VIA MEDICA

ORIGINAL ARTICLE

Folia Morphol.
Vol. 71, No. 3, pp. 173–177

ISSN 0015–5659
www.fm.viamedica.pl

The relationship between the carrying angle and the distal extent of the 2nd and 4th fingertips

M. Sönmez, Y. Taţtemur, K. Karacan, M. Erdal

Medical Faculty of Cumhuriyet University, Department of Anatomy, Sivas, Turkey

[Received 21 March 2012; Accepted 19 June 2012]

The angle towards the lateral side between the arm and forearm when the forearm is in full extension and supination is defined as the carrying angle. It is well known that the 2nd finger is longer in women whereas the 4th finger is longer in men, due to in-utero hormonal effects. In the present study, the relationship between the carrying angle and the distal extent of the 2nd and 4th fingertips is studied. The findings reveal that the carrying angle was greater both in left and right sides in women than in men. In addition, while the distal extent of the 2nd fingertips was longer in women, the 4th fingertip was longer in men. There was a moderately positive correlation between the carrying angle and the distal fingertip lengths. Therefore, it could be suggested that the morphometric factors play role on the distal extent of the fingertips other than the hormonal effects. (Folia Morphol 2012; 71, 3: 173–177)

Key words: carrying angle, distal extent of fingertips, finger length

INTRODUCTION

Measurement of the angle between the forearm and arm was first done by Potter [17]. The angle towards the lateral side between the arm and forearm when the forearm is in full extension and supination is defined as the carrying angle. This angle disappears when the forearm is in pronation. London [10] reported that the angle was prevented when the forearm was in flexion. It has been well established that this angle was found to be between 155 and 180 degrees. The supplementary angle was found to be 0–25 degrees, and this angle was mostly used in literature [13], as in the present study.

As a general view, this angle is accepted as a secondary sex characteristic, and in most studies it was shown to be greater in women than in men [1, 16]. There is some debate regarding the formation mechanism of the angle, and various hypotheses are available [16].

In recent studies, the opinion that the 2nd and 4th finger lengths and the ratio between them, 2D/4D, differs between genders (2nd finger is longer in women, 4th finger is longer in men) and that this is an indicator of in-utero androgen exposure has gained acceptance [11, 18, 19]. Researchers have put forward the relationship between the 2D/4D ratio in a wide range of areas including the nature of individuals, reproductive success and sexual performance, sexual orientation, sex hormone levels, verbal talents, developmental anomalies, physical and mental health and diseases, and musical and sports skills [4, 5, 7].

Various methods have been used for the measurement of finger lengths in recent studies. While one group of researchers performed measurements using the photocopies of hands [11] others used the hands directly [2] and some researchers performed measurements based on bone structure through direct radiographies [20, 23].

A number of previous studies used the distal extent of fingertips rather than finger lengths. When

Address for correspondence: Dr. M. Sönmez, Medical Faculty of Cumhuriyet University, Department of Anatomy, 58140 Sivas, Turkey, tel: +905425753327, e-mail: msonmez@cumhuriyet.edu.tr

distal lengths of fingers are taken into consideration, it can easily be seen that they have different lengths. However, it should be stated that a longer distal length does not mean a longer finger. The distal extents of fingertips were given as i < r, i = r, and i > r in those research studies [15].

Therefore, the following question arises: "Does the angle between the arm and forearm have an influence on the distal extent of the fingertips?" There has not been a previous study directly investigating this influence. Various researchers have pointed out the importance of a neutral position of the hand in order to avoid the influence of lateral and medial deviation of the hand on the distal extent of the fingertips when measuring finger lengths. They emphasised that lateral deviation of the hand was in favour of prominence of the 2nd distal fingertip and medial deviation of the hand was in favour of prominence of the 4th distal fingertip [15]. Similarly the question awaits to be answered, "does any deviation above the wrist joint, e.g. in the elbow, have a similar influence on the distal extent of the fingertips?" Therefore, the aim of the present study was to find out the relationship between the carrying angle and the distal extent of the fingertips.

MATERIAL AND METHODS

Study subjects

The study was performed on volunteer students and staff of the Medical Faculty and Faculty of Health Sciences of Cumhuriyet University. There were 63 females and 53 males (total: 116) with a mean age of 22 and 18, SD: 6,91 (range, 17–52 years), repectively. All participants were informed of the protocol and signed informed consent statements. The study plan was accepted by the Cumhuriyet University Local Ethics Committee (Approval Number: 2012/03/12).

