). During the measurements, the wrist was regarded to be in a neutral position. The measurement was made in three successive replications and the average value was used as data. Values were recorded in kilograms [24].

Statistical analysis

Data were evaluated with SPSS for Windows 21.0 program, descriptive values were shown as "arithmetical mean ± standard deviation. Mann-Whitney U test and independent samples t-test was used for comparisons between groups, and results of analyses were analyzed within 95% confidence interval.

III. Results

With varying ages of subjects between 18 and 25 in the study, the athlete's average ages, heights and weights were identified as 22.07±2.29, 171.97±9.34, and 67.70±13.20, respectively. Of the 117 fencing athletes, 63 were identified to be at national team athletes and 95 were licensed. The subjects were determined to play sports for 2.09±0.69 hours in a day, 3.42±1.27 days in a week, and 7.59±4.85 years in their lifetime.

When the distribution of hand preference of the subjects (n=117) was considered, 88.4% (n=103) of the subjects preferred the right hand and 11.4% (n=14) the left hand. No ambidexter athlete was identified (Table 1).

Table 1: Numerical distribution of the hand preference groups based on the results of the lateralization survey.

Variables		Lateralization Survey Scoring	Score	Distribution of hand preference	n	%	Total	
							n	%
Hand Preference	Right-handed	Between +80 and+100	92	Strong right-handed	56	48,1	103	88,4
		Between +20 and +75	70	Weak right-handed	47	40,3		
	Left-handed	Between -20 and -75	-66	Weak left-handed	12	10,2	14	11,6
		Between -80 and -100	-94	Strong left-handed	2	1,4		

When the distribution of foot preference of the fencing athletes was analyzed, 87.2% (n=102) were observed to prefer the right foot, and 12.8% (n=15) the left foot. Similarly, when the distribution of the eye preference of the subjects was analyzed, 88.4% were observed to prefer right eye (n=103) and 11.6% (n=14) left eye. However, when the distribution of ear preference of the subjects was analyzed, 85.8% (n=100) were observed to prefer the right ear and 14.5% (n=17) the left ear. We did not identify any fencing athletes who use both feet, eyes and ears in our study (Table 2).

Table 2: Distribution of the dominant foot, eye and ear preferences of the subjects.

Variables		n	%
Foot Preference	Right Foot	102	87,2
	Left Foot	15	12,8
Eye Preference	Right Eye	103	88,4
	Left Eye	14	11,6
Ear Preference	Right Ear	100	85,5
	Left Ear	17	14,5

When we compared the hand, foot, eye and ear dominance of the subjects together, we resulted in that 86.41% (n=86) preferred right hand, foot, eye and ear dominantly, and observed that the left hemisphere was dominant. However, the preference of 14.29% of the subjects were left hand, foot, eye and ear dominantly, and the right hemisphere was dominant among those subjects (Table 3).

Table 3: Evaluation of hand, foot, eye, ear dominance of the subjects.

Hand	Foot	Eye	Ear	n	%
R	R	R	R	89	86,41
R	R	R	L	2	1,94
R	R	L	R	2	1,94
R	L	R	R	6	5,83
R	L	R	L	2	1,94
R	L	L	L	2	1,94
			Total R	100	100
L	R	R	R	1	7,14
L	R	L	L	8	57,14
L	L	R	R	2	14,29
L	L	R	L	1	7,14
L	L	L	L	2	14,29
			Total L	100	100

(R: Right, L:Left)

Among the fencing athletes participated in our study, the dominance of the right hand and foot frequency were identified as 90.29% (n=93), the dominance of right hand and eye frequency were determined as 96.12% (n=99) and the dominance of right hand and ear frequency were 94.17% (n=97), respectively. A statistically significant difference was observed between left hand and left foot dominances ($p<0.05$) (Table 4).

Table 4: Evaluation of dominance frequency of hand, foot, eye and ear of the subjects.

