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Comparison of all hand digit length ratios in left- and right-handed individuals

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Aim: To compare and detect possible differences between the digit length and digit length ratios in left- and right-handed female and male students. One of the cerebral hemispheres is dominant over the other. Knowing a person's dominant hemisphere can be a useful guide in some personal activities.

Materials and methods: Digit lengths (D) of the students were measured, followed by calculating the ratio of each digit to the others (1D:2D, 1D:3D, 1D:4D, 1D:5D, 2D:3D, 2D:4D, 2D:5D, 3D:4D, 3D:5D, and 4D:5D).

Results: In males, no significant difference was found between digit lengths and digit length ratios. Among left-handed females, the fifth digit length was significantly longer. The 2D:5D, 3D:5D, and 4D:5D ratios were significantly smaller in their left hands, which indicated that the fifth digit was longer in left-handed females.

Conclusion: The results of this study suggest that left-handed women could be especially successful in sports that require grasping a ball. This criterion should be considered for left-handed women while selecting athletes.

Key words: Hand, sex, left-handed, right-handed, digit length ratios

Solak ve sağlak bireylerde el parmak oranlarının karşılaştırılması

Amaç: Beyin hemisferlerinden bir tanesi daha baskındır ve hangi hemisferin daha baskın olduğunun bilinmesi bireysel aktivitelerin yönlendirilmesinde önemlidir. Bu çalışma sağlak ve solak kız ve erkek öğrencilerde parmak uzunluğu ve parmak uzunluklarının birbirlerine oranları arasındaki olası farklılıkları saptamak için yapıldı.

Yöntem ve gereç: 1-5. parmak uzunlukları ölçüldü (D). Ardından tüm parmakların diğer parmaklara olan oranı hesaplandı (1D:2D, 1D:3D, 1D:4D, 1D:5D, 2D:3D, 2D:4D, 2D:5D, 3D:4D, 3D:5D ve 4D:5D).

Bulgular: Erkeklerde parmak uzunlukları ve birbirlerine olan oranları arasında anlamlı fark bulunamadı. Solak kızlarda 5. parmak uzunluğu ve 2D:5D, 3D:5D, 4D: 5D oranları arasında istatistiksel olarak anlamlı fark vardı. Solak kızlarda bu oranlar sol ellerinde sağ ellerine göre daha küçüktü ve 5. parmağın solak kızlarda daha uzun olduğunu gösteriyordu.

Sonuç: Bu sonuçlar solak kızların topu yakalamayı gerektiren sporlarda daha başarılı olabileceklerini göstermektedir ve sporcu seçiminde solak kızlarda bu kriterin göz önünde bulundurulması faydalı olacaktır.

Anahtar sözcükler: El, cinsiyet, solak, sağlak, parmak uzunluk oranları

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Introduction

The brain prefers to use one hemisphere for certain processes. The left hemisphere is rational, analytic, and verbal, while the right hemisphere is visual, intuitive, and reactive. One of the hemispheres is dominantly used (1). Various studies have revealed anatomical asymmetries between the hemispheres. For instance, a wider occipital region in left-handed individuals and a wider frontal region in right-handed individuals, as well as a wider right lateral sulcus (sylvian fissure), have been reported (2). Hand movements and manipulation particularly activate the left inferior frontal and right parietal regions, both of which contain physiological asymmetry. This asymmetry was detected particularly in the occipital and frontal lobes of the brain (3). Studies on brain asymmetry in right- and left-handed individuals have failed to find a significant relationship. There was a significant effect of sex on brain morphology. An increase in the gray matter was detected in the cingulate, calcarine, and parahippocampal gyri in females and in the temporal lobe and the entorhinal and perirhinal cortices in males (4). Visual-motor control is better on the side of the preferred hand. Hand performance was shown to be related to hand preference. The results indicated that the right brain would be an important factor determining the right-bias in right-handed skills, especially in right-handed people. This asymmetric control was found to be less pronounced in males than in females. Detailed studies have revealed that the degree of right-handedness is determined by the right hemisphere, while the left hemisphere plays a dominant role in determining the degree of left-handedness (5). It is of interest to us whether there is morphological asymmetry in left- and right-handed individuals. The present study was conducted to reveal the asymmetry in the digit length and digit ratios of right- and left-handed individuals.

