

Correlation of Elbow Carrying Angle with Height and Forearm Length among Bangladeshi Adolescent

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ABSTRACT

Background: Carrying angle is a medial acute angle between median axis of the upper arm with the fully extended and supinated forearm. It plays a vital role in carrying objects and keeps upper extremity away from the pelvis during walking and disappears when the forearm is pronated and flexed. It increases with age from childhood to adolescent and is greater in female and in dominant arm; also differs with race, ethnicity and number of anthropometric body parameters. Present study was designed to evaluate the carrying angle in normal adolescents of Bangladesh and to see its correlation with height and forearm length in both sexes.

Materials and methods: This cross-sectional analytical study was conducted in the Department of Anatomy, Chittagong Medical College, Chattogram upon 100 male and 100 female adolescents of 10-19 years. After getting permission from the ethical review committee, carrying angle, height and forearm length of the participants were measured by standard method. Recorded data were analyzed by using SPSS version 25. For statistical analysis Pearson's correlation test was done. *p*-value was considered significant if it was <0.05 at 95% level of confidence.

Results: Carrying angle of both sides in both sexes have shown significant positive correlation with height (*p*<0.05) but have non-significant positive correlation with forearm length of respective side in both sex (*p*>0.05).

Conclusion: Reference value of carrying angle is essential for management and follows up of supracondylar elbow fracture causing cubitus varus deformity, diagnosis, and treatment of epicondylar disease, elbow implantation and sex determination by forensic experts.

Key words: Adolescent; Carrying angle; Cubitus Varus; Forearm length; Height; Supracondylar fracture.

Introduction

The males' wide shoulders and small hips allow the arms to hang straight downward, with the long axes of the upper and lower segments roughly in the same straight line. In contrast, the female body type necessitates a splaying out of the forearm axis in order to allow the dangling arms to clear the hips due to the narrower shoulders and wider hips. Hooton's (1946) finding served as the foundation for the "carrying angle" theory.¹

In anatomical position, the forearms are often inclined slightly outward in relation to the arm's line, which is known as the carrying angle.² A carrying angle of 10-15° is typical. If it is less than five degrees and more than 15°, it is referred to as cubitus valgus malformation.³

The superior articular surface of the coronoid process of the ulna is positioned oblique to the long axis of the bone, which is the fundamental factor generating the carrying angle, and the medial flange of the humerus' trochlea is six millimeters deeper than the lateral flange.⁴ Fick (1911) claimed that the brachioradialis and extensor carpi radialis longus are two potent muscles responsible for the outward deviation of the forearm.⁵ These muscles help generate the carrying angle since they are situated on the radial side, which allows them to radially abduct the forearm. When the forearm is supinated, the elbow is fully extended, and the shoulder is externally rotated, the angle is most noticeable and easiest to observe.⁶ This angle is neutralized if the forearm pronates or flexes from an extended or supinated posture.⁷

In 1895, Potter first noticed the sex difference of carrying angle and discovered that carrying angle was more noticeable in women. Braune and Kyrklund first described the angle in 1879.^{8,9} The hormonal contribution and increased joint laxity that allow for a

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greater degree of extension may be the cause of this increased carrying angle. The carrying angle is completely developed in newborns and is present even throughout pregnancy.¹⁰

The dominant arm's carrying angle is larger than the non-dominant arm.^{11,12} The disparity between the right and left carrying angles is caused by ligamentous laxity at the medial elbow and asymmetrical bone development.¹³ Greater angle in the dominant arm may be the result of force imposed on the dominant limb, bone remodeling to accommodate that stress, and increased muscle development.¹⁴ From childhood to adolescence, carrying angle rises with age¹⁵. They discovered that the angle grows up to the age of 15, following which it remains consistent throughout an individual's lifespan. The carrying angle may alter with skeletal maturation and growth.¹⁶ When walking and swinging an upper limb while carrying anything, carrying angle allows the forearms to clear the hips¹⁰. The slightest deviation from the ideal carrying angle restricts the motion of the elbow joint and puts the elbow at risk of fracturing easily.¹⁶ Non-traumatic ulnar neuropathy is also brought on by an increased carrying angle.¹⁷ The objective of the study was designed to evaluate the carrying angle in normal adolescents of Bangladesh and to see its correlation with height and forearm length in both sexes.

