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# Analysis of the Association between Hand Preference, Gender, Eye Dominance, 2D:4D Ratio and Handgrip Strength in Young Healthy Individuals

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Objective: The purpose of this study is to examine the association between hand preference in young healthy individuals and handgrip strength (HGS), (which is accepted to be an objective measurement in the assessment of gender), 2D:4D ratio (ratio of the length of index finger to that of ring finger), eye dominance and upper limb performance.

Methods: A total of 198 individuals, 111 males and 87 females, participated in our study. Oldfield Inventory was used to find out hand preference. Baseline hand dynamometer was used to find out HGS. The test developed by Rosenbach was used for determination of the dominant eye. For assessment of 2D:4D ratio, measurement was made starting from the basal fold of the finger to the fingertip.

Results: According to the results of the statistical analysis, no significant difference was found between hand preference and 2D:4D ($p>0.05$). Statistically significant difference was found between eye dominance and hand preference ($p<0.05$). Statistically significant difference was found between right and left hand preference and right and left HGS of males ($p<0.05$). Statistically significant difference was found between right hand preference and right and left HGS of females ($p<0.05$), where significant difference was not found between left hand preference and right and left HGS of females ($p>0.05$).

Conclusions: The association of hand preference with other parameters is important to determine cerebral lateralization. We believe that the result which shows hand preference was directly proportional to eye dominance and HGS means that these parameters can be a guide in determining the dominant hemisphere.

**Keywords:** hand preference, dominant eye, 2D:4D ratio, handgrip strength

## Introduction

The right and left symmetry of the body is realized through brain hemispheres which look the same. Sensual and motor centers, which are symmetrically located in brain hemispheres, make diagonal connections with the right and left side of the body [1]. Thus, the centers on the left hemisphere of the brain control the right side of the body, while the centers on the right hemisphere control the left side of the body. Hand preference is a guide in finding out which brain hemisphere is dominant. Studies have shown that hand preference is the most practical method in determining the dominant hemisphere [2]. Hand preference is one of the most studied subjects by clinical and preclinical sciences as an indicator of motor dominance [3, 4]. The left hemisphere of our brain controls our right hand while the right hemisphere controls our left hand. In line with this information, it is possible to say that the left hemisphere is dominant in right-handed people while right hemisphere is dominant in left-handed people. Thus, it can easily be said that the superiority of the left hand to the right hand in left-handed is connected with the right hemisphere while the superiority of the right hand to the left hand in right-handed is connected with the

left hemisphere [5]. Studies have proposed some theories related with hand preference. According to Geschwind and Behan, testosterone suppresses the left hemisphere and this causes left-hand preference [5]. In their study, Dane and Balcı found that the hand preferred in writing was associated with the lengths of the second and fourth fingers (2D:4D ratio — the ratio of the length of index finger to that of ring finger) of the hand [6]. In addition, a great number of studies which examined hand preference and dominant eye have been conducted to find out the functional asymmetry of the brain. However, the association between hand preference and dominant eye have not been fully explained [7-9]. The purpose of this study is to examine the association between hand preference in young healthy individuals with HGS [10, 11], (which is accepted to be an objective measurement in the assessment of gender), 2D:4D ratio, eye dominance and upper limb performance.

## Material and Methods

This research was undertaken under the approval no. 2016/47 of Malatya Clinical Research Ethics Committee. A total of 198 voluntary students studying at İnönü University, 111 males (average age: 21.42±1.67 years) and 87 females (average age: 21.38±1.50 years), who did not have an exercising (were not involved in any exercise programs) were included in the study. The inclusion criteria were: (a) presence of a physically healthy appearance and absence of participation in a resistance exercise at least six months before the study, (b) freedom from drug use or absence of any medical restraints to participate in the study, (c) absence of usage of dietary supplement to increase performance (as for example, creatine), (d) absence of any illnesses and previous orthopedic operations. All the subjects were informed about the study, volunteering consent forms were read and signed. Experimental protocols were conducted in line with Helsinki declaration. Turkish translation of Oldfield Hand preference Inventory modified by Geschwind and Behan was used to find out hand preference [12, 13]. The questions were about functions within daily activities and the hands used while conducting these functions were found. The results were divided in five groups as "always right hand", "generally right hand", "both hands", "generally left hand", "always left hand". The scores were as "always right hand" +10 points, "generally right hand" +5 points, "both hands" 0 (zero) points, "generally left hand" -5 points, "always left hand" -10 points. The results of scoring were interpreted: between 100 and 80 points as "strong right-handed", between 20 and 75 as "weak right-handed", between 15 and -15 as "Ambidextrous", between -20 and -75 as "weak left-handed" and between -80 and -100 as "strong left-handed". Negative scores are in favor of left hand preference while positive scores are in favor of right hand preference. Male and female students who had +80 points were accepted as right handed. HGS was measured at standard test position recommended by American Society of Hand Therapists (ASHT) [14]. It was measured while the subject was in upright sitting position on a chair placed on a smooth surface. Hips and knees had 90° flexion, feet touched the ground, elbow touched the body at 90° flexion, forearm had neutral position and the wrist was placed at 0-30° extension and 0-5° ulnar deviation. During the measurements, the subject whose HGS was measured was asked to grip the holds of the test device as strong as possible [15]. The test developed by Rosenbach was administered for determination of the dominant eye [16]. For 2D:4D ratio, before the measurement, care was taken for the participants' hands not to have any factors that could influence the measurement such as trauma, edema, swelling and inflammation. The measurements were made by using Astor digital caliper. The lengths of the second and fourth fingers of the participants were measured starting from the basal folds of the fingers to the fingertip and separate (2D:4D) ratios were calculated for both hands.