All subjects fulfilled a 26-item questionnaire [14] to determine handedness. Study was performed on right-handed subjects. Subjects with upper limb anomalies, deformities, or left-handedness were excluded from the study.

Measurement positions

Subjects were put in a supine position on a horizontal table. Their forearms were positioned with full extension and supination. The carrying angle and distal extent of the fingertips were measured at the same time.

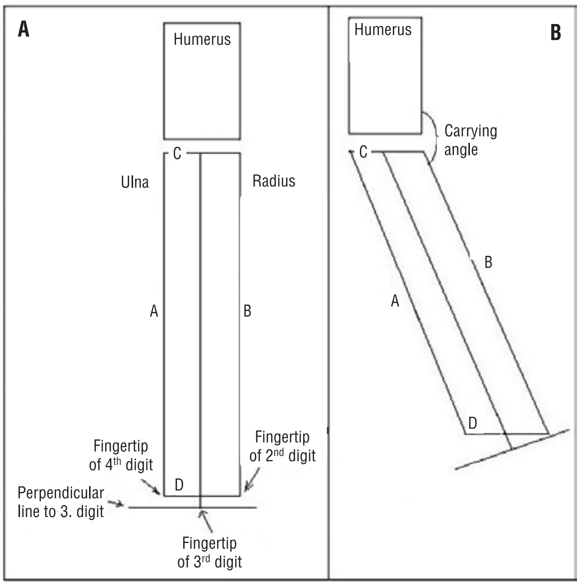

Figure 1. The position of the forearm without any angulation (**A**), and the position of the forearm with the carrying angle, demonstrating the lengthening of side B towards the 2nd fingertip (**B**).

Theoretical basis of the relationship between carrying angle and fingertips

Imagine a rectangle with long margins A and B and short margins C and D (Fig. 1). Margin A is the line from the proximal end of the ulna and the distal end of the 4th finger; margin B is the line from the proximal end of the radius and the distal end of the 2nd finger; margin C is the line joining the proximal ends of the ulna and the radius, and margin D is the line joining the distal ends of the 2nd and 4th fingers. It could be theoretically stated that when the rectangle is deviated to the lateral, the distal end of the long margin on the deviated side (A) would be prominent. When it is deviated to the other side, the distal end on that side (B) would be prominent. The distal ends of the 2nd and 4th fingers could be prominent, respectively, depending on these deviations. The deviation movement (abduction and adduction) could not be carried out when the forearm is in full extension and supination. Also, the presence of a natural structural deviation (carrying angle) was known. We consider that the carrying angle might have an influence on the distal end of the finger. The radial side of the forearm, and thereby the 2nd finger, would be pushed forward as the angle increases. The ulnar side could come forward while the radial side was drawing back as the angle decreased, and thereby the 4th finger would come forward. In order to investigate the possibility of this, we analysed the association between the carrying angle and the distal length of the fingers.

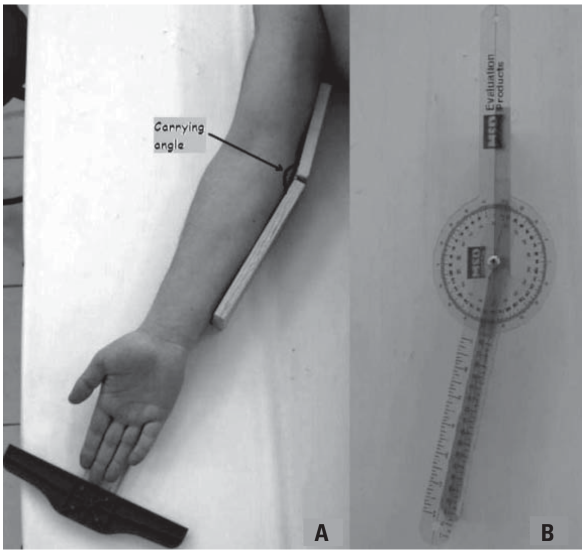

Figure 2. A. Formation of the carrying angle measured by a wooden attachment; **B.** The measurement of the determined carrying angle using a goniometer.

