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Evaluation of the abduction angles between hand fingers

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Abstract

This study aimed to reveal the angular values of abduction between the fingers and evaluated the right-left sides angular asymmetry and the differences between the genders. Participants were asked to place their hand fingers on a table with maximum finger abduction. Hand photographs were taken at a distance of 50 cm on the vertical axis, focusing on the metacarpophalangeal joint of the middle finger. Angular measurements between fingers on the photographs were taken by using the Image-J program. Statistical analysis was performed with SPSS software. The mean values of the abduction angles between thumb-index, index-middle, middle-ring, and ring-little fingers on the right hand were 53.94º, 19.99º, 17.29º and 27.72º in males; 48.38º, 20.78º, 18.23º and 29.41º in females, respectively. On the left hand, the mean values of abduction angles between thumb-index, index-middle, middle-ring, and ring-little fingers were 54.83º, 21.16º, 20.15º and 29.93º in males; 49.38º, 22.35º, 19.93º and 31.55º in females, respectively. The average abduction angles of the fingers are thumb-index> ring-little > index-middle> middle-ring, from largest to smallest. When the right-left sides were compared for abduction angles, a significant difference was found for the middle-ring and ring-little fingers in females and the index-middle, middle-ring and ring-little fingers in males ($p<0.005$). A significant difference was found in only thumb-index abduction angles in the comparison between genders, $p<0.005$. The normative descriptive angular data of our society obtained from the study will contribute to the literature revealing the anatomical differences between different racial and ethnic groups.

Keywords: Fingers, hand, range of motion, gender differences, thumb, abduction

Introduction

Joints are anatomical structures that allow movement to the skeletal system. Knowing the functional anatomy and biomechanics of joint movements is essential. Classical knowledge of the range of motion of the joints is written in classical anatomy books; It is likely to vary depending on racial, ethnic and geographical differences. Methods such as goniometry, pollexograph, inclinometer and spectrophotometry are used to evaluate the range of motion of joints [1, 2].

Hand fingers can perform various degrees of flexion, extension, abduction, adduction, and circumduction movements with the metacarpophalangeal and interphalangeal joints. This hand mobility is critical during daily activities, especially in tasks that require fine motor skills, such as using the keyboard [3]. In addition, the flexion and abduction angles of the thumb are significant during phone and tablet use. The flexion range at the metacarpophalangeal, proximal interphalangeal, and distal interphalangeal joints are 90º, 100º, and 90º, respectively. The metacarpophalangeal and distal interphalangeal joints can perform extension 45º and 10º, respectively [4]. In the fist-shaped hand, the extension of the fingers in flexion cannot be performed

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independently due to the several juncturae tendinum located in the extensor digitorum muscle. The degree of abduction between the fingers will likely change after the movement in extension.

When the degrees of abduction movement of the hand fingers are compared, it is reported that the 2nd finger has the most abduction movement range, followed by the 5th, 4th and 3rd fingers, respectively, in terms of the range of motion in the textbooks. It has been reported that angulation is a maximum of 25º, and the range of motion slightly increases while its combination with flexion, extension, and slight rotational movements in the joint [5].

The thumb has a flexion-extension angle of 53º. The abduction-adduction movements of the thumb are different from the other fingers. The thumb performs these movements over the carpometacarpal joint, and this angulation is approximately 42º [6].

In osteoarthritis and rheumatoid arthritis, the range of movements may increase or decrease depending on the joint involvement. The flexion-extension angle was reported to decrease in both osteoarthritis and rheumatoid arthritis patients. (82º in patients with osteoarthritis, 74º in patients with rheumatoid arthritis). The same study reported that the abduction-adduction angle means value slightly increased (approximately 2.5º) in patients with osteoarthritis. In contrast, it slightly decreased (approximately 3.8º) in rheumatoid patients [6].

In the literature, there are not enough anatomical studies comparing the normative values of the joint range of motion of the fingers in individuals with different racial, ethnic, geographical and social characteristics. This study is one of the first studies in which the degree of abduction of the fingers was evaluated after simultaneous abduction movement of the fingers. This study aimed to obtain descriptive data on the abduction angles of the hand fingers and to indicate gender and side differences.

Material and Methods

This study was conducted on 91 (48 female and 43 male) adult volunteers aged between 18-5. Ethical approval of the study was obtained by the decision of the Non-Interventional Ethics Committee of Izmir Katip Celebi University, numbered 24.02.2022-0045. The individuals participating in the study were those with no acquired or congenital deformity, trauma, or surgery history in their upper extremities, and none were professional athletes. Participants signed voluntary informed consent forms after they were informed about the study. Participants were seated, instructed to place their hands with palms facing down on the table. They were instructed to keep their wrists straight and middle fingers on the sagittal axis, while the fingers were in maximum abduction. The same researcher took the photos from a distance of 50 cm focusing on the metacarpophalangeal joint knuckle at a vertical angle of the middle finger with a Canon 800D camera. For standardization, a millimetric ruler was also photographed. Abduction angle measurements were made on the photos of both hands by using ImageJ software. The angles between the lines drawn tangentially to the lateral side of the fingers on the images were measured (Figure 1). A total of 8 angle values were obtained between the fingers of the right and left hands. The angles were measured between the thumb-index, index-middle, middle-ring, and ring-little fingers.