### Statistical Analysis

Normality of the data was analyzed with Shapiro-Wilk test. Mann Whitney U test was applied because the data did not show normality. IBM SPSS Statistics 22.0 software was used for the analysis. The data represented as arithmetic mean (X) +/- standard deviation (SD) and the significance level was set at 0.05.

## Results

Some of the demographic data of the 111 males and 87 females in the study such as age, height and weight are presented below (Table 1).

It was found that 81.08% of the males in the study were right handed, while 18.92% were left handed. 87.35% of the females in the study were right handed, while 21.65% were left handed. Mann-Whitney U analysis was conducted on the data in order to find out whether there was statistically significant difference between gender and hand preference. According to the analysis result, no significant difference was found between gender and hand preference ($p>0.05$), (Table 2).

It was found that the right hand 2D:4D ratio of the right handed males in the study was 0.97±0.35 mm, while their left hand 2D:4D ratio was 0.98±0.09. The right hand 2D:4D ratio of the right handed females in the study was 1.03±0.11, while their left hand 2D:4D ratio was 0.98±0.12. Mann-Whitney U analysis was conducted on the data in order to find out whether there was statistically significant difference between hand preference

**Table 1.** The values as X±SD, Min and Max of some parameters of men and women participating in study

| Parameters | Male | | | Female | | |
|---|---|---|---|---|---|---|
| | X ±SD | Min | Max | X ±SD | Min | Max |
| Age (year) | 21.42 ±1.67 | 18 | 26 | 21.38 ±1.50 | 18 | 25 |
| Height (cm) | 178.43 ±5.70 | 160 | 192 | 164 ±5.37 | 152 | 178 |
| Body weight (kg) | 72.01 ± 10.30 | 50 | 110 | 55.82 ±8.43 | 43 | 85 |

*SD - Standard deviation.*

**Table 2.** The numerical values of gender and hand preference. Mann-Whitney U analysis results.

| Gender | Hand preference | | | | p |
|---|---|---|---|---|---|
| | Right | | Left | | |
| | N | % | N | % | |
| Male | 90 | 81.08 | 21 | 18.92 | |
| Female | 76 | 87.35 | 11 | 12.65 | |
| Total | 166 | 83.83 | 32 | 16.17 | 0.235 |

**Table 3.** The numerical values of hand preference and 2D:4D ratio. Mann-Whitney U analysis results.

| Hand preference | 2D:4D ratio | | | | p |
|---|---|---|---|---|---|
| | Male | | Female | | |
| | N | SD | N | SD | |
| Right | 0.97 | ±0.35 | 1.03 | ±0.11 | 0.532 |
| Left | 0.98 | ±0.09 | 0.98 | ±0.12 | 0.376 |

*SD - Standard deviation.*

**Table 4.** The numerical values of eye dominance and hand preference. Mann-Whitney U analysis results.

| Hand preference | Dominant eye | | | | p |
|---|---|---|---|---|---|
| | Right | | Left | | |
| | N | % | N | % | |
| Right | 137 | 82.53 | 29 | 17.47 | |
| Left | 9 | 28.12 | 23 | 71.88 | |
| Total | 146 | 76.04 | 52 | 23.96 | 0.000 |

and 2D:4D ratio. According to the analysis result, no statistically significant difference was found between hand preference and 2D:4D ratio ($p>0.05$), (Table 3).

166 of the participants were found to use their right hands, while 32 were found to use their left hands. Of the 166 participants who used their right hands, right eyes of 137 were dominant while left eyes of 29 were dominant. Of the 32 participants who used their left hands, right eyes of 9 were dominant while left eyes of 23 were dominant. According to Mann-Whitney U analysis, statistically significant association was found between dominant eye and hand preference ($p<0.05$), (Table 4).

