

Study of elbow carrying angle and its relationship with the length of second and fourth digit

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Abstract: *Background:* The acute angle produced medially when the axis of the forearm deviates laterally from the long axis of the humerus, with the arm extended and the palm facing forward, is referred to as the carrying angle. Variations in the angle have clinical as well as pathological significance. *Aims and Objectives:* This study was conducted to evaluate the elbow carrying angle in normal males and females and its relationship with length of second and fourth digit of same side and also analyse the data to find out any correlation between carrying angle, gender variance due to in utero difference in androgen exposure and ratio of length of ipsilateral second and fourth digit within the study population. *Methods:* 195 subjects with age varying from 12 to 32 years were studied. Carrying angle was measured using goniometer. Length of second and fourth digit was measured from distal palmar crease to tip of finger. *Results:* The result of the study showed that carrying angle is more in females than males on both sides. Lower values of carrying angle seen in males is strongly associated with longer ring finger and higher values of carrying angle seen in females associated with a longer index finger. There was only a moderately positive correlation between the carrying angle and fingertip lengths. *Conclusion:* Carrying angle is greater in women than in men. The second distal fingertip is longer in women and the fourth distal fingertip is longer in men. There is a moderate positive correlation between the carrying angle and the distal extent of fingertip. In utero androgen exposure has an indirect effect on finger length.

Keywords: Carrying Angle, Elbow Joint, Finger Length Ratio.

Introduction

Measurement of the angle between forearm and arm was first done by Potter [1]. The angle between arm and forearm when forearm is in full extension and supination is defined as the carrying angle. This angle disappears when forearm is in pronation. This angle has been found to be 0° to 25° [2]. Carrying angle is considered as a secondary sexual characteristic and has shown to be greater in women than in men. Olecranon-Coronoid angle shows sexual dimorphism [3]. Carrying angle is partly due to more distal position of the tip of medial lip of the trochlea [4]. A curved ridge joins the prominence of coronoid process and olecranon, the obliquity of the shaft of the ulna to this ridge accounts for carrying angle at elbow [5].

It has been suggested in recent studies that gender difference of carrying angle and its relation with ratio between second digit (2D) and fourth digit (4D) length (2D/4D ratio) is an indicator of in utero androgen exposure [6-8]. It has been

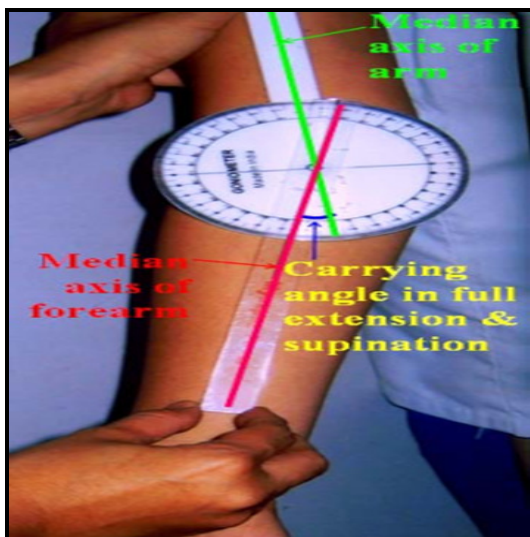
hypothesized that 2D/4D ratio reflects prenatal androgen levels and the individual's sensitivity to androgens [9]. Knowledge of the carrying angle can be useful for reduction of fractures, as the most common complication of supracondylar fractures is loss or increase in carrying angle resulting in cosmetic deformity. Aim of the present study was to find out any correlation with 2D/4D ratio and carrying angle in males and females.

Material and Methods

The study was performed on volunteer students and patients of Al-Ameen dental college and Al-Ameen nursing college, Vijayapur, Karnataka, India. Study was conducted on a total of 195 subjects out of which 126 were males and 69 were females. Age of the subjects ranged from 12-32 years. All subjects were informed of the study protocol and an informed verbal consent was taken from all participants of the study. Study was performed on right handed subjects.