Materials and methods

After obtaining approval from the ethics committee of our university, this study was carried out with a total of 186 students, aged between 18 and 22 years, at Abant İzzet Baysal University. There were 94 females, of whom 55 were right-handed and 39 were left-handed, and 92 males, of whom 56 were right-handed and 36 were left-handed (Table 1).

Table 1. Number of right- and left-handed people.

	Female	Male	Total
Right-handed	55	56	111
Left-handed	39	36	75
Total	94	92	186

All of the right- and left-handed individuals were included in the study. Students who did not have hand preference were excluded from the study. Handedness was assessed using the Oldfield Handedness Inventory, in which the questions regarding which hand is preferred were modified (6).

Morphological measurements were done as follows: to gather data on digit length in each individual, the distance between the middle of the proximal crease and the tip of the digit on the palmar surface (D) was measured (Figure 1).

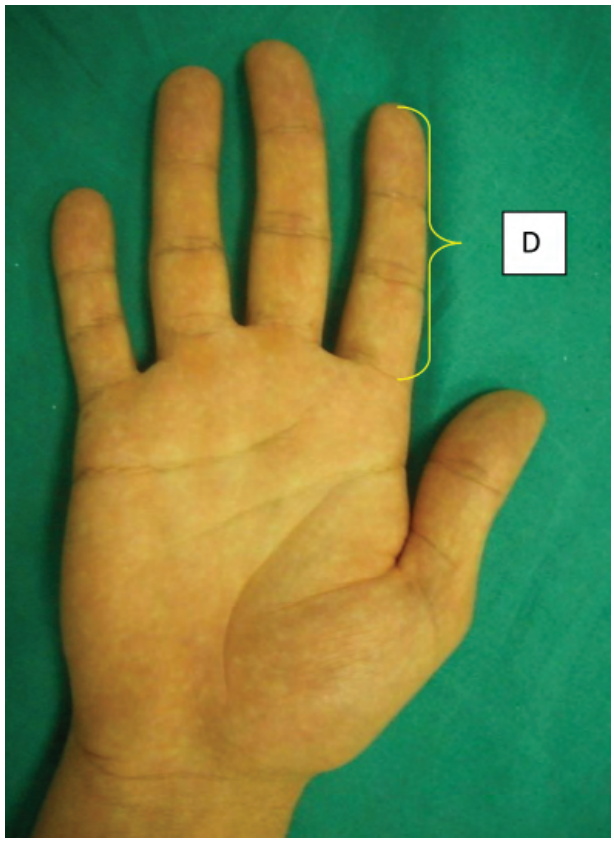

Figure 1. Measurement of digit length.

Subsequently, the ratio of each digit length to the others (1D:2D, 1D:3D, 1D:4D, 1D:5D, 2D:3D, 2D:4D, 2D:5D, 3D:4D, 3D:5D, and 4D:5D) was calculated (7,8).

The measurements were performed by a single researcher, using a digital caliper of 0-150 mm with a reading sensitivity of 0.01 mm. The results were fed into SPSS 13.0 statistical software. To understand the interactions between the various factors, we analyzed the data with mixed-model analysis of variance (ANOVA), which took into account the between-subject and within-subject factors. We used ANOVA with Tukey's post hoc test to compare the hands of the left-handed and right-handed females and males separately. $P < 0.05$ was considered as significant.

Results

Digit length measurements were taken independently in both right- and left-handed subjects; the results for males are given in Tables 2 and 3, while Tables 4 and 5 show the results for females. The standard error bars associated with the measurements of the males and females are shown in Figures 2 and 3, respectively.

Mixed-model ANOVA (repeated measures ANOVA with 2 between-subject and 2 within-subject factors) revealed an interaction only between hand and digit lengths ($P = 0.03$) (Table 6). There was a significant difference between the thumbs of both hands, with the thumb being longer on the left hand. There were no significant differences among the other digits.

Table 2. Mean values of right-handed male digit lengths (mm).

	Number	Minimum	Maximum	Mean	Std. dev.
1D left	56	56.96	76.63	67.72	4.40
2D left	56	63.61	81.91	72.88	4.25
3D left	56	69.7	88.70	79.62	4.46
4D left	56	64.21	83.91	73.99	4.30
5D left	56	50.00	72.15	60.43	4.80
1D right	56	59.01	78.30	67.10	6.31
2D right	56	64.80	83.58	73.05	4.38
3D right	56	68.10	90.10	79.60	4.86
4D right	56	66.43	83.23	74.37	4.30
5D right	56	51.83	69.56	61.03	4.23

Table 3. Mean values of left-handed male digit lengths (mm).

