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Comparing laterality and handedness between successful male and female athletes and ordinary population

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Abstract---Background and Purpose: Through comparing handedness and laterality between successful athletes and ordinary people, this study endeavored to investigate the probable relationship between these two factors and skills and abilities which distinguish successful athletes from other members of the society. Procedure: The sample population in the current study included Iranian men and women who were assigned into two groups of ordinary population (group 1) and successful male and female athletes (group 2). Carter's Laterality Inventory and The Edinburgh Handedness Inventory were employed to measure laterality and handedness, respectively. It needs to be noted that validity and reliability of Persian translation of both inventories have been proved. Following the completion of the inventories, individuals' laterality and handedness were determined, and the data were prepared for statistical analysis. Findings: The participants included 212 individuals, out of which 135 (63.7%) were male and 77 (36.3%) were female. The individuals were compared in two groups. The first group consisted of successful athletes. Out of the 130 individuals, 45 (34/6%) were female and 85 (65/4%) were male. The second group were ordinary people from private schools in Tehran which entailed 32 (39%) women and 50 (61%) men. The two groups were homogeneous in terms of gender, i.e., there was no significant difference between the percentage of participating men and women ($P=0/307$, $\chi^2=0/423$). Hence, gender was not an intervening variable. With regard to the prevalence of left-handedness, a total of five individuals (2/4%) were left-handed: one individual (20%) in the ordinary and five (80%) in the athlete population. The prevalence of left-handedness was not significantly different between the two groups

($P=0/358$, $\chi^2=0/735$). Left-hand dominance was compared between the two groups. Overall, the population included 10 left-handers: two individuals (20%) in the ordinary and eight (80%) in the athlete population. According to the chi-square test, this difference was not significant ($P=0/183$, $\chi^2=1/544$). Right-handedness was further compared between the two groups. One hundred and thirty two individuals (62.3%) out of the 212 participants were right-handed: 59 individuals (44/7%) in the ordinary and 73 (55/3%) in the athlete population. Statistical analysis revealed that right-handedness was significantly more prevalent in the athlete population ($P=0/015$, $\chi^2=5/341$). Left-hemisphere dominance was compared between the two groups. One hundred and eighteen individuals (92%) in the athlete and 82 (98%) in the ordinary population fell into this category. Statistical tests reported no significant differences in this regard. Right-hemisphere dominance was further compared between the two groups. Four individuals (3%) in the athlete and one (1.5%) in the ordinary population fell into this category. Statistical tests revealed no significant differences in this regard. Lack of hemispheric dominance was observed in seven cases (3/3%), all of which belonging to the athlete group. This difference was significant according to the statistical tests ($P=0/031$, $\chi^2=5/4$). Conclusion: Given the significance of the distribution of right-handedness and lack of hemispheric differences between the athletes and ordinary population, sports policies and investments can be pushed toward individuals with a higher chance of success.

Keywords---Laterality, Handedness, Athletes

Introduction

Handedness refers to an individual's preferential use of one hand in doing certain activities. This characteristic, despite seeming so obvious, is among unknown aspects of human motor function. Although the majority of experts believe that handedness originates in differences in the neural control of each hand, the precise mechanism responsible for differences in handedness is still disputable (1).

Handedness is related to behavioral laterality, skill, and structural and functional differences in motor system. Laterality is an effective yet unknown feature of human motion which affects individuals' abilities beyond hand skills (2).

Almost 90% of people worldwide prefer to use the right hand in doing most tasks and 10% use the left hand. Handedness is influenced by genetic and environmental factors. In identical twins, the likelihood of left-handedness in the second twin of a left-handed infant is almost 76%. Distribution of individuals' handedness varies across various geographical areas, ages, and gender (3).

However, evidence of success in left-footed footballers, left-handed artists and tennis players helps refute this traditional belief (4). Various reports as to the

relatively large presence of left-handers among successful male and female athletes provide examples against this common belief. Besides, some researchers believe that left-handers, given their more spatial-motor skills, have innate superiority over the right-handers and attribute the superiority of the left-handed athletes to this feature (5).