Subjects with upper limb anomalies, deformities were excluded from the study. Subjects were placed in supine position on a horizontal flat table. Forearms were positioned with full extension and supination (Figure-1). Carrying angle was measured using a goniometer as proposed by Atkinson and Elftman [10]. Length of second and fourth digit were measured on the palmar surface from metacarpophalangeal crease to the tip of finger using a ruler. Carrying angle and digit length were measured on both right and left sides at the same time. Digit length was measured with hand in neutral position. Digit length was calculated and expressed as <1 or >1 or as equal while tabulating the measurements with length of second digit as numerator and length of fourth digit as denominator and expressed as 2D/4D ratio.

Fig-1: Carrying angle measurement



Results

| Total | 195 |
|---------|-----|
| Males | 126 |
| Females | 69 |

| Ratio | Total | Male | Female |
|-----------|-------|------|--------|
| 2D/4D < 1 | 143 | 97 | 46 |
| 2D/4D > 1 | 22 | 10 | 12 |
| 2D = 4D | 30 | 19 | 11 |

| Ratio | Total | Male | Female |
|-----------|-------|------|--------|
| 2D/4D < 1 | 120 | 84 | 36 |
| 2D/4D > 1 | 30 | 14 | 16 |
| 2D = 4D | 45 | 29 | 16 |

| Range | Total | Male | Female |
|-----------|-------|------|--------|
| 5° - 10° | 114 | 86 | 28 |
| 11° - 15° | 71 | 39 | 32 |
| 16° - 20° | 10 | 1 | 9 |

| Range | Total | Male | Female |
|-----------|-------|------|--------|
| 5° - 10° | 128 | 92 | 36 |
| 11° - 15° | 67 | 34 | 33 |
| 16° - 20° | 0 | 0 | 0 |

| Carrying Angle | 2D < 4D | 2D > 4D | 2D = 4D |
|----------------|---------|---------|---------|
| 5° - 10° | 87 | 7 | 20 |
| 11° - 15° | 46 | 15 | 10 |
| 16° - 20° | 10 | 0 | 0 |

| Carrying Angle | 2D < 4D | 2D > 4D | 2D = 4D |
|----------------|---------|---------|---------|
| 5° - 10° | 82 | 13 | 33 |
| 11° - 15° | 38 | 17 | 12 |
| 16° - 20° | 0 | 0 | 0 |

Discussion

Upper limb bones are like the rings of an articulated chain. Radius and Ulna articulates with humerus, carpal bones with radius, metacarpal bones with phalanges. Position of this chain or any angulation in this upper limb bony arrangement which is analogous to a chain would affect the distal extent of fingertips. Present study was designed to

investigate this effect of carrying angle on second and fourth finger length expressed as a ratio. Lateral deviation of the hand has been found to favour prominence of second distal fingertip and medial deviation of hand found to favour prominence of fourth distal fingertip [11]. Hence digit length was measured with hand in neutral position. Findings suggested that Androgen Receptor (AR) is a negative modulator of WNT 5a expression in digits. Fourth finger has higher levels of AR and Estrogen Receptor (ER) than second finger [12-13]. AR and ER activities influence the 2D/4D ratio by modulating levels of skeletogenic gene expression and cell proliferation in a digit specific manner.

Another interesting fact was reported that the intrauterine timing of phalangeal growth regulation by AR and ER correlates with the timing of masculinization or feminization of brain by the steroids. It was also observed that several genes have role in the development of brain and different sexually dimorphic structures [14-15]. So, 2D/4D ratio which was proposed as a reflection of prenatal androgen exposure is found to be caused by androgen and estrogen signaling [16].

Contrary to this view, Kratochvil and Flegr suggested that gender did not have a significant effect on the 2D/4Dratio and that the difference between genders resulted from a shift along the common allometric line with non-zero intercept [17]. Napier reported that second finger was smaller than fourth finger in both gender but the incidence of fourth finger being longer than second was much lower in women [18]. Our

results indicated a statistically significant positive correlation between carrying angle and 2D/4D ratio at lower values of carrying angle of its normal range. As carrying angle increases the correlation between carrying angle and 2D/4D ratio becomes less statistically significant. There was only a moderate correlation.

We found that carrying angle to be greater in females compared to males. However greater carrying angle in females did not significantly correlate with 2D/4D ratio. We believe that difference between genders in terms of 2D/4D ratio is due to difference in carrying angle rather than due to in utero exposure to androgens. However, difference in carrying angle could be due to difference in morphological arrangement of bones at elbow joint which might be influenced by in utero exposure to androgens. Thus differences in 2D/4D ratio are an indirect effect of carrying angle and not directly influenced by in utero exposure to androgens.