Materials and methods

This cross-sectional analytical study was conducted in Anatomy Department, Chittagong Medical College, Chattogram from July 2019 to June 2020. After getting consent from the local ethical review committee, 200 (100 male and 100 female) adolescents were selected by convenient sampling technique from Prabartak School and College of Chattogram, Bangladesh. Participants were Bangladeshi by nationality, with normal body structure and were interested to be in the study. Adolescents with metabolic bone disease, history of injury, dislocation, surgery or any sort of deformity or congenital malformation of upper limb were excluded. After taking demographic data, the carrying angle of both sides, height and forearm length were measured by the same observer and with the same instruments to avoid any technical or interobserver error.

Procedure of Measurement of Carrying Angle

The carrying angle was measured with a goniometer. Participants were instructed to stand straight, forearm extended and supinated, with arm abducted. The goniometer's fulcrum was positioned in the cubital crease, the fixed arm was positioned along the median arm axis, and the moveable arm was positioned along

the forearm axis. The median axis of the arm and the forearm were identified anatomically by the bicipital groove, the biceps brachii tendon at its insertion, and the palmaris longus tendon at the wrist, respectively. In the measuring plate, the angle was measured from the body's right and left sides.¹³



Figure 1 Procedure of measurement of carrying angle

Procedure of Measurement of Height

The individual was instructed to stand with his or her toes apart, heels together and back as straight as possible. To gauge someone's height, they should stand such that their heels, buttocks, shoulders and heads all touch the wall. The participant was instructed to take off any headwear, jewelry, buns or braids. The participant's arms were left hanging at the sides, palms towards the thighs, and the participant's head was positioned in the Frankfort horizontal plane. To ascertain the maximum height or stature on the wall, a steel plate was placed against the head and marked with a black pencil. After that, the subject was instructed to back away from the wall. The height was then assessed using a measuring steel tape.



Figure 2 Procedure of measurement of stature

Procedure of Measurement of Forearm Length

Both upper limbs were exposed up to midarm while an individual was instructed to stand straight with their feet together. The forearm was fully extended at the elbow with the palm facing forward when the arm was abducted. The observer stood in front of the object of observation. Holding the zero of the measuring tape at the mark and extending the tape upward toward the tip of the styloid process of the ulna (Bony prominence at the medial aspect of the wrist joint), the bony prominence on the most medial aspect of the elbow joint, also known as the medial epicondyle, was palpated and marked. Centimeters were used to mark and record the measurement. The forearm length is as shown. This method involved measuring both forearms.¹⁸



Figure 3 Procedure of Measurement of Forearm Length

All collected data were summarized by SPSS (Statistical Package for Social Science) version-25 software. Quantitative data was expressed as mean ± Standard Deviation (SD) and correlation was ascertained by Pearson’s correlation test. p value was considered significant if it was <0.05 at 95% level of confidence.

Results

Mean carrying angle of right side was 13.070 ± 1.565 degree in male and 15.190 ± 2.077 degree female. Mean carrying angle of left side was 12.010 ± 1.547 degree and 13.940 ± 1.963 degree in male and female

respondents respectively. Mean carrying angle of right side was greater than left side both in male and female. Mean height was 166.760±4.934 cm in male and 157.570±4.321 cm in female. In male mean forearm length was 26.380±1.733 cm in right side and 26.400±1.721 cm in left side. In female mean forearm length was 25.330±1.352 cm in right side and 25.155±1.370 cm in left side. All these measurements were greater in male than female (Table-I).

Table I Values of measurement of variables among male and female (n=200)

Variables	Sex	
	Male (n=100)	Female (n=100)
	Mean ± SD	Mean ± SD
Carrying angle of right side in degree (°)	13.070 ± 1.565	15.190 ± 2.077
Carrying angle of left side in degree (°)	12.010 ± 1.547	13.940 ± 1.963
Height (cm)	166.760±4.934	157.570±4.321
Forearm length (cm) (Right side)	26.380±1.733	25.330±1.352
Forearm length (cm) (Left side)	26.400±1.721	25.155±1.370

Pearson's correlation coefficient test was done to see correlation, as data was normally distributed. There was significant positive correlation between height and carrying angle among both the male and female respondents but no significant correlation between forearm length and carrying angle among neither the male nor the female respondents (Table-II and III).