In right handed males in the study, right HGS was found to be 50.51±7.32 kg, while left HGS was found to be 46.33±7.49 kg. In left handed males in the study, right HGS was found to be 44.28±4.5 kg, while left HGS was found to be 50±7.01 kg. According to Mann-Whitney U analysis, statistically significant association was found between right hand preference and left hand preference and right and left HGS in males ($p<0.05$). In right handed females in the study, right HGS was found to be 29.06±6.26 kg, while left HGS was found to be 26.60±5.58 kg. In left handed males in the study, right HGS was found to be 21.27±5.96 kg, while left HGS was found to be 23.63±5.69 kg. According to Mann-Whitney U analysis, statistically significant association was found between right hand preference and right and left HGS in females ($p<0.05$), while no statistically significant association was found between left hand preference and right and left HGS ($p>0.05$), (Table 5).

## Discussion

Hand preference gives information about the functional asymmetry of the brain. Bryden [2] stated that hand preference is the easiest method in determining the dominant hemisphere of the brain. Experts making researches in this area have recommended hand preference to be determined through questionnaires like in our study. There are questionnaires prepared by Annett [17] and Oldfield [13] for this purpose. In a study prepared by Bryden [2] to find out hand preference with questionnaire method, whether the practical application reflected the preference was researched and the two methods were found to be very consistent. In their study, Gündoğan [12], Gökbel [18] and Çalışkan [19] examined hand preference in five groups similar to our study. In their study about hand preference, Gündoğan et al. [12] found right hand preference high in both female and male students with rates of 92.2% and 93.4%, respectively. In our study, these rates were found to be 81.08% and 87.35%, respectively. Our results are in

**Table 5.** Right and left handgrip strength values in kg and hand preference. Mann-Whitney U analysis results.

| Gender | Right hand preference | | p | Left hand preference | | p |
|---|---|---|---|---|---|---|
| | Handgrip strength | | | Handgrip strength | | |
| | Right | Left | | Right | Left | |
| Male | 50.51 ±7.32 | 46.33 ±7.49 | 0.000 | 44.28 ±4.5 | 50 ±7.01 | 0.021 |
| Female | 29.06 ±6.26 | 26.60 ±5.58 | 0.001 | 21.27 ±5.96 | 23.63 ±5.69 | 0.178 |

parallel with the results of Gündoğan et al.[12]'s study. Özdemir and Soysal [20] reported that left hand preference incidence varied between 8-10% in general population. Hoosain [21] reported left hand preference incidence as 10.9% in his study. Gökbel et al. [18] found left hand preference incidence as 12.6% while Tan [22] found this incidence as 10.3%. In our study, left hand preference incidence was 16.17%. Right hand preference incidence was found as 87.7% by Tan [22], as 93.9% by Gökbel et al. [18] and as 92.6% by Gündoğan et al. [12]. Right hand preference incidence was found as 83.83% in our study this rate was found to be similar to the rates in other studies. According to Geschwind [5], testosterone suppresses the left side of the brain and this causes left hand preference. However, left hand preference in the family, which is hereditary factors, influence this association. In our study, the rate of left hand preference in females was 12.65% while it was 18.92% in males. Similarly, Moffat and Hampson [23] stated that testosterone could have a role in the development of hand preference. Seizeur et al. [24] stated that right hand preference was more common in women since lateralization was different for men and women. In their study, Öztaşan and Kutlu [25] could not find a statistically significant association between hand preference and 2D:4D ratio. Our results supports this study. Annett [26] reported that right eye preference rate between right handed was higher than right eye dominance rate between left handed. Similarly, Dane and Gümüştekin reported that 83.33% of right handed and 50% of left handed preferred to use their right eyes [27]. Some researchers reported that there may be a weak association between hand preference and eye preference [28]. 82.53% of the right handed and 28.12% of the left handed in our study used their right eyes. In addition, according to the results of our study, 73.04% of the participants used their right eyes. The direct proportion between hand preference and dominant eye in literature matches our study. Peterson et al. found that the dominant hand had 10% more HGS when compared with the non-dominant hand [29]. The 10% rule shown by Peterson et al. is valid only for the people who use their right hand dominantly [29], while in people whose left is dominant, HGS is equal in both hands. Armstrong et al. found 0.1% - 0.3% difference in HGS between the dominant and nondominant hand [30]. Guedo Rojas et al. [31] stated that HGS was high for the dominant hand in both sexes. A directly proportional association was found between HGS and the dominant hand in our study. The association between HGS and the dominant hand in our study was found to be similar with the results in other studies.

## Conclusion

In a conclusion, when men and women were discussed together, it was found that right hand preference is dominant for both genders; however, left hand preference was found to be more frequent in men in comparison to women. In addition, no significant association was found between hand preference and 2D:4D ratio. However, hand preference, eye dominance and HGS were found to be directly proportional in both men and women. The association between hand preference and other parameters are also important in terms of cerebral lateralization. We believe that the direct proportion between hand preference, eye dominance and HGS will be a guide in finding out the dominant hemisphere. We hope that our study will be a resource for extensive studies on this subject.

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