Variables	**Right Handedness** (n=103)		**Left Handedness** (n=14)		p
	n	**%**	**n**	**%**	
Right Foot Dominance	93	90,29	9	64,29	***0,012***
Left Foot Dominance	10	9,71	5	35,71	
Right Eye Dominance	99	96,12	4	28,57	0,236
Left Eye Dominance	4	3,88	10	71,43	
Right Ear Dominance	97	94,17	3	21,43	0,183
Left Ear Dominance	6	5,83	11	78,57	

Among the fencing athlete subjects participated in our study, the dominant hand grip strength was identified as 44.2 kg for the right-handers (n=103, 88.4%) and 43.9 kg for the left-handers (n=14, 11.6%). However, the nondominant hand grip strength was found to be 42.8 kg in the right-handers and 41.5 kg in the left-handers. No statistically significant difference was observed between the dominant hand (p=0.065) and the nondominant hand (p=0,081) preferences, and the grip strengths. (p<0.05) (Table 5).

Table 5: Evaluation of the relationship between hand preferences and grip strengths of the subjects.

Variables	**Hand Preference**			**Grip Strength**			
		n	**%**	**Dominant Hand**	**p[1]**	**Nondominant Hand**	**p[2]**
Right-handed	Strong Right	56	48,1	44,3	0.065	43,1	0.081
	Weak Right	47	40,3	44,1		42,5	
	Total	**103**	**88,4**	**44,2**		**42,8**	
Left-handed	Strong Left	12	10,2	44,1		41,5	
	Weak Left	2	1,4	43,7		41,5	
	Total	**14**	**11,6**	**43,9**		**41,5**	

p[1]: Between the right-handed and left-handed groups by grip strength of dominant hand.
p[2]: Between the right-handed and left-handed groups by grip strength of non-dominant hand.

IV. Discussion

In recent studies related to hemispheric asymmetry, determination of the performance of individual's hand, foot and eye was aimed in order to be able to form a study basis on cerebral lateralization. Based on the study results, performances of hand, foot and eye preferences were determined to play an important role in the evaluation of brain lateralization (Barut et al., 2004).

Hemispheric asymmetry has been presented to be different abilities that the brain hemispheres show in performance and control of some neurological functions (Tan and Çalıskan, 1987), and many behavioral asymmetries that are the result of hemispheric asymmetry have been described (Tanrıdağ, 1994). Ambidextrous and left-handers were considered to provide significant advantages in boxing, fencing, judo (Baker and Schorer, 2013), basketball, handball and wrestlers, furthermore, it also provides important advantages for sculptors, surgeons and players of musical instruments (Uzun and Alkan, 2002).

Fencing has been a very old sport with well-developed pedagogies for techniques and tactics. Consistent with its predictions, in professional rankings of interactive sports such as table tennis or fencing, where athletes can directly influence and constrain actions of each other, the athletes using their left hand for tasks such as holding a racket or a foil were found to be overrepresented (Raymond et al., 1996; Loffing and Hagemann, 2012; Grouios, 2004).

In the current study, we investigated the relationships between cerebral lateralization, hand, foot, eye, ear preference and the hand grip strength among the elite fencing athletes and 48.1% of the athletes were identified as strongly right-handed, 40.3% were weakly right-handed, 1.4% were strongly left-handed, and 10.2% were weakly left-handed.

In his study, Bescos et al., (2009) detected that 18 (21%) of the fencers (n=87) that were attended to Barcelona 2008 Fencing World Cup from 32 different countries were left-handed. Voracek, Reimer, & Dressler, (2010) reported that 11.1% of the subject fencers in their study (n=99) were observed to be left-handed. Among

the athletes of national weightlifting, gymnastics, taekwondo and wrestler sports participated in their researches, Gümüş and Akalın, (2016) determined the ratio of right-handedness, strong right-handedness, left-handedness and strong left-handedness as 84.1%, 42.9%, 12.7% and 3.2%, respectively. In another study where the relationship between the hand preferences and the eye dominance, 91.6% of the subjects were reported to have right hand preference, and 8.4% left hand preference (Gündoğan et al., 2007). In a research performed on the student athletes of the Yaşar Doğu Physical Education and Sports College of the Ondokuz Mayıs University, 39,27% of the students were reported to be strong right-handed, 52,81% weak right-handed, 2,97% ambidexter, 3,30% weak left-handed and 1.65% strong left-handed (Tat, 1999). Akalın et al., (2016) observed the right-footedness ratio as 87.18%, and the left-footedness as 10.26% among the women soccer players. Loffing et al., (2012) identified the left-handedness rate as 11.11% among the volleyball players (n=36) participated in their study. Elalmış and Tan, (2005) found in their study, which were performed on 22461 students, that 89.9% of the subject students were right-handed, 7.6% were left-handed and 2.5% were ambidexter. Our results also show parallelism with the studies in the literature. We believe that the reason why there is no ambidexter athlete were identified in our research is because of the active use of one hand specific in the fencing sport branch.