Table II Correlation of height and forearm length with carrying angle among the male respondents (n=100)

Variables		Correlation coefficient (r)	r ²	p value
Height	Right side	0.208	0.043	<0.05
	Left side	0.242	0.059	<0.05
Forearm length	Right side	0.176	0.031	>0.05
	Left side	0.190	0.036	>0.05

p value <0.05 = Significant, p value >0.05 = Non significant.

Table III Correlation of height and forearm length with carrying angle among the female respondents (n=100)

Variables		Correlation coefficient (r)	r ²	p value
Height	Right side	0.223	0.050	<0.05
	Left side	0.251	0.063	<0.05
Forearm length	Right side	0.177	0.031	>0.05
	Left side	0.178	0.032	>0.05

p value <0.05= Significant, p value >0.05 = Non significant.

Discussion

This study revealed mean carrying angle of right side was greater in female respondents than in male respondents (15.19 ± 2.077 degree vs. 13.07 ± 1.565 degree). Mean carrying angle of left side was also greater in female respondents than in male respondents (13.94 ± 1.963 degree vs. 12.01 ± 1.547 degree). The finding of present study is similar to finding of some other studies.^{12,13} This increased carrying angle in female may be due to hormonal influences and increased joint laxity in female permitting greater degree of extension and smaller olecranon-coronoid angle or more projection of olecranon process of female is the cause of greater carrying angle in female.^{13,19} In another study the mean carrying angle among male population in right hand was 10.740 ± 2.82 and in left hand as 10.050 ± 2.79 with the smaller mean value in females as 10.590 ± 2.45 in right hand and 9.690 ± 2.38 in left hand without significant differences ($p=0.743$ of right side and 0.450 of left side).¹¹ These results have shown dissimilarity with this study. This dissimilarity may be due to difference in age group of study subjects and sample size variations. Difference between right and left carrying angle is due to ligamentous laxity at medial elbow and asymmetrical bony growth and greater angle in dominant arm may be due to imposed stress over the dominant limb, bony remodeling to adapt to that stress and more development of muscles.¹⁴ But the finding of other is contradictory to present study findings.⁷ They found greater carrying angle in non-dominant arm.

In present study, in case of male, significant positive correlation of right carrying angle with height ($r=0.208$, $r^2=0.043$, $p=0.038$) and also of left carrying angle with height ($r=0.242$, $r^2=0.059$, $p=0.015$) are revealed. Correlation analysis of height with carrying angle in case of female also reveals significant positive result in right and left. Here for right carrying angle values are as $r=0.223$, $r^2=0.050$, $p=0.026$ and for left carrying angle $r=0.251$, $r^2=0.063$, $p=0.012$. Oladipo et al. (2019) have shown significant positive ($p<0.01$) correlation of height with right and left carrying angle in both gender (height and right carrying angle male $r=0.49$, $r^2=0.24$, female $r=0.43$, $r^2=0.18$, height and left carrying angle male $r=0.32$, $r^2=0.10$, female $r=0.44$, $r^2=0.19$).²⁰ Shiva et al. found non-significant positive correlation among height and carrying angle at right side ($r=0.040$, $p=0.762$) and carrying angle at left side ($r=0.068$, $p=0.603$).²¹ These studies have shown similarity with the present study. Thejeshwari et al. found significant negative correlation of height with degrees of left carrying angle (Height and left carrying angle male $r=-0.68$, female $r=-0.74$) and right carrying angles (Height

and right carrying angle male $r=-0.67$, female $r=-0.73$). In both the sexes values were highly significant ($p < 0.01$).²² According to Kothapali et al. in female height is non significantly negatively correlated with carrying angle in both sides (height and right carrying angle $r=-0.083$, $p=0.38$, height and left carrying angle $r=-0.057$, $p=0.55$) and in male there is non-significant positive correlation of carrying angle of right side and non-significant negative correlation of carrying angle of left side with height. (Height with right carrying angle $r=0.014$, $p=0.88$, height with left carrying angle $r=-0.030$, $p=0.75$).⁵ Both the results have shown dissimilarity with present the study.