IBM SPSS v25 software was used for statistical analysis. Descriptive statistical data (minimum, maximum, mean, and SD) were obtained. Distribution was evaluated with the Shapiro-Wilk test. Differences between the right and left sides were obtained using the paired t-test, and the differences between the genders were obtained using the independent t-test. Correlation values between angles were obtained by Pearson correlation.

Results

The mean values of the abduction angles between thumb-index, index-middle, middle-ring, and ring-little fingers for the right hand were found to be 53.94º, 19.99º, 17.29º and 27.72º in males; 48.38º, 20.78º, 18.23º and 29.41º in females, respectively. On the left hand, the mean values of abduction angles between thumb-index, index-middle, middle-ring, and ring-little fingers were 54.83º, 21.16º, 20.15º and 29.93º in males; 49.38º, 22.35º, 19.93º and 31.55º in females, respectively. The mean and standard deviation of the abduction angles of the fingers are given in Table 1. The mean of the abduction angles of the fingers from largest to smallest are angle thumb-index > ring-little > index-middle > middle-ring (Figure 1).

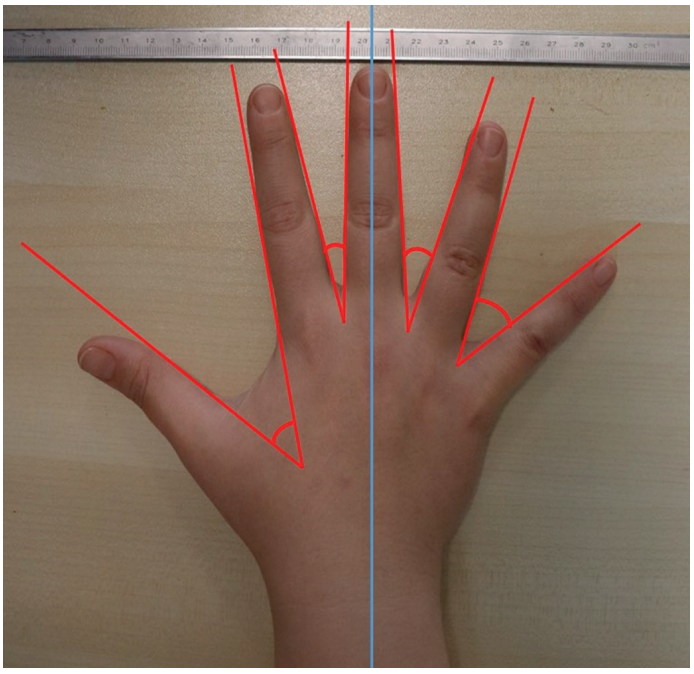

Figure 1. The abduction angles between fingers

When the abduction angles of the right and left sides were compared, a significant difference was found for the angles middle-ring and ring-little in females and for the angles index-middle, middle-ring and ring-little in males $p<0.005$ (Table 1).

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In comparison between the genders, a significant difference was found only on the angle thumb-index p<0.005 (Table 1). The correlation between the corresponding abduction angles in the right and left hands were evaluated. The correlation values from largest to smallest were found in angles thumb-index > ring-little > middle-ring > index-middle in males and angles thumb-index > middle-ring > index-middle > ring-little in females (Table 2,3).

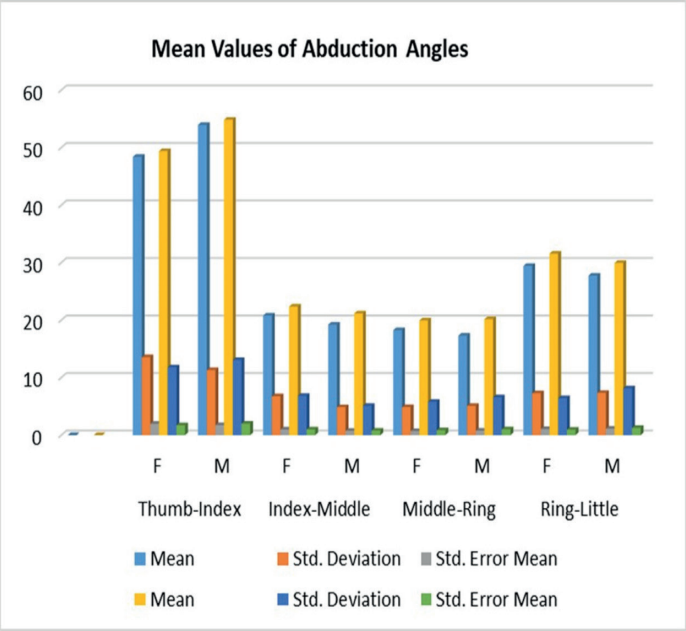

Figure 2. The mean values of abduction angles, standard deviations and standard errors in males and females