Various factors have been found to affect the distribution of handedness and laterality. For example, some studies regard gender as an influential factor in determining handedness and consider left-handedness more common among men than women (6). In contrast to studies which show that left-handers enjoy superiority over right-handers in terms of skills, some research indicate that neurological diseases such as epilepsy, Down syndrome, autism, mental retardation, and deafness (7) are more common among the left-handers than the ordinary population (8, 9).

Studies conducted on male and female athletes demonstrated that the frequency of left-handers was more among athletes who managed to receive a medal than those who did not. Also, the number of victories and obtained scores in the left-handers was more than right-handers or individuals without a clear hand preference (10).

Handedness has been considered and investigated in various sports fields including tennis, swordsmanship, baseball, cricket, and boxing (11)(12)(13).

A study by Ant and colleagues revealed that hand skills and handedness are related to lateralization of brain functions, neuromuscular junction, and genetic factors (14).

Some prior studies have examined the effects of handedness on the reaction time, movement time, target position, and precision in doing goal-directed hand movements. On the other hand, laterality affects, apart from hand skills, an individual's overall abilities and skills (15).

Given the significance of physical skills, several studies have examined the relationship between sports success and handedness and laterality across various countries.

Considering the effect of individual capabilities and skills on athletes' success rate, the relationship between these skills and handedness and laterality, and the available contradictions as to the probable effect of these two features on individuals' skills and success, the question arises whether successful athletes and ordinary members of the society differ in terms of handedness and laterality.

An awareness of various factors affecting athletes' success can assist us in training successful athletes and can provide us with the opportunity to make better selections and more effective talent identification. Given this, handedness and laterality can serve as two effective factors on the success of prominent athletes. Hence, an awareness of their probable effects on athletes' abilities, skills, and success can help us in making better selections and talent identification.

Through comparing handedness and laterality between successful athletes and ordinary people, this study endeavored to investigate the probable relationship

between these two factors and skills and abilities which distinguish successful athletes from other members of the society.

Material and method:

The sample population in the current study included Iranian men and women who were assigned into two groups of ordinary population (group 1) and successful male and female athletes (group 2).

The inclusion criteria in the case group entailed proving sports success in the examined fields and the researcher-developed questionnaire. And, the individuals were included in the control group if they reported no history of professional sports activities. The study considered no age and gender restrictions for participation. The individuals who did not complete the questionnaire were excluded from the study. Two groups of successful athletes and ordinary population were investigated in the present study.

Sixty individuals visiting private schools in Tehran without a history of professional sports activities were included in the first group (male=30, female=30).

Sixty successful athletes at the national and international level from 12 fields were included in the second group (male=30, female=30). In other words, five individuals from each field were examined. Sports fields consisted of nine individual sports (weightlifting, wrestling, taekwondo, judo, swimming, shooting, karate, equestrianism, and sailing) and three team sports (football, futsal, and volleyball). The main reason for selecting these fields was that Iranian athletes demonstrated higher success rates in them.

Sampling of the first group was done based on convenience sampling and visitors of cultural and recreational centers were examined.

With regard to the second group, a list of successful athletes of each field was initially made, lots were then drawn between the athletes. Finally, the athlete whose number was drawn was examined in terms of the inclusion criteria. Lots continued until the target sample size was reached.

The participants in both groups were fully debriefed as to the conditions and purposes of the study and were entered into the study after obtaining their written consent for cooperation.

Carter's Laterality Inventory and The Edinburgh Handedness Inventory were employed to measure laterality and handedness, respectively. It needs to be noted that the validity and reliability of Persian translation of both inventories have been proved with a Cronbach alpha of above 0.75% (16).

A researcher-developed questionnaire was employed for determining sports success and individuals' qualification in the athlete group. The questionnaire which consisted of two sections was completed by the athlete and the coach.

Individuals' success was determined through 14 questions relating to the athletes' performance in various competitions.

Laterality was investigated using Philip Carter's Laterality Inventory. This inventory includes 30 three-choice questions. Each choice's score ranges from 0 to 2. Based on the obtained scores, the individuals were divided into three categories: right-hemisphere dominants, individuals without hemispheric dominance, and left-hemisphere dominants.