In a study performed with 10314 people in China, on the other hand, the ratios of right-handed, two–handed and ambidexter people were determined as 90.84%, 8.90% and 0.26%, respectively (Guo, 1984). The preference of right hand in this study showed resemblance to the ratio which our study revealed (88.4%). However, it was noteworthy that preference of the left hand (0.26%) was less than our study findings. It is possible to explain why the preference of left hand is very less with the cause of traditional culture structure. In a study performed in Hong Kong University with 556 students (n=336 female, n=220 male), the ratios of right-handed, ambidexter and left-handed student were found as 95.2%, 3.2% and 1.6%, respectively. It was indicated that the subjects in this study were influenced in terms of their hand preference during childhood; hence, as the result of pressure, the preference ratios of right hand, two hand and left hand varied about 4.1%, 88.9%, 55.6%, respectively (Hoosain, 1990). The results revealed that these people were pressured in their traditional cultures in the direction of hand preference. In a society, about 90% of the people prefer to use their right hand, whereas, 10% left hand (Annett, 1972; Volkmann et al., 1998; Carey et al., 2001; Cavil and Bryden, 2003; Dossey, 2003; White, 2004). The data of current study obtained from the elite national fencing athletes is also in parallel with the literature and supports the general results.

While one of the hemispheres to be more dominant than the other is considered as the anatomic lateralization, the hand preference is considered as the functional cerebral lateralization. Similar to the hand use preference, the eye, ear and foot dominances are also used to determine cerebral lateralization (Dane and Balcı, 2007). When the foot preference distributions of fencing athletes participating in our study were examined; 87.2% of the athletes preferred right foot and 12.8% left foot. When the eye preference distributions were examined; 88.4% preferred the right eye and 11.6% left eye, and the ear preference distributions were examined; 85.5% preferred the right ear and 14.5% left ear.

Chapman et al., (1987) revealed the as total right-handed subjects in their research, 94% used their right foot and 6% left foot; however, among the left-handed subjects, rate of left and right foot use was 41% and 59%, respectively. Baykal et al., (1995) reported that, among the right-handed subjects, 85%, 11% and 4% were identified for the eye dominance of right, left and binocular, respectively; however, among the left-handed subjects the eye dominance was 67%, 22% and 11% for the right eye, left eye and binocular, respectively. In a study conducted by Öztaşan and Kutlu, (2014) about the hand preferences, nonverbal intelligence, motor skills, audiovisual and verbal reaction times of 439 subjects with ranging ages from18 to 25, the hand preferences of the subjects were identified as 87.2% for right hand, 11.4 for left hand and 1.4 for ambidexter. The foot preferences were also determined as 68,1% for right foot, 13,4% left foot and 18,5% both feet. Similarly, the eye preferences were reported as 62,9% for the right eye, 18,7% left eye, 18,5% binocular. Dane and Gümüştekin, (2002) reported that of all the right-handed subjects 83.33% had dominance in use of their right eye, 10.26% left eye and 6.41% both eyes; however, the left-handed subjects had 50% of eye dominance for both left and right eyes. Dane et al., (2003) stated that the right-handed subjects had 85.51%, 10.15% and 4.35% dominance for the right eye, left eye and both eyes, respectively; however, the left-handed subjects had 53.33% dominance for the right eye and 46.66% for the left eye.

It has been reported that there is generally a harmony between the use of hand preference and the eye dominance. Accordingly, there is a general acceptance that individuals who prefer to use the right hand also use the right eye, and the left-handed people also use left eye dominantly. In our study, similarly, the frequency of dominance of right eye among the right-handed individuals and left eye dominance among the left-handed individuals were identified as 96.12% and 71.43%, respectively. However, in a meta-analysis study, 65% of the right-handed individuals were reported to use their right eyes and 57% left-handed individuals were dominantly used their left eyes. Accordingly, the dominance in using left eye and right eye were 35% and 43% among the right-handed and left-handed people, respectively (Bourassa, McManus and Bryden, 1996). These results indicate that there is an asymmetry between hand preference and eye dominance. This asymmetry is due to irregular variation in the biologic nature of lateralization (McManus et al., 1999). Another scientific theory

about the hand preference is the Previc theory. Previc argued that the hand preference originates from the position of baby in the uterus (Previc, 1991). The baby may remain in normal position, head down, back left and right ear front positions in mother's womb. Thus, in a normal posture, the bladder pressures the right craniofacial region and results in narrowing the outer – inner ear distance in the right ear so that the conduction speed increases in the right ear. The increase in the right ear conduction rate leads to higher stimulation in the left hemisphere and it develops better than the right hemisphere. The dominance of the left hemisphere of the brain results in right hand, foot, and eye dominance (Yıldırım and Dane, 2007). Dane and Bayırlı, (1998) reported that there are advantages in young adults who are right-handed for the right ear and left-handed for left ear. In addition, Dane et al., (2002) also determined that the lengths of the left and right ear distances are also related to the right and left ear hearing sensitivities. In conclusion, studies performed by Dane et al., (2002) on the anatomical and auditory functions support the Previc hypothesis, and our results are also in parallel with the literature.

Among the fencing athletes participated in our study, the frequencies between the dominance of right hand and the dominance of right foot, eye and ear was determined as 90.29%, 96.12% and 94.17%, respectively. A statistically significant difference was found between the dominance of left hand and feet ($p<0.05$). When compared the hand, foot, eye and ear dominances together, 86.41% of the subjects were dominantly observed to prefer the right hand, foot, eye and ear, and the left hemisphere of the brain was dominant. About 14.29% of the subjects; however, were observed to prefer left hand, foot, eye and ear dominantly, and the right hemisphere of the brain was dominant.

Several studies have been conducted in which the hand preference and dominant eye are examined together in order to determine the functional asymmetry of the brain; however, the relationship between the hand preference and the dominant eye has not been fully exploited. Based on the results of our study, the hand preference and eye and ear preference were precipitated in parallel; however, an opposite relationship between left hand and foot preferences were identified. Our results show that there is a positive correlation between the dominant hand and the preferred eye and ear, and it is predicted that all three preferences may be reliable in determining cerebral hemispheres.

In a study conducted by Tarman, (2007), the relationship between the hand dominance and cerebral lateralization in musicians was investigated. Three-hundred and thirteen music graduate students from four different universities participated in the study. The Oldfield survey was used to determine the hand dominance, and 88% of the musicians were identified as right-handed, 5% ambidexter and 7% left-handed. In conclusion, the vast majority of the subjects participated in the study were right-handed and their left hemisphere was dominant. In a research performed by Börklü and Dolu, (2010) entitled as 'the hemispheric differences in the audial stimulation potentials of the athletes,' the control and subject athletes, which their right-handedness and left-handedness ratio was kept the same, were studied via Annette hand preference survey, and they reached to a conclusion that while only one hemisphere was dominant in control group, two hemispheres were actively used by the athletes group.

The hemispheres are differentiated in anatomical and cellular levels within a process. These differences have given ability to one of the hemisphere to analyze time dimension relatively and the other hemisphere to gain the ability of analyzing in spatial dimension. Therefore, control of complex and sequential movements has been lateralized in the left hemisphere and control of the holistic-spatial functions in the right hemisphere (Pençe, 2000).

The grip strength of the dominant hand was 44.2 kg among the right-handers, 43.9 kg among the left-handers, and were 42.8 kg and 41.5 kg for the nondominants, respectively. For the right-handed individuals, the difference between dominant right hand and nondominant hand grip strength was 3.16%, and this ratio was identified as 5.46% for the left-handed individuals. Gümüş and Akalın (2016) identified the dominant hand grip strength as 57.6±15.0 kg among the right-handed athletes of national weightlifting, gymnastics, taekwondo and wrestlers. This value was 53.5±7.7 ($p=0.748$) for the left-handed athletes of the same branches. For the nondominant hands; however, these values were 47.5±12.4 kg and 47.5±9.2 kg ($p=0.542$), respectively. The researcher also identified that the difference between dominant and nondominant hand grip strength was 19.27% for the right-handers and 11.21% for the left-handers. In a study performed by Peterson et al., (1989) on male and female students (n=310), there was 12.72% difference between the dominant and the nondominant hand grip strength among right-handed student. However, this value was 0.08% among the left-handed students.

This study revealed that there has been a relationship between the hand dominance and the handgrip strength ($p=0.065$, $p=0.081$). This shows that athletes who have been forced to use hands actively and dominantly in a sport branch have started to operate their both hands or hemispheres unwilled after a while. Making sport is thought to dominate the use of both hemispheres, and influencing the dominant and nondominant hand development in a parallel level.

V. Conclusion

Functional asymmetry of the brain is of interest to many scientific fields, and especially dominantly left-handed athletes is important in the selection of talent in sport branches. This tradition in sport is based on the very old style and is seen as an indispensable element in talent selection and afterwards. It was observed in this research that there was a relationship between handedness and hand strength in fencing sport. Left brain hemisphere was thought to be dominant according to functional lateralization.

It has been observed that the athletes participating in our study use preferably the right hand, foot, eye and ear. Accordingly, it has been anticipated that the fencing athletes participated in our study might be using the left hemisphere as a dominant hemisphere.

References

[1] Aggleton JP, Wood CJ, Is there a left-handed advantage in 'ballistic' sports? *International Journal of Sport Psychology, 21,* 1990, 46-47.
[2] Annett MA, *Left, right, hand and brain: The right shift theory* Hove, UK: Lawrence Erlbaum Associates Ltd. 1985.
[3] Aze´mar G, *L'homme asymme´trique: gauchers et droitiers face a` face.* Paris: CNRS e´ditions. 2003.
[4] Edwards S, Eaton AB, Howzat? Where is there an over-representation of left-handed bowlers in professional cricket in the UK? *Laterality, 1,* 1996, 45-50.
[5] Faurie C, Schiefenho¨vel W, Le Bomin S, et al., Variation in the frequency of left-handedness in traditional societies. *Current Anthropology, 46,* 2005, 142-147.
[6] Guiard Y, Left-handedness and performance: A review and a prospect. Current Psychology of Cognition, 1982: 2; 271-289.
[7] Tan Ü, Alaskan S, Allometry and asymmetry in the dog brain: right hemisphere is heavier regardless of paw preference. *Inf. J. Neurosci, 35,* 1987, 189-194.
[8] Geschwind N, Galaburda AM, Cerebral lateralization biological mechanisms. *Ass. and pathology.part I. Arch Neurol., 42,* 1985, 428-459.
[9] Kütükçüoğlu Y, *El Baskınlığının Yönü ve Derecesinin Araştırılması* Ankara: GATA Nöroloji AD, Uzmanlık Tezi, 1993.
[10] Özbek H: *Takım Sporu Yapan Kişilerde Hemisferik Farklılıkların Elektrodermal Aktivite ile Belirlenmesi*, Fizyoloji AD, Yüksek Lisans Tezi, 2008.
[11] Tan U, The distribution of Geschwind scores to familial left handness. *Intern J Neurosci, 42,* 1988, 85-105.
[12] Barut Ç, Özer CM, Yünten Z, et al., Genç Erişkinlerde El, Ayak ve Göz Tercihi Sıklığının Belirlenmesi, *Zonguldak Karaelmas Üniversitesi Tıp Fakültesi Dergisi Medi Forum, 2(2),* 2004.
[13] Bourassa DC, McManus IC, Bryden MP, Handedness and eye-dominance: A metaanalysis of their relationship. *Laterality, 1(1),* 1996, 5-34.
[14] Elias LJ, Bryden MP, Footedness is a better predictor of language lateralization than handedness. *Laterality, 3(1),* 1998, 41–51.
[15] Annett M: *Left, right hand and brain, the right shift theory*. London, Lawrence Erlbaum Associates,1985.
[16] Tanrıdağ O, *Teoride ve Pratikte Davranış Nörolojisi*. Istanbul; Nobel Tip Kitapevi; 1994: 80-81.
[17] Dossey L, Left handedness: insupport of the ten-percenters. *Alternative Theraphies in Health and Medicine, 9(5),* 2003, 10-18.
[18] McManus IC, *"The history and geography of human handedness"*, Language Lateralization and Psychosis. Ed. Iris E. C. Sommer and René S. Kahn. 1st ed. Cambridge: Cambridge University Press, 2009: 37-58.
[19] Augustyn C, Peters M, On the relation between footedness and handedness. *Perceptual and Motor Skills, 63,* 1986, 1115-1118.
[20] Hijazi MMK, Attention, Visual Perception and their Relationship to Sport Performance in Fencing. *Journal of Human Kinetics, 39,* 2013, 195-201.
[21] Tan U, The distribution of hand preference in normal men and women. *International Journal of Neuroscience, 41(1-2*), 1988, 35–55.
[22] Kulaksız G, Gozil R, The effect of hand preference on hand anthropometric measurements in healthy individuals. *Annals of Anatomy, 184(3),* 2002, 257–265.
[23] Saudino K, McManus IC, Handedness, footedness, eyedness and earedness in the Colorado Adoption Project. *British Journal of Developmental Psychology, 16,* 1998, 167-174.
[24] Mathiowetz V, Kashman N, Volland G, et al., Grip and pinch strength: normative data for adults. *Arch Phys Med Rehabil., 66,* 1985, 69-72.
[25] Tan Ü, Çalıskan S, Allometry and asymmetry in the dog brain: right hemisphere is heavier regardless of paw preference. *Inf JNeurosci, 35,* 1987, 189-194.
[26] Baker J, Schorer J, The Southpaw Advantage? - Lateral Preference in Mixed Martial Arts. *PLoS One, 8(11),* 2013, e79793.
[27] Uzun N, Alkan N, El Dominansı ve Adli Belge İncelemesi Açısından Önemi, *Yeni Symposium, 40(1),* 2002, 3-9.
[28] Raymond M, Pontier D, Dufour AB, et al., Frequency-dependent maintenance of left handedness in humans. *Proc R Soc Lond B Biol Sci, 263,* 1996, 1627-1633.
[29] Loffing F, Hagemann N, *Side bias in human performance: A review on the left-handers' advantage in sports*. In: Dutta T, Mandal M, Kumar S, editors. Bias in Human Behaviour. Hauppauge, NY: Nova Science, 2012: 163–182.
[30] Grouios G, Motoric dominance and sporting excellence: Training versus heredity. *Percept Motor Skills, 98,* 2004, 53-66.
[31] 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. *Journal of Sports Sciences, 27(6),* 2009, 625-632.
[32] Voracek M, Reimer B, Dressler SG, Digit ratio (2D:4D) predicts sporting success among female fencers independent from physical, experience, and personality factors. *Scandinavian Journal of Medicine & Science in Sports, 20,* 2010, 853–860.
[33] Gümüş M, Akalın TC, The hand preference of the national sportsmen and evaluation of the grasp forces. *International Journal of Academic Research, 8(6), 2016,* 45-50. Doi: 10.7813/2075-4124.2016/8-6/A.5.
[34] Gündoğan NÜ, Yazıcı AC, Ögüs E, et al., El tercihi ile dominant göz arasındaki ilişkinin farklı yöntemlerle incelendiği farklı bir çalışma. *Türkiye Klinikleri J Med Sci, 27,* 2007, 155-163.
[35] Tat H: *Genç erkek ve bayanlarda Lateralizasyonun El Kavrama Kuvveti ve Reaksiyon Zamanına Etkisi*, OMÜ Sağlık Bilimleri Enstitüsü Beden Eğitimi ve Spor Anabilim Dalı Yayınlanmamış Yüksek Lisans Tezi, Samsun, 1999.
[36] Akalın TC, Gümüş M, Göktepe M, et al., Cerebral Laterality of Women Soccer's. *International Journal of Academic Research, 8(5),* 2016, 48-52.
[37] Loffing F, Schorer J, Hagemann N. et al., On the advantage of being left-handed in volleyball: further evidence of the specificity of skilled visual perception, *Atten Percept Psychophys, 74(2),* 2012, 446-53.
[38] Elalmış DD, Tan Ü, Hand preference in Turkish population. Intern. J. Neuroscience, 115, 2005, 705-712.

[39] Guo NF, *Studies of Chinese language functions*. In H.S.R. Kao and R. Hosain (Eds.), Psychological Studies of the Chinese Language. Hong Kong: Chinese Language society of Hong Kong, 1984.
[40] Hoosain R, Left and handedness switch amongst the Chinese. *Cortex, 26,* 1990, 451-4.
[41] Annett M, The distribution of manual asymmetry. *Br J Psychol, 63,* 1972, 343-358.
[42] Volkmann J, Schnitzler A, Witte OW, et al.: Handedness and asymmetry of representation in human motor cortex. *J. Neurophysiol, 79,* 1998, 2149–2154.
[43] Carey DP, Smith G, Smith DT, et al.: Footedness in world soccer: an analysis of France '98. *Journal of Sports Sciences, 19,* 2001, 855-864.
[44] Cavil, S. & Bryden, P. Development of handedness: Comparison of questionnaire and performance-based measures of preference. *Brain and Cognition, 53,* 2003, 149-151.
[45] Dossey L, Left handedness: insupport of the ten-percenters. *Alternative Theraphies in Health and Medicine, 9(5),* 2003, 10-18.
[46] White CJ, *The relevance of footedness to the asymmetrical incidence of developmental dysplasia of the hip.* Lisans tezi, University College Northampton, Northampton, İngiltere, 2004.
[47] Dane Ş, Balcı N, Handedness, eyedness and nasal cycle in children with autism. *Internatıonal Journal of Neuroscıence, 25,* 2007, 223-226.
[48] Chapman JP, Chapman LJ, Allen JJ, The measurement of foot preference. *Neuropsychologia, 25(3),* 1987, 579-584.
[49] Baykal O, Dane Ş, Akar S, et al., Relationships between hand preference and eye dominance in normal human subjects. *Turk J Med Sci, 24,* 1995, 95-7.
[50] Öztaşan N, Kutlu N, Sağlıklı bireylerde parmak uzunluk oranlarının (2d: 4d); el tercihi, nonverbal zeka, görsel, işitsel ve verbal yetenekler, motor beceri ve serebral lateralizasyon ile ilişkisi. *Balıkesir Sağlık Bil Derg, 3(1),* 2014, 11-15.
[51] Dane S, Gümüştekin K, Correlation between hand preference and distance of focusing points of two eyes in the horizontal plane. *Intern J Neurosci, 112,* 2002, 1041-47.
[52] Dane S, Gümüştekin K, Yazıcı AT, et al., Correlation between hand preference and intraocular pressure from right- and left-eyes in right- and left-handers. *Vision Res, 43,* 2003, 405-8.
[53] McManus IC, Porac C, Bryden MP, et al., Eye dominance, writing hand, and throwing hand. *Laterality, 4,* 1999, 173-92.
[54] Previc FH, A general theory concerning the prenatal origins of cerebral lateralization in humans. *Psychological Review, 98,* 1991, 299-334.
[55] Yıldırım S, Dane Ş, Cerebral Lateralization and Hand Preference. *The Eurasian Journal of Medicine (EAJM), 39(1),* 2007, 45-48.
[56] Dane S, Bayirli M, Correlations between hand preference and durations of hearing for right and left ears in young healthy subjects. *Percept Mot Skills, 86,* 1998, 667-72.
[57] Dane S, Gümüştekin K, Polat P, et al., Relations among hand preference, craniofacial asymmetry, and ear advantage in young subjects. *Percept Mot Skills, 95,* 2002, 416–22.
[58] Tarman S, *Müzisyenlerde El Dominansı ve Serebral Lateralizasyon.* Ankara, Müzik Eğitimi Yayınları, 2007.
[59] Börklü T, Dolu N, Sporcularda işitsel uyarılma potansiyellerindeki hemisferik farklılıklar. *Journal of Health Sciences,19(2),* 2010, 108-118.
[60] Pençe S, Serebral Lateralizasyon. *Van Tıp Dergisi, 7(3),* 2000, 120-125.
[61] Peterson P, Petrick M, Connor H, et al., Grip strength and hand dominance: challenging the 10% rule. *Am J Occup Ther, 43,* 1989, 444-447.

NOTES;
Congress; This manuscript has been presented in 21th Annual Congress of the ECSS (European College of Sport Science), mini-oral presentation in Vienna/AUSTRIA, 06-09 July, 2016.

Mustafa Gümüş. "Analysis of the Relationship between Cerebral Lateralization and Grip Strength in Elite Fencing Athletes." IOSR Journal of Sports and Physical Education (IOSR-JSPE) , vol. 4, no. 5, 2017, pp. 01–08.