Table 1. Comparison of abduction angles of the fingers by hand side and gender

Angles	Gender	Right	Left	p value[a]
		Mean±SD	Mean±SD	
Thumb-Index	F	48.38 ±13.55	49.38±11.77	0.455
	M	53.94±11.30	54.83±13.05	0.549
p value[b]		0.037*	0.039*	
Index-Middle	F	20.78±6.75	22.35±6.82	0.091
	M	19.19±4.85	21.16±5.09	0.029*
p value[b]		0.204	0.353	
Middle-Ring	F	18.23±4.86	19.93±5.78	0.007*
	M	17.29±5.08	20.15±6.57	0.001*
p value[b]		0.372	0.866	
Ring-Little	F	29.41±7.28	31.55±6.40	0.049*
	M	27.72±7.33	29.93±8.12	0.030*
p value[b]		0.275	0.289	

SD: standard deviation
[a]p values represent Right and Left hand comparison within same gender
[b]p values represent Male and Female comparison within same handside
*Values are significantly different between groups (p<0.05)

Table 2. Correlations of the abduction angles between right and left sides in males

			Right				Left			
			Thumb-Index	Index-Middle	Middle-Ring	Ring-Little	Thumb-Index	Index-Middle	Middle-Ring	Ring-Little
Right	**Thumb-Index**	r	1							
		p								
	Index-Middle	r	-0.218	1						
		p	0.160							
	Middle-Ring	r	0.075	-0.024	1					
		p	0.632	0.881						
	Ring-Little	r	0.326*	-0.058	-0.138	1				
		p	0.033	0.710	0.378					
Left	**Thumb-Index**	r	0.690**	-0.098	0.064	0.290	1			
		p	0.000	0.531	0.686	0.060				
	Index-Middle	r	0.062	0.339*	0.018	0.169	-0.063	1		
		p	0.694	0.026	0.907	0.279	0.686			
	Middle-Ring	r	0.141	0.078	0.640**	0.202	0.102	0.113	1	
		p	0.369	0.619	0.000	0.194	0.516	0.470		
	Ring-Little	r	0.201	-0.107	-0.114	0.659**	0.253	0.020	-0.014	1
		p	0.196	0.494	0.467	0.000	0.101	0.899	0.929	

*Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed)

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Table 3. Correlations of the abduction angles between right and left sides in females

			Right				Left			
			Thumb-Index	Index-Middle	Middle-Ring	Ring-Little	Thumb-Index	Index-Middle	Middle-Ring	Ring-Little
Right	Thumb-Index	r	1							
		p								
	Index-Middle	r	0.080	1						
		p	0.588							
	Middle-Ring	r	-0.230	0.367*	1					
		p	0.116	0.010						
	Ring-Little	r	0.291*	0.412**	0.327*	1				
		p	0.045	0.004	0.023					
Left	Thumb-Index	r	0.743**	0.057	-0.138	0.222	1			
		p	0.000	0.702	0.349	0.129				
	Index-Middle	r	0.444**	0.568**	0.157	0.459**	0.254	1		
		p	0.002	0.000	0.286	0.001	0.081			
	Middle-Ring	r	-0.083	0.477**	0.708**	0.225	-0.054	0.166	1	
		p	0.575	0.001	0.000	0.124	0.717	0.259		
	Ring-Little	r	0.336*	0.252	0.213	0.429**	0.189	0.410**	0.281	1
		p	0.019	0.084	0.146	0.002	0.198	0.004	0.053	

*Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed)

Discussion

The range of motion of the fingers is essential in performing many fine, detailed motor functions. In the literature, numerous studies in the field of health and engineering examine the degrees of flexion and extension of the fingers. However, comparing studies of different societies and races on finger abduction angles in the literature is rare. The angular values of the interdigital ranges that obtained in this study are essential for comparing different racial and ethnic groups.