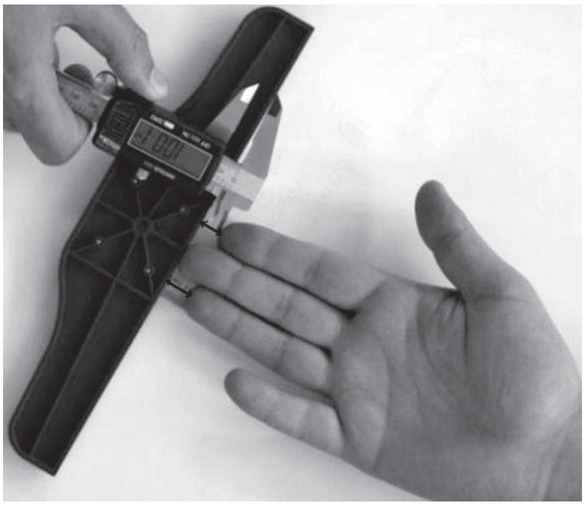

Figure 3. The T ruler is placed parallel to the long axis of the hand and forearm. The T part of the ruler is in contact with the 3rd fingertip perpendicular to its long axis. Finally, the distances between the 2nd and 4th fingertips and the T part of the ruler are measured by an electronic vernier.

Measurement of the carrying angle

Measurement of the carrying angle was carried out as proposed by Atkinson and Elftman [1]. The angle between the long axis of the arm and the long axis of the forearm was measured as seen in Figure 2. Subjects were placed in a transverse position and their arms were positioned in extension and full supination, which was followed by the measurement of the carrying angle. A wooden attachment with a hinge in the middle of it was used, and its angle was determined using a goniometer. The results are given as degrees.

Measurement of the distal extent of the fingertips

The index, middle, and ring fingers were placed in a closed position, and the wrist was fixed in a neutral position. To avoid lateral flexion of the wrist (toward either the thumb or the little finger), the middle finger was held in alignment with the long axis of the forearm. A T-square was placed under the hand and forearm with the same alignment (Fig. 3). The T piece of the ruler was in contact with the tip of the middle finger. The distances between the tip of the 2nd digit and the T piece of the ruler and the tip of the 4th digit and the T piece of the ruler were measured. The lower value was deducted from the higher value, and the result indicated the distance between those two fingers (deducted value). Values were measured in millimetres. Results were shown positive when the deducted value was longer, and they were shown negative when they were shorter for the 2nd fingertips. An electronic vernier was used in all measurements.

Statistical methods

The results were analysed using SPSS statistical package V 15.0. Student's t-Test and Pearson's correlation test were used for the statistical analysis of data, and $p < 0.05$ was accepted as the level of significance for Student's t-Test.

RESULTS

All data are presented in Tables 1 and 2.

The carrying angles, both in left and right, were greater in women than in men, and the difference was statistically significant. The mean differences in women between the 2nd and 4th fingertips were 1.92 mm in the right and 2.42 mm in the left. While the 4th fingertip was greater by 1.57 mm in the right and 1.38 mm in the left sides than the 2nd fingertip in men. Both in the left and in the right, the differences between the 2nd and 4th fingertip distal extents were statistically significant both in women and men (Table 1).

The distal extents of the 2nd fingertips (i) in women were greater in 71.4% in the right and 76.1% in the left. The distal extents of the 4th fingertips (r) in men were greater in 64.2% in the right and 68% in the left. When all subjects (T) were considered together, the 2nd distal extent of the fingertips was greater than the 4th distal extent of the fingertips in 55.2% in the right and 56% in the left, respectively (Table 2).

There was a statistically significant and a moderately positive correlation ($r = 0.33$, $p < 0.001$)

Table 1. The carrying angle values and the distal extent of 2nd fingertip are given. While negative values demonstrate that the 2nd fingertips are shorter than the 4th fingertips, positive values show the contrary

		N	Mean	SD	P
Right angle [degree]	Male	53	20.20	5.35	< 0.001
	Female	63	25.39	4.30	
Right 2nd digit [mm]	Male	53	–1.57	3.33	< 0.001
	Female	63	1.92	3.60	
Left angle [degree]	Male	53	19.83	5.45	< 0.001
	Female	63	24.65	4.27	
Left 2nd digit [mm]	Male	53	–1.38	2.95	< 0.001
	Female	63	2.42	3.34	

Table 2. The percentages of being greater of index (i) and ring (r) fingertip lengths between genders (male and female) and in total subjects

		i > r (%)	i < r (%)	i = r (%)
Right	Male	35.8	64.2	0.0
	Female	71.4	25.5	3.1
	Total	55.2	40.1	1.7
Left	Male	32.0	68.0	0.0
	Female	76.1	20.8	3.1
	Total	56.0	44.0	0.0

between the carrying angle and distal extent of the 2nd fingertip on the left side, which was similar to those seen on the right side ($r = 0.22$, $p < 0.05$).