	Number	Minimum	Maximum	Mean	Std. dev.
1D left	36	61.07	84.41	67.81	4.76
2D left	36	68.80	81.30	73.93	3.54
3D left	36	72.66	87.96	80.65	3.64
4D left	36	66.75	86.26	74.32	3.98
5D left	36	55.82	70.13	60.99	3.51
1D right	36	58.14	83.63	67.54	5.06
2D right	36	68.35	83.83	73.93	3.68
3D right	36	75.36	88.78	81.00	3.31
4D right	36	68.70	84.50	74.81	3.60
5D right	36	55.74	69.62	60.94	3.43

Table 4. Mean values of right-handed female digit lengths (mm).

	N	Minimum	Maximum	Mean	Std. dev.
1D left	55	47.55	74.05	61.44	4.78
2D left	55	57.69	75.19	67.09	4.32
3D left	55	64.35	83.17	73.78	4.86
4D left	55	56.19	78.78	67.97	5.15
5D left	55	45.01	65.43	55.25	4.64
1D right	55	52.53	74.90	61.58	3.96
2D right	55	57.35	75.65	67.45	4.17
3D right	55	65.10	82.89	73.94	4.63
4D right	55	57.62	77.18	68.28	4.63
5D right*	55	44.83	63.75	54.98	4.44

*P < 0.05.

Table 5. Mean values of left-handed female digit lengths (mm).

	N	Minimum	Maximum	Mean	Std. dev.
1D left	39	56.40	70.13	62.09	3.63
2D left	39	61.23	77.29	68.45	3.84
3D left	39	66.70	82.60	74.87	4.00
4D left	39	57.68	78.67	69.39	4.48
5D left*	39	48.20	68.13	57.37	4.02
1D right	39	53.79	74.61	62.04	3.99
2D right	39	61.10	75.10	68.05	3.60
3D right	39	68.20	82.18	74.94	3.76
4D right	39	60.35	77.30	69.46	4.00
5D right	39	48.13	63.06	56.40	3.77

*P < 0.05.

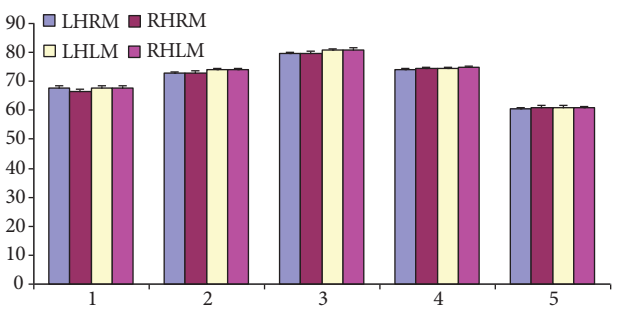

Figure 2. Standard error bar graph for males. LHRM: left hand of right-handed male, RHRM: right hand of right-handed male, LHLM: left hand of left-handed male, RHLM: right hand of left-handed male.

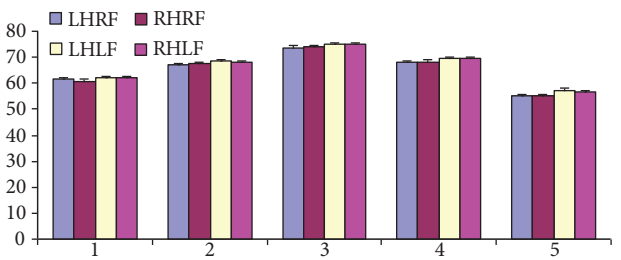

Figure 3. Standard error bar graph for females. LHRF: left hand of right-handed female, RHRF: right hand of right-handed female, LHLF: left hand of left-handed female, RHLF: right hand of left-handed female.

Table 6. Interactions among the various factors.