Coupier et al. investigated the range of motion of the fingers in 20 healthy Belgian individuals aged 22-65 years using the spectrophotometric method. They found the abduction-adduction range of motion between fingers from thumb to little 37º, 13º, 7º, 15º and 29º in the right hand; 35º, 12º, 8º, 17º and 30º in the left hand, respectively [7]. In this study, mean values of abduction angles between fingers from thumb to little were 51º, 20º, 17º and 28º in the right hand and 52º, 22º, 20º and 30º in the left hand, respectively for all subjects. The values belonging to males and females were similar (Table 1). Jerome et al. reported that they could not find any difference between the right and left sides regarding the range of motion [7]. These results do not agree with the current study results. In this study, the middle-ring and ring-little abduction angles in both hands were found to have statistically significant differences in both genders. In addition, index-middle abduction angles in males were statistically significantly different between the right and left sides in this study. Possible reasons for the difference between the results of the two studies include methodological and racial differences. Coupier et al. also found no significant difference between genders [7]. In current study, there was no statistically significant difference between genders in the abduction range of motion except for the thumb-index angle. In this respect, the results of the two studies are similar.

Gracia-Ibáñez et al. found 35.2º, 25.7º and 28.4º for the mean abduction angle values from index-middle, middle-ring and ring-little, respectively. They reported that the differences between angular values were not statistically significant regarding genders [8]. Angular values obtained by Gracia-Ibáñez et al. were higher than the current study findings. This may be due to the methodological difference between the two studies. They found the order of magnitude of the abduction angle as index-middle> ring-little> middle-ring. But in this study, it was ring-little> index-middle> middle-ring. Their results differed from this study in terms of mean values of abduction angles and the order of magnitude.

Barakat et al. reported that the mean value of the radial abduction angle range of the thumb was 62.9º (between 53-71º) in their study on 62 females [9]. This value is higher than the radial abduction angle of the thumb obtained from the females in this study (Table 1). This is because methodologically, they only

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looked at the radial abduction angle from the fingers of the thumb. In this study, the angulation between the fingers was measured while the fingers of the hand were abducted simultaneously. Therefore, in current study, the abduction of the second finger can be interpreted as a reduction in the radial abduction angle of the thumb.

In a study conducted by Gurbuz et al. with an electronic digital inclinometer (20 male, 20 female), they reported that the lowest abduction degree was 4.12º for the metacarpophalangeal joint of the thumb. And the highest abduction degree was 80.98º for the middle finger. The abduction angle in other fingers; was reported to be 41.9º for the index finger, 41.57º for the ring finger, and 48.53º for the little finger [10]. These angular values differ from the current study's results (Table 1). However, this research did not perform an abduction angle assessment for the metacarpophalangeal joint of the thumb. In this study, the radial abduction angle of the thumb was evaluated. This angle was larger than the other angles that measured and it was approximately 50º (Figure 2). The order of abduction angle widths of the other fingers from largest to smallest was the abduction of the ring-little, index-middle, and middle-ring fingers for both genders, respectively (Figure 2). The order of largest to smallest for these 3 fingers was similar in both studies.

The active palmar abduction angle measured by the pollexograph-thumb method on 25 (9 male, 16 female and 3 left-handed) healthy individuals by Kracker et al. was found to be 62±5º (range 54-72º) on average. In the same study, they measured 57±6º (in the range of 45-70º) with a goniometer [2]. This study shows that the results of the studies conducted with two different methods are similar. However, gender differences were not evaluated in this study. In this study, unlike the palmar abduction angle of the thumb, the radial abduction angle of the thumb was evaluated. When the genders were compared, the difference between men and women in the radial abduction angles of the thumb was found statistically significant. There was no gender difference in the abduction angles of the other fingers.

Anatomy studies show a significant difference between the genders regarding hand length and width and for determining gender from hand sizes [11]. Literature information suggests that there may be a difference between the genders regarding abduction angles between the fingers. However, in this study, no gender difference was found between abduction angles for the index-middle and ring-little finger. There was a difference between the genders only in terms of thumb radial abduction angles.

White et al. found 51.1±5.5º for the abduction of the thumb in their study [12]. Although their measurement methods were different, this result was similar to ours. They reported a weak negative correlation when they evaluated the abduction angle according to age groups. The 65+age group had a 4.5º lower abduction angle than the 35-49 age group. In our study, the abduction angle was not evaluated according to age. They also found that the thumb's flexion, extension and abduction angles did not change according to age and gender groups. Still, in our study, the thumb abduction angle showed differences between the genders [12].

The current study evaluates the abduction angles between the fingers when all fingers are abducted simultaneously (except the middle finger). This study did not assess the maximal abduction range of motion between the fingers. Studies evaluating the maximal abduction angles of each finger are planned for the future.

Conclusion

The middle-ring and ring-little fingers abduction angles in females and index-middle, middle-ring and ring-little fingers abduction angles in males were determined statistically significantly different regarding the right and left sides. In addition, only the thumb-index fingers abduction angle was statistically different in comparing the genders. Current study will contribute to the literature in terms of anatomical comparison of finger movement characteristics of people from different geographical regions.

Conflict of interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical approval
Non-Interventional Ethics Committee of Katip Çelebi University, numbered 24.02.2022-0045.

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