In male, this present study shows the non-significant positive correlation of carrying angle of right side with forearm length of right side ($r=0.176$, $r^2=0.031$, $p=0.079$) and non-significant positive correlation of carrying angle of left side with forearm length of left side ($r=0.190$, $r^2=0.036$, $p=0.058$). In case of female it is also non-significant positive correlation of carrying angle of right side of female with forearm length of right side ($r=0.177$, $r^2=0.031$, $p=0.078$) and non-significant positive correlation of carrying angle of left side with forearm length of left side ($r=0.178$, $r^2=0.032$, $p=0.076$). Similar result was found in the study by Shiva et al. where non-significant positive correlation of right forearm length and carrying angle at right side was ($r=0.070$, $p=0.596$) and left forearm length and carrying angle at left side was ($r=0.830$, $p=0.528$) was found.²¹ Kothapali et al. suggested similar findings in female that is non-significant positive correlation between forearm length and carrying angle but in male significant negative correlation between forearm length and carrying angle (Female right forearm length and right carrying angle: $r=0.188$, $p=0.49$, left forearm length and left carrying angle: $r=0.216$, $p=0.23$, male: right forearm length and right carrying angle: $r=-0.199$, $p=0.03$, left forearm length and left carrying angle: $r=-0.198$, $p=0.03$).⁵ Bari et al. have shown no correlation between carrying angle and length of the forearm in either sex.²³ According to Kazi et al. in female right carrying angle have shown non significant negative with forearm length ($r=-0.023$, $p=0.84$) but left carrying angle have significant negative correlation ($r=-0.225$, $p=0.042$) and both sided carrying angle of male have significant negative correlation with forearm length (Right carrying angle and right forearm length: $r=-0.269$, $p=0.012$, left carrying angle and left forearm length: $r=-0.265$, $p=0.014$).¹³

Limitation

In a short period of time, the study was carried out in a particular location. Therefore, the study's findings might not fully reflect the typical reference levels for

the entire population of healthy Bangladeshi adolescents. The study used a manual measurement process that would have resulted in a small measurement error and the possibility of skin damage, which might have been prevented with a computer-based method.

Conclusion

These findings point out that women have significantly greater carrying angles on both sides than men. Male and female respondents showed a non-significant positive correlation with forearm length, but a substantial positive correlation between height and carrying angles on both sides. When treating and monitoring a pediatric elbow disease, an orthopedic surgeon should take into account the typical reference values. Biomedical engineers should do the same when creating elbow prostheses.

Recommendation

To create a more acceptable standard carrying angle value and ensure that the study is truly representative, a similar study can be carried out over an extended period of time with a sizable sample size drawn from various regions of Bangladesh. Digital goniometry can be used to increase measurement accuracy for carrying angles.