Compared properties	P
Sex-handedness	0.63
Sex-hand	0.35
Hand-handedness	0.71
Sex-hand-handedness	0.36
Sex-digit length	0.20
Digit length-handedness	0.93
Sex-digit-handedness	0.36
Hand-digit length	0.03
Sex-digit length-hand	0.24
Hand-digit length-handedness	0.11

Our goal was to reveal whether there were any differences in digit lengths according to handedness between right-handed males and left-handed males and between right-handed females and left-handed females. The results of ANOVA and Tukey's post hoc test showed no statistically significant difference between the digit lengths of left-handed males and right-handed males, while the length of the fifth digit of the left-handed females (56.40 ± 3.77 mm) was found to be significantly longer than in right-handed females (54.98 ± 4.44 mm) (P = 0.034). Tukey's test showed that the difference was more evident between the right hand of the right-handed females and the left hand of the left-handed females (P = 0.043).

Digit length ratios: The ratio of each digit to the others was calculated independently in males and females (1D:2D, 1D:3D, 1D:4D, 1D:5D, 2D:3D, 2D:4D, 2D:5D, 3D:4D, 3D:5D, and 4D:5D), and the ratios were statistically compared (Tables 7 and 8).

In females, the 2D:5D (P = 0.015), 3D:5D (P = 0.009), and 4D:5D (P = 0.015) ratios were found to be significantly smaller among the left-handed subjects, suggesting that the fifth digit was longer in left-handed females. The difference for these ratios was between the right hand in right-handed females and the left hand in left-handed in females. It was found that between the right hand in right-handed females and the left hand in left-handed females, the level of significance for 2D:5D was P = 0.012, for 3D:5D was P = 0.005, and for 4D:5D was P = 0.007 (Table 7). In men, there were no statistically significant differences among the digit ratios (Table 8).

A comparison of the 4 handedness groups revealed that the 4D:5D ratio was significantly greater on the right side among right-handed females. Furthermore, the 3D:5D and 4D:5D ratios were significantly greater on the right side among left-handed females, with the 3D:5D ratio being the most statistically significant difference (P = 0.005). These results indicate that the left fifth digit of the females was significantly shorter in right-handed individuals.

Table 7. Mean value of female digit ratios.

	Right-handed (mm)		Left-handed (mm)	
Ratio	**Left hand**	**Right hand**	**Left hand**	**Right hand**
1D:2D	0.91 ± 0.06	0.91 ± 0.05	0.90 ± 0.04	0.91 ± 0.04
1D:3D	0.83 ± 0.05	0.83 ± 0.04	0.82 ± 0.03	0.82 ± 0.03
1D:4D	0.90 ± 0.06	0.90 ± 0.05	0.89 ± 0.04	0.89 ± 0.04
1D:5D	1.11 ± 0.08	1.12 ± 0.08	1.08 ± 0.07	1.10 ± 0.06
2D:3D	0.90 ± 0.02	0.91 ± 0.02	0.91 ± 0.02	0.90 ± 0.02
2D:4D	0.98 ± 0.03	0.98 ± 0.03	0.98 ± 0.03	0.98 ± 0.03
2D:5D*	1.21 ± 0.05*	1.22 ± 0.06*	1.19 ± 0.06*	1.20 ± 0.05*
3D:4D	1.08 ± 0.03	1.08 ± 0.02	1.08 ± 0.03	1.07 ± 0.03
3D:5D*	1.33 ± 0.05	1.34 ± 0.06	1.30 ± 0.06*	1.33 ± 0.05*
4D:5D*	1.23 ± 0.04*	1.24 ± 0.05*	1.21 ± 0.05*	1.23 ± 0.03*

*P < 0.05.

Table 8. Mean value of male digit ratios.

	Right-handed (mm)		Left-handed (mm)	
Ratio	**Left hand**	**Right hand**	**Left hand**	**Right hand**
1D:2D	0.92 ± 0.04	0.91 ± 0.04	0.91 ± 0.04	0.91 ± 0.05
1D:3D	0.85 ± 0.04	0.84 ± 0.04	0.84 ± 0.05	0.83 ± 0.06
1D:4D	0.91 ± 0.04	0.90 ± 0.04	0.91 ± 0.06	0.90 ± 0.06
1D:5D	1.12 ± 0.07	1.10 ± 0.06	1.11 ± 0.08	1.11 ± 0.092
2D:3D	0.91 ± 0.03	0.91 ± 0.02	0.91 ± 0.02	0.91 ± 0.02
2D:4D	0.98 ± 0.04	0.98 ± 0.03	0.99 ± 0.03	0.98 ± 0.03
2D:5D	1.20 ± 0.074	1.19 ± 0.06	1.21 ± 0.04	1.21 ± 0.055
3D:4D	1.07 ± 0.03	1.07 ± 0.02	1.08 ± 0.02	1.08 ± 0.02
3D:5D	1.32 ± 0.07	1.30 ± 0.061	1.32 ± 0.04	1.33 ± 0.06
4D:D5	1.22 ± 0.06	1.22 ± 0.04	1.21 ± 0.04	1.22 ± 0.051

*$P < 0.05$.