The Edinburgh Handedness Inventory was used to measure handedness. This is a 10-component inventory which measures hand preference in writing, drawing, throwing, using scissors, teeth brushing, cutting with a knife, using spoon, sweeping, striking a match, and opening and closing the lid of a box. Accordingly, the individuals were classified into four groups: right-handers, left-handers, right-hand dominants, and left-hand dominants.

The Edinburgh Scale enjoys a satisfactory level of validity and reliability. The test's internal consistency was measured through correlation of all test components with the overall score. The correlation coefficient ranged from 0.83-0.98. This questionnaire's correlation with Chapman's handedness inventory was 0.75. The inventory's Cronbach's alpha was 0.97, and split-half correlation coefficient was 0.92.

Following the completion of the inventories, individuals' laterality and handedness were determined, and the data were prepared for statistical analysis. The data were entered into SPSS version 18, and descriptive statistics and χ^2 were used for data analysis. A p value of less than 0.05 was considered to be statistically significant.

Result

The participants included 212 individuals, out of which 135 (63.7%) were male and 77 (36.3%) were female. The individuals were compared in two groups. The first group consisted of successful athletes. Out of the 130 individuals, 45 (34/6%) were female and 85 (65/4%) were male. The second group were ordinary people from private schools in Tehran which entailed 32 (39%) women and 50 (61%) men. The two groups were homogeneous in terms of gender, i.e., there was no significant difference between the percentage of participating men and women ($P=0/307$, $\chi^2=0/423$) (Table 1). Hence, gender was not an intervening variable.

The prevalence of left-handedness was not significantly different between the athlete and ordinary population ($P=0/358$, $\chi^2=0/735$).

The prevalence of left-hand dominance was compared between the two groups. Chi-square test did not reveal significant difference between the two groups ($P=0/183$, $\chi^2=1/544$).

The prevalence of right-handedness was also compared between the two groups. The statistical test found a significant difference between the two groups. The athlete group were significantly more right-handed ($P=0/015$, $\chi^2=5/341$).

The relationship between right-handedness and being an athlete was significant ($P=0/021$, Pearson's $R=1/59$).

Furthermore, the prevalence of right-hand dominance was compared between the two groups. Statistical tests did not show significant difference between the two groups ($P=0/311$, $\chi^2=0/410$). (Table 3)

With respect to the right-hemisphere and left-hemisphere dominance, the difference between the two groups was not significant.

Lack of hemispheric dominance was observed in seven cases (3/3%), all of which belonging to the athlete group. According to the statistical tests, lack of hemispheric dominance was significantly more in the athlete group than the ordinary population ($P=0/031$, $\chi^2=5/4$)(Table 3).

Discussion

The current study compared handedness and laterality between successful athletes and ordinary people. This was the first study which demonstrated a difference between successful athletes and ordinary people in terms of handedness and laterality. Handedness or hand preference is defined as individuals' preferential use of one hand in efficiency tests which are done with one hand. The frequency of right-handedness is estimated approximately 90%, left-handedness almost 8 or 9%, and ambidexterity almost 1 or 2%. Psychologists, particularly neuropsychologist, consider handedness an indirect index of hemispheric dominance or laterality (17). According to The Edinburg Inventory, 55% of the American people are strongly right-handed and 3-2% are strongly left-handed, and the rest are in the middle of this range.

Handedness or hand preference is defined as individuals' preferential use of one hand in efficiency tests which are done with one hand. The frequency of right-handedness is estimated approximately 90%, left-handedness almost 8 or 9%, and ambidexterity almost 1 or 2%. Neuropsychologists consider handedness an indirect index of hemispheric dominance or laterality (3). That is, in the left-hand dominants, the right hemisphere is dominant and in the right-hand dominants, the left hemisphere. Several studies have investigated handedness in terms of hemispheric dominance. According to the results, right-hand dominants are more inclined to choose images with the main content in the right side, and left-hand dominants are more inclined to balanced images in the left side or show no preference (18).