DISCUSSION

We can imagine the upper extremity bones as the rings of an articulated chain: the radius and ulna which articulate with the humerus, the carpal bones jointed to the radius and ulna, the metacarpal bones, and, in the end, the proximal, medial, and distal phalanges. It would not be wrong to say that the position of this chain would affect the distal extent of the fingertips. Probably, as the angle between the arm and forearm increases, the radial side of the forearm, the 2nd fingertip length increases. As the angle decreases, the radial side would decrease and the ulnar side length would increase, so the 4th fingertip length would increase. The present study was designed to investigate this effect.

Our results indicated a positive correlation between carrying angle and finger length both on the right and the left sides. This was a moderate correlation. It was seen that the distal end of the 2nd finger was longer as the angle increased and the distal end of the 4th finger was longer as the angle decreased.

We found the carrying angle to be significantly greater in women compared to men. This result has also been put forward in many studies in literature [1, 9]. Most of the investigators except Baker [3] and Romich [21] (reported that there was not a difference between i and r lengths in terms of gender) obtained data supporting the results that i > r in women and r > i in men. Napier [12] reported that i < r was small in both gender but that r > i was much lower in women. In our study, when the distal extents of the 2nd and 4th fingertips were compared, the distal extent of the 4th fingertip was seen to be longer in men and the distal extent of the 2nd fingertip was seen to be longer in women.

Ruperelia et al. [22] investigated the association of carrying angle with height and forearm length. It showed a higher stature, longer forearm, and a smaller angle in men, but shorter stature, shorter forearm, and a greater angle in women. They reported that there was no difference between genders in terms of carrying angle.

Researchers who measured finger lengths either directly or through photocopies put forward the idea that 2D/4D ratio measurements indicated the distance between distal fingertips and flexion line. The most proximal point of the fold was taken when flexion lines were not clear [11]. There are various objections about determining finger lengths with this method. These objections are focused on two points. Firstly, measurement points do not give the real length of the finger because real the length of the finger is the distance between the base of the proximal phalanx and the farthest point of the finger [23]. The second is related to the measurement points. The flexion line in the base of the finger is taken as a landmark when measuring the finger length. The most proximal line is taken as the measurement point when the flexion line is not clear. However, the flexion line is a relative point. Differences of soft tissue structures and amounts between individuals would naturally affect measurements [6]. Studies are available in literature indicating that a wide variety of clinical conditions are effective on the 2D/4D ratio. Researchers suggested that prenatal sex hormones were effective on 2D/4D ratio and put forward the idea that finger lengths showed sexual dimorphism [11, 18, 19]. Contrary to this view, Kratochvil and Flegr [8] suggested that gender did not have a significant effect on the 2/4 index and that the difference between genders resulted from a shift along the common allometric line with non-zero intercept. The researcher showed that one of the factors influencing the ratio is finger length and stated that we should ask which physiological mechanisms affect finger length rather than the different effects of factors on finger lengths.

Vehmas et al. [23] measured finger lengths as bone lengths on radiographs (from the proximal phalanx basis to the end of the distal phalanx) and posited that there was not a relationship between the 2nd and 4th fingers. Researchers postulated that there was not a relationship between finger bone length and anthropometric variables, behavioural changes, nutrition, work-related changes, health-related variables, or fertility variables.

Morphometric measurements on living individuals include some problems because of the effects of soft tissues and difficult standardisation of measurement points. In the present study the effects of the aforementioned problems on measurement of both carrying angle and distal fingertips could not be denied.

We believe that the difference between genders in terms of distal fingertip measurements resulted from the angulation between the arm and forearm rather than in-utero hormonal effects. We absolutely accept that a gender effect on this angulation would also influence finger length. Therefore, it could be suggested that this is an indirect effect and the morphometric factors could play role on the distal extent of fingertips other than the hormonal effects.

CONCLUSIONS

The results of this study have indicated that: The carrying angle is greater in women than in men. The second distal fingertip is longer in women and the 4th distal fingertip is longer in men. There is a moderate positive correlation between the carrying angle and the distal extent of fingertips.