Discussion

Defining hand and digit parameters during adulthood will provide greater information on individual variations. Knowledge about digit variations may help diagnose the developmental pathologies or anomalies of the skeleton and the endocrine system. The parts and shape of the hand and digits are significant indicators of an individual's developmental characteristics during the fetal and postnatal periods (9-11).

Digital and metacarpal formulas are morphological variables that may also have a functional significance in the understanding of how certain hand forms may be ill-fitted for certain tasks (12).

Many researchers have measured digit lengths radiologically or morphometrically using digital calipers (13-15). Many researchers have revealed the relationship between bone development and hormones, concluding that these could be determinants of certain diseases. Under the influence of hormones, the size of the fifth digit is greater than the second digit in most males, while it varies in females (12,14-16).

Martin et al. reported that the second and fourth digits are longer in the left hand in males and in the right hand in females (17).

Most studies have used the ratio of the length of the second to that of the fourth digit (2D:4D).

In their studies on females and males, Robinson and Manning and Manning et al. reported that the ratio of the second digit to the fifth digit (2D:4D) is greater (positive) under estrogen influence and negative under the influence of testosterone (18,19).

Firman et al. reported that the mean 2D:4D ratios were 0.964 ± 0.004 in the right hand and 0.962 ± 0.004 in the left hand in males, but the difference was not statistically significant (20).

In their study, Paul et al. suggested that a smaller 2D:4D ratio presented an advantage in sporting activities for females (21).

Voracek et al. reported that there was no significant difference between the right and left hands in the 2D:4D ratio with respect to sex (22).

In the present study, we measured all of the digit lengths morphometrically using a digital caliper, and, unlike in other studies, we calculated all of the digit ratios. The 2D:5D, 3D:5D, and 4D:5D ratios were found to be significantly smaller in the left-handed females when compared to the right-handed females. In other words, only the length of the fifth digit was significantly longer in left-handed females. In contrast

to the literature, we did not detect any significant difference between males and females for the 2D:4D ratio. However, the 2D:5D, 3D:5D, and 4D:5D ratios were significantly smaller in the left-handed females, a difference that was only observed for the fifth digit. Among these ratios, the most statistically significant difference was for the 3D:5D ratio (P = 0.005). When all of the groups were analyzed, thumb length was found to be significantly longer on the left hand.

Given the hand's adaptability, the functional significance of digital and metacarpal formulas is not to seek the best hand type for certain tasks, but rather to determine which hands are relatively disadvantaged in performing those tasks.

Consequently, the fifth digit on the left hands of the left-handed females was found to be significantly longer than that of the right-handed females, whereas no significant result was found in the right hands between right-handed and left-handed females.

Hand size asymmetry among right- and left-handers was reported in previous studies. The second metacarpal, for example, is consistently larger in the right hand among both right-handers and left-handers in terms of asymmetry of hand length (23). In another study, right-handed males had longer right than left hands, while males who were not right-handed had longer left than right hands. Females also had a significant association, with the direction of asymmetry the reverse of that found in males (24).

Because the asymmetry of digit length between left- and right-handed adults has not yet been reported in the literature, this study was conducted to explore whether there is a difference in the digit length between left- and right-handed adults. According to our results, there is an asymmetry between left- and right-handed adults for digit length.

Digit length is known to enhance potential, particularly in sporting activities. It is especially necessary to measure digit length of the hand for practical reasons. In handball and basketball, the longer the digit length, the better the accuracy of the shot or throw (25). A longer fifth digit may help stabilize the second digit when throwing objects, and this would increase throwing accuracy. In turn, this would give more of an advantage in sporting activities (26).

Conclusion

In light of our findings, we report that left-handed women may have better sporting abilities, due to the left hand in left-handed women, and they might be more successful, particularly in sports that require grasping a ball**.** The length of a girl's fifth digit could be an early indicator of her future sporting potential. Therefore, we suggest that this criterion should be taken into consideration while selecting left-handed females for certain sports.

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