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Disclosure

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References

1. Mbagwu SI and Aligwekwe AU. Carrying Angle of an Adult Nigerian Population. *International Journal of Research (IJR)*. 2014; 1(4): 8-15.
2. Blom A, Warwick D, Whitehouse M, Solomon L. *Apley & Solomon's system of orthopaedics and trauma*. 10th ed. Bristol, UK: CRC Press. 2018: 779.
3. David J. Magee, *Elbow, Orthopedic Physical Assessment*, 6th edition, St. Louis-Missouri, Saunders-Elsevier Inc. 2014; 392-393.
4. Standring S., *Pectoral girdle and upper limb*, Susan Standring & Neil R. Borley, 'Gray's Anatomy, The Anatomical Basis of Clinical Practice'. 40th ed, Spain, Churchill, Livingstone, Elsevier. 2008; 1427.
5. Kothapalli J, Murudkar PK, Seerla LD. The carrying angle of elbow- a correlative and comparative study. *IJCRR*. 2013; 5(7):71-76.
6. Zampagni M L, Casino D, Martelli S, Visani A, Marcacci M. A protocol for clinical evaluation of the carrying angle of the elbow by anatomic landmarks, *Journal of shoulder and elbow surgery*. 2008; 17(1): 106-112.
7. Sharma K, Mansur D I, Khanal K, Haque M K. Variation of Carrying Angle with Age, Sex, Height and Special Reference to Side. *Kathmandu University of Medical Journal*. 2013; 11(4): 315-318.
8. Potter Hp. The Obliquity of the Arm of the Female in Extension. The Relation of the Forearm with the Upper Arm in Flexion. 1895;29(Pt 4):488-491.
9. 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*. 2003;26: 19-23. DoI:10. 1007/s00276-003-0185-z.
10. Yadav S K, Malla B K, Srivastava A K, Verma A, Kumar A. An Anthropometric Study Of Carrying Angle And Other Parameters In Young Adults Of Kathmundu, Nepal', *Revista Român de Anatomie func•ional•i clinic•, macro- •i microscopic• •i de Antropologie*. 2018; XVII(2): 99-105.
11. Pandeya A, Timalisina B, Khadka B, Chaudhary D, Sah S K. Carrying Angle and its Variations with Anthropometric Parameters among the Medical Students of Rupandehi District, Nepal', *Saudi J. Med. Pharm. Sci*, 2017;3(10A): 1043-1046.
12. Bhat M A, Bhat T A, Ganie P A, Mir W A. Comparative study of carrying angle between dominant and non-dominant limb in Kashmiri population, *International Journal of Contemporary Medical Research*. 2019; 6(6): F1-F3.
13. Kazi S, Keche H A, Joshi P K, Wanjari A N. The Comparison and Evaluation of Carrying Angle of Elbow with Anthropometric Measurements in Both Sexes, *International Journal of Anatomy and Research*. 2017; 5(4.3): 4686-4690.
14. Imtiaz GY, Sharon N and Malarvizhi D. To Compare the Efficacy of Variation of Carrying Angle in Normal College Students VS Sportsmen Using Hand Activities. *Indian Journal of Research*. 2018; 7(4): 105-107.
15. Kumari K. L. and Sekhar R. C., A Comparative Study of Carrying Angle between Children and Adult in Andhra population, *IOSR journal of dental and medical sciences*. 2016; 15(6): 33-36.

- 16.** Srivastava A. K. and Solanki S., Comparative Study of Goniometric and Radiographic Carrying Angle in Human, *International Journal of Science and Research*. 2015; 4(2): 292-294.
- 17.** Chinweife K. C., Ejimofor O. C. and Ezejindu D. N., Correlation of Carrying Angle of the Elbow in Full Extension and Hip-Circumference in Adolescents of Nnewi People in Anambra State, *International Journal of Scientific and Research Publications*. 2014; 4(10): 1-8.
- 18.** Rajesh B, Reshma V R, Jaene R C, Somasekhar I T, Vaithilingam A. An evaluation of carrying angle of the elbow joint in adolescents. *International Journal of Medicine and Biomedical Research*. 2013; 2(3): 221-225.
- 19.** Purkait R, Chandra H. An Anthropometric Investigation into the Probable Cause of Formation of 'Carrying Angle': A Sex Indicator, *Journal of Indian Academy of Forensic Medicine*. 2004; 26(1): 14-19.
- 20.** Oladipo et al. (2019) (Oladipo G S, Paul J N, Amasiatu V C, Alabi A S, Amadi P N. An examination of carrying angle of students in Madonna University. Elele, Port Harcourt, Rivers State, Nigeria. *Journal of applied Biotechnology and Bioengineering*. 2019;6(2): 95-99. DOI: 10.15406/jabb.2019.06.00179.
- 21.** Shiva PSS, Amardeep G and Manjappa CN. Evaluation of the carrying angle of the elbow joint in children's and adolescents and its correlation with various parameters. *International Journal of Orthopaedics Science*. 2017; 3(3): 996-999.
- 22.** Thejeshwari HG, Makandar UK, Rajendra R, The correlative study of degrees of carrying angle with height of body in both the sexes of south Indian population. *Indian J Clin Anat Physiol*. 2017;4(3):369-372.
- 23.** Bari W, Alam M, Omar S. Goniometry of elbow carrying angle: a comparative clinical study on sexual dimorphism in young males and females. *International Journal of Research in Medical Sciences*. 2015;3482-3484.