REFERENCES

1. Atkinson WB, Elftman H (1945) The carrying angle of the human arm as a secondary sex character. Anat Record, 91: 49–52.
2. Almasry SM, El Domiaty MA, Algaidi SA, Elbastawisy YM, Safwat MD (2011) Index to ring digit ratio in Saudi Arabia at Almadinah Almonawarah province: a direct and indirect measurement study. J Anat, 218: 202–208.
3. Baker F (1888) Anthropological notes on the human hand. Am Anthropol, 1: 51–75.
4. Chai XJ, Jacobs LF (2012) Digit ratio predicts sense of direction in women. PLoS One, e32816, 7(2).
5. Hiraishi K, Sasaki S, Shikishima C, Ando J (2012) The second to fourth digit ratio (2D:4D) in a Japanese twin sample: heritability, prenatal hormone transfer, and association with sexual orientation. Arch Sex Behav [Epub ahead of print].
6. Honekopp J, Watson S (2010) Meta-analysis of digit ratio 2D:4D shows greater sex difference in the right hand. Am J Human Biol, 22: 619–630.
7. Kilduff LP, Cook CJ, Manning JT (2011) Digit ratio (2D:4D) and performance in male surfers. J Strength Cond Res, 25: 3175–3180.
8. Kratochvil L, Flegr J (2009) Differences in the 2nd to 4th digit ratio in humans reflect shifts along the common allometric line. Biol Lett, 5: 643–646.
9. Kumar B, Pai S, Ray B, Mishra S, Siddaraju KS, Pandey AK, Binu S (2010) Radiographic study of carrying angle and morphometry of skeletal elements of human elbow. Romanian J Morphol Embryol, 51: 521–526.
10. London JT (1981) Kinematics of the elbow. J Bone Joint Surg Am, 63: 529–535.
11. Manning JT, Scutt D, Wilson J, Lewis-Jones RS (1998) The ratio of 2nd to 4th digit length: a predictor of sperm numbers and concentrations of testosterone luteinizing hormone and oestrogen. Hum Reprod, 13: 3000–3004.
12. Napier J (1980) Hands. Pantheon Boks, New York.
13. Paraskevas G, Papadopoulos A, Papaziogas B, Spanidou S, Argiriadou H, Gigis J (2004) Study of the carrying angle of the human elbow joint in full extension: a morphometric analysis. Surg Radiol Anat, 26: 19–23.
14. Peters M (1998) Description and validation of a flexible and broadly usable handedness questionnaire. Laterality, 3: 77–96.
15. Peters M, Mackenzie K, Bryden P (2002) Finger length and distal finger extend patterns in humans. Am J Physical Anthropol, 117: 209–217.
16. Purkait R, Chandra H (2004) An anthropometric investigation into the probable cause of formation of 'carrying angle': a sex indicator. J Indian Academy Forensic Med, 26: 19–23.
17. Potter HP (1895) The obliquity of the arm of the female in extension. The relation of the forearm with the upper arm in flexion. J. Anat, 29: 488–493.
18. Puts DA, Gaulin SJC, Sporter RJ, Mc Burney DH (2004) Sex hormones and finger length: what does 2D:4D indicate? Evol Hum Behav, 25: 182–199.
19. Puts DA, McDaniel MA, Jordan CL, Breedlove SM (2008) Spatial ability and prenatal androgens: meta-analyses of CAH and digit ratio (2D:4D) studies. Arch Sex Behav, 37: 100–111.
20. Robertson J, Zhang W, Liu JJ, Muir KR, Maciewicz RA, Doherty M (2008) Radiographic assessment of the index to ring finger ratio (2D:4D) in adults. J Anat, 212: 42–48.
21. Romich S (1932) Fingerlangen bei verschiedenen Konstitutionstypen (Finger lengths in different somatotypes). Anthropologischer Anzeiger, 9: 254–267.
22. Ruparelia S, Patel S, Zalawadia A, Shah S, Patel SV (2010) Study of carrying angle and its correlation with various parameters. NJIRM, 1: 28–32.
23. Vehmas T, Solovieva S, Leino-Arjas P (2006) Radiographic 2D:4D index in females: no relation to anthropometric, behavioural, nutritional, health-related, occupational or fertility variables. J Negat Results Biomed, 25: 5–12.