Conclusion

Digit ratio and elbow carrying angle is sexually dimorphic and can be used as window for in utero exposure to androgens. 2D:4D ratio is <1 in males and 2D:4D ratio >1 in females. However association of this with carrying angle is strong at lower values of carrying angle as seen in males and tends to be weak at higher values of carrying angle as seen in females.

References

1. Potter HP. The obliquity of the arm of the female in extension. The relation of the forearm with the upper arm in flexion. *J. Anat*, 1895; 29:488-493.
2. Paraskevas G, Papadopoulos A, Papaziogas B, Spanidou S, Argiriadou H, Gigis J. Study of the carrying angle of the human elbow joint in full extension: a morphometric analysis. *Surg Radiol Anat*, 2004; 26(1):19-23.
3. Purkait R, Chandra H. An anthropometric investigation into the probable cause of formation of 'carrying angle': a sex indicator. *J Indian Academy Forensic Med*, 2004; 26:14-19.
4. Steel Fld, Tomlinson JDW. The carrying angle in man. *J Anat*, 1958; 92(2):315-317.
5. McMinn RMH, Upper limb. In: McMinn RMH (ed), Last's anatomy: regional and applied, 8th edition. *Churchill Livingstone, Edinburgh*, 1990; 53-144.
6. Manning JT, Scutt D, Wilson J, Lewis-Jones RS. The ratio of 2nd to 4th digit length: a predictor of sperm numbers and concentrations of testosterone/luteinizing hormone and oestrogen. *Hum Reprod*, 1998; 13:3000-3004.
7. Puts DA, Gaulin SJC, Sporter RJ, Mc Burney DH. Sex hormones and finger length: what does 2D:4D indicate?. *Evol Hum Behav*, 2004; 25:182-199.
8. Puts DA, McDaniel MA, Jordan CL, Breedlove SM. Spatial ability and prenatal androgens: meta-

- analyses of CAH and digit ratio (2D:4D) studies. *Arch Sex Behav*, 2008; 37:100-111.
9. Breedlove SM. Mini review: Organizational hypothesis: instances of the fingerpost. *Endocrinology* 2010; 151:4116-4122.
 10. Atkinson WB, Elftman H. The carrying angle of the human arm as a secondary sex character. *Anat Record*, 1945; 91:49-52.
 11. Peters M, Mackenzie K, Bryden P. Finger length and distal finger extend patterns in humans. *Am J Physical Anthropol*, 2002; 117:209-217.
 12. Zheng Z, Cohn M. Developmental basis of sexually dimorphic digit proportions (2D:4D ratio). *Developmental Biology*. 2011; 356(1):171.
 13. Yang Y, Topol L, Lee H, Wu J. Wnt5a and Wnt5b exhibit distinct activities in coordinating chondrocyte proliferation and differentiation. *Development*. 2003; 130:1003-1015.
 14. Furuta Y, Piston DW, Hogan BL. Bone morphogenetic proteins (BMPs) as regulators of dorsal forebrain development. *Development*. 1997; 124:2203-2212.
 15. Andersson ER, Prakash N, Cajanek L, Minina E, Bryja V, Bryjova L et al. Wnt5a regulates ventral midbrain morphogenesis and the development of A9-A10 dopaminergic cells in vivo. *PLoS ONE*. 2008; 3:e3517.
 16. Manning J. Resolving the role of prenatal sex steroids in the development of digit [35] ratio. *Proceedings of the National Academy of Sciences*. 2011; 108(39):16143-16144.
 17. Kratochvil L, Flegr J. Differences in the 2nd to 4th digit ratio in humans reflect shifts along the common allometric line. *Biol Lett*, 2009; 5:643-646.
 18. Napier J. Hands. Chapter 2 Structure of Hand. *Pantheon Books, New York*. 1980; 13-21.

Cite this article as: Biradar RK, Adarsha HM. Study of elbow carrying angle and its relationship with the length of second and fourth digit. *Al Ameen J Med Sci* 2019; 12(1):27-30.

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