

Variation of Carrying Angle of Elbow in Relation to Age, Sex and Dominant Arm in Adolescent Bangladeshi Population

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Abstract

Background: Elbow carrying angle changes with skeletal growth and maturity, helps in carrying objects and keeps upper limb away from pelvis during movement. Variation of carrying angle value has been observed in relation to age, gender, and some selected anthropometric parameters. Present study was aimed to evaluate the carrying angle in normal adolescents of Bangladesh in relation to age, gender, and hand dominance.

Materials and methods: This cross-sectional observational study was conducted in the Department of Anatomy, Chittagong Medical College, Chattogram, upon 100 male and 100 female adolescents (10-19 years) by dividing them into two groups (Group A: 10-15 years, Group B: 16-19 years) and all were right hand dominant. Recorded data were analyzed by using SPSS version 25. For statistical analysis unpaired student's 't' test was done. p value was considered significant if it was <0.05 at 95% level of confidence.

Results: Carrying angle of both sides was significantly higher in age group 16 to 19 years and in female (p<0.001) also significant greater value found in dominant hand (p<0.001).

Conclusion: Knowledge of normal carrying angle value is important for management of elbow fracture, designing of total elbow prosthesis, and differentiation of sex in skeletal remain in medicolegal purpose.

Key words: Adolescent; Carrying angle; Dominant hand.

Introduction

In anatomical position, that is when the elbow is fully extended and forearm is supinated, the forearm does not lie in same line with the arm. It

deviates lateral to the arm axis forming carrying angle. Males have a normal carrying angle of 5°-10°, whereas females have a higher carrying angle value of 10°-15°. This angle is called cubitus valgus if it is greater than 15 degrees, and cubitus varus if it is less than 5 degrees.¹

Two important anatomical factors for formation of the carrying angle are superior articular surface of the coronoid process of the ulna is oblique to the long axis of the bone, and the medial flange of the trochlea of the humerus is 6mm deeper than the lateral flange.² The angle is most apparent and best seen during the external rotation of shoulder and when the elbow is completely extended, and forearm is supinated.³ If the forearm becomes flexed or pronated from extended or supinated position, this angle is neutralized.⁴

According to some study carrying angle increases with age from childhood to adolescents. They revealed that the angle increases up to the age of 15 years there after it remains constant for the lifetime of individual.⁵ Other suggested that the carrying angle changes with skeletal growth and maturity and increases with age up to 15 years after which there is a slight drop in the angle.⁶ Potter (1895) first observed the sex difference and found that the mean carrying angle is 5.80° greater in woman than men (in women it is 12.60° and in men 6.80°).⁷ Sex difference is more prominent during puberty period.⁸

Increased carrying angle may cause reduction of degree of elbow flexion, instability at elbow joint causing easy elbow dislocation, elbow pain during exercise and throwing sport activity.⁶ Carrying angle value varies with age, sex, arm length, forearm length, Height, BMI, hip circumference and waist circumference.⁸⁻¹³ Carrying angle may also vary with race and ethnicity and between normal person and athletes.¹⁴⁻¹⁵

Materials and methods

This cross-sectional observational study was carried out in the Anatomy Department of Chittagong Medical College, Chattogram. Approval was taken from ethical review committee of

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Chittagong Medical College. Right-hand dominant subjects were confirmed by asking and observing the skills of both hands. All the participants were Bangladeshi by nationality, having normal bony configuration and were interested to participate in the study. Adolescents with metabolic bone disease, history of any injury, dislocation, surgery or any kind of deformity or congenital malformation of upper limb, tribals were excluded. As per enrollment criteria 200 (100 male and 100 female) adolescents were selected by convenient sampling technique from Prabartak School and College, Chattogram, Bangladesh. Participants were divided into two groups. Group A included participants of age 10 to 15 years (Not more than 15 years) and Group B included participants aging from 16 to 19 years. The study was carried out during the period from July 2019 to June 2020. For age determination, the date of birth of participants was confirmed from school and college records. After taking demographic data, the carrying angle of both sides was measured by the same observer and with the same instrument to avoid any technical and/or interobserver error.

Procedure of Measurement of Carrying Angle

An improvised instrument goniometer was used to measure the carrying angle. Participants were asked to stand erect, with arm adducted, forearm fully extended and supinated with palm facing forwards. The fulcrum of the goniometer was placed in the center of the cubital crease (Midway between medial and lateral humeral epicondyle). The fixed arm of goniometer was aligned along the median axis of arm and the moveable arm was adjusted with the median axis of forearm. Bicipital groove, biceps brachii tendon at its insertion and palmaris longus tendon at the wrist were palpated and marked as anatomical landmark to demarcate the median axis of arm and the forearm respectively (Figure 1). The angle was measured from measurement plate. The reading of the angle was taken from both the right and left side of the body to find out any difference.¹⁰

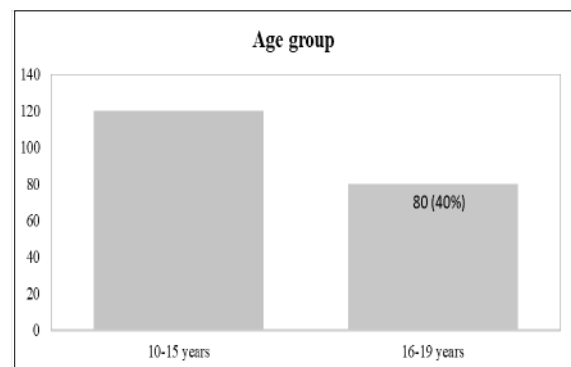


Figure 1 Procedure of carrying angle measurement

All collected data were entered into computer and analyzed by SPSS (Statistical Package for Social Science) version-25 software program. Relationships between numerical variables were found out by the unpaired “t” test. $p < 0.05$ was considered as statistical significance in 95% level of confidence interval.

Results

The age of the respondents ranged from 10-19 years with the mean \pm SD age of 14.54 ± 2.835 years. There were 120 (60%) participants in age group of 10-15 years with mean \pm SD age of 12.60 ± 1.779 years and 80 (40%) participants in the age group of 16-19 years with mean \pm SD age of 17.44 ± 1.123 years (Figure 2).



Mean \pm SD = 14.54 ± 2.835

120 (60%)

Figure 2 Bar diagram showing age distribution of the respondents (n=200)

Mean carrying angle of right side was 13.117 ± 1.875 degree and 15.650 ± 1.459 degree in respondents of age group from 10 to 15 years and from 16 to 19 years respectively. There was a very highly significant difference of mean carrying angle of right side among the different age groups ($p < 0.001$). Mean carrying angle of left side was 12.042 ± 1.835 degree in respondents of age group from 10 to 15 years and 14.375 ± 1.344 degree in respondents of age group from 16 to 19 years. This difference of mean carrying angle of left side among the different age groups was very highly significant ($p < 0.001$) (Table-I).

Table I Carrying angle of right side and left side among different age group (n=200)

Age	Carrying angle of right side in degree (°) Mean \pm SD	p-value	Carrying angle of left side in degree (°) Mean \pm SD	p-value
10-15 years (n=120)	13.117 ± 1.875	$p < 0.001$	12.042 ± 1.835	$p < 0.001$
16-19 years (n=80)	15.650 ± 1.459		14.375 ± 1.344	

p value < 0.001 = Very highly significant.

Mean carrying angle of right side was 13.070 ± 1.565 degree and 15.190 ± 2.077 degree in male and female respondents respectively. There was a very highly significant difference of mean carrying angle of right side between male and female ($p < 0.001$). Mean carrying angle of left side was 12.010 ± 1.547 degree in male respondents and 13.940 ± 1.963 degree in female respondents. The difference of mean carrying angle of left side between male and female was highly significant ($p < 0.001$) (Table-II).

Table II Carrying angle of the right side and left side between male and female (n=200)

Sex	Carrying angle of right side in degree (°) Mean \pm SD	p-value	Carrying angle of left side in degree (°) Mean \pm SD	p-value
Male (n=100)	13.070 ± 1.565	$p < 0.001$	12.010 ± 1.547	$p < 0.001$
Female (n=100)	15.190 ± 2.077		13.940 ± 1.963	

p value < 0.001 = Very highly significant.

Mean carrying angle was 14.155 ± 2.126 degree in dominant arm and 12.950 ± 1.989 degree in non-dominant arm. Mean carrying angle between dominant arm and non-dominant arm was highly significant ($p < 0.001$) (Table-III).

Table III Comparison of carrying angle between dominant and nondominant arms (n=200)

Arm type	Carrying angle in degree (°)		p-value
	Mean	Standard deviation	
Dominant (n=200)	14.155	± 2.126	$p < 0.001$
Non-dominant (n=200)	12.950	± 1.989	

p value < 0.001 = Very highly significant.

Discussion

In the present study, the mean carrying angle of right side was smaller in respondents of age group from 10 to 15 years than in respondents of age group from 16 to 19 years (13.117 ± 1.875 degree vs 15.650 ± 1.459 degree). Mean carrying angle of left side was smaller in respondents of age group from 10 to 15 years than in respondents of age group from 16 to 19 years (12.042 ± 1.835 degree vs 14.375 ± 1.344 degree). There was very highly significant difference of mean carrying angle of both right side and left side among the different age groups ($p < 0.001$). The finding of a study conducted in Mandya, India is quite similar with present study finding.¹⁶ They have compared the carrying angle between two age groups (5-12 years and 13-18 years) and found there was very highly significant difference ($p < 0.001$) between them with carrying angle of $9.97^0 \pm 2.71$, $11.93^0 \pm 2.62$ on right side and $9.33^0 \pm 2.86$, $11.57^0 \pm 2.38$ on left side respectively.¹⁶ This change of Carrying angle with age is more likely due to osseous development instead of surrounding soft tissue structure.¹⁷ On the other hand, there was a study conducted on school going children of south India aged 5-18 years, were divided into 5 groups like (5-6, 8-9, 11-12, 14-15, 17-18) years and found that the carrying angle increases with age up to 15 years, following which there is slight fall in angle.⁹ They described that the possible cause of this decrease may be the continuation of the growth of upper humerus and lower forearm. This study shows dissimilarity with present study.

This study revealed mean carrying angle of right side was smaller in male respondents than in female respondents (13.070 ± 1.565 degree vs 15.190 ± 2.077 degree). Mean carrying angle of left side was also smaller in male respondents than in female respondents (12.010 ± 1.547 degree vs 13.940 ± 1.963 degree). There was a very highly significant difference of mean carrying angle of

both right side and left side between male and female ($p < 0.001$). The finding of present study is similar to finding of some other studies.^{10,18} 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.^{10,8} In another study the mean carrying angle among male population in right hand and left hand was 10.740 ± 2.82 and 10.050 ± 2.79 degree respectively with the lower mean value in female population in right and left hand was 10.590 ± 2.45 and 9.690 ± 2.38 degree respectively, 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.

According to present study, mean carrying angle was 14.155 ± 2.126 degree in dominant arm and 12.950 ± 1.989 degree in non-dominant arm. Difference between mean carrying angle value between dominant arm and nondominant arm was very highly significant ($p < 0.001$). The result of present study is consistent with some studies.^{11,18,19} 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.²⁰ But the finding of other is contraindicatory to present study findings.⁴ They found greater carrying angle in non-dominant arm.

Limitations

We conducted the study in a selected area within short time frame. So, the result obtained from the present study may not be fully representative of the normal reference values for the whole population of normal Bangladeshi adolescents. The study was based on manual measurement procedure, that may have produced minor error of measurement, and chance of skin injury, that could have been avoided by computer-based method.

Conclusion

Based on these results it may be concluded that carrying angle of both sides is significantly greater in female than male; in dominant arm than non-dominant one; and significantly greater in late adolescent group than early one. The normal reference value should be considered by an orthopedic surgeon to