Cerebral hemispheres have structural and functional differences. As a result, each is specialized to serve a particular cognitive function. Given the functional lateralization of cerebral hemispheres and the hemispheric difference between left-hand dominants and right-hand dominants, it is expected that these two groups vary in terms of mental and cognitive functions. Therefore, the distinction between left-hand dominants and right-hand dominants is so significant. Studies on the functions of cerebral hemispheres demonstrated that the left hemisphere controls articulation and the right hemisphere enjoys highly advanced capabilities

for spatial perception and schemas. The right hemisphere is responsible for comprehension and emotional facial expressions (19).

Another study conducted in Italy investigated and recorded handedness of 111 professional basketball players with 5-12 years of playing experience. According to the results, the athletes showed more preference for using the left hand or a combination of both hands (18).

Analysis of the findings of all sports fields is compared in the next section which revealed no difference among the variables ($P > 0.05$). Lack of hemispheric dominance was most frequent in chess: one out of eight cases (12/5%). Lack of hemispheric dominance was also recorded in basketball (9/1%), swimming (6/7%), wrestling (10%), chess (12/5%), judo (12/5%), and shooting (12). We only found one case of this feature ($P = 0.773$, $\chi^2 = 67/490$).

It needs to be further noted that success in sport, particularly championship sport, and a competitive atmosphere necessarily encounter one with stressful situations. When encountering such situations, individuals deploy various methods and strategies to control, guide and regulate emotions which are defined by the individuals so as to preserve, inhibit, and increase experience and emotional expression (21). Emotion regulation refers to a process by which individuals influence what emotions they have, when they have them, and how they experience and express them (22). Therefore, the findings can be interpreted based on the amounts of competitiveness and excitement.

Right-handedness existed in various fields. In particular, it was most frequent in taekwondo, i.e., six out of the eight individuals (75%) were right-handed. This was followed by basketball in which seven out of 11 individuals (63/6%) were right-handed. Right-handedness was least frequent in wrestling where five out of 11 individuals (45/5%) were right-handed. The difference in right handedness was not significant among various sports fields ($P = 0.983$, $\chi^2 = 2/932$).

One of the limitations of the study included small sample size. Hence, future researchers can replicate the study with larger sample size (considering racial diversity) and more accurate instruments for measuring handedness. Besides, findings may not be generalizable to broader populations due to the cross-sectional nature of the study. Therefore, given the significance of the distribution of right-handedness and lack of hemispheric differences between the athlete and ordinary population, sports policies and investments can be pushed toward individuals with a higher chance of success. Prospective studies on handedness in relation to visual, auditory, and motor activities are recommended as complementary investigations of athletes.

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Conflicts of Interest:

The authors declare that they have no conflicts of interest.

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Table 1

Group	Gender	Frequency	Percentage	χ^2	P
Athlete	Female	45	35	0/423	0/307
	Male	85	65		
Ordinary people	Female	32	39		
	Male	50	61		

Table 2

Variable	Ordinary population(person)	Athlete group (person)	Overall
Frequency and percentage of population (male)	50 (37%)	85 (63%)	135 (64%)
Frequency and percentage of population (male)	32 (42%)	45 (58%)	77 (36%)
Frequency and percentage of left-handedness	1 (20%)	4 (80%)	5 (2%)
Frequency and percentage of left-hand dominance	2 (20%)	8 (80%)	10 (4%)
Frequency and percentage of right-handedness	49 (44/7%)	73 (55/3%)	122 (62%)
Frequency and percentage of right-hand dominance	30 (41/7%)	45 (58/3%)	75 (32%)
Frequency and percentage of left-hemisphere dominance	1 (20%)	4 (80%)	5 (2/4%)
Frequency and percentage of right-hemisphere dominance	81 (40%)	118 (60%)	199 (94/3%)
Frequency and percentage of lack of hemispheric dominance	0	7 (100%)	7 (3/3%)

Table 3

Variable	χ^2	P
Left-handedness	0/735	0/358
Left-hand dominance	1/544	0/183
Right-handedness	5/341	0/015
Right-hand dominance	0/410	0/311
Right-hemisphere dominance	0/342	0/581
Left-hemisphere dominance	1/532	0/455
Lack of hemispheric dominance	5/621	0/012
Gender (male and female)	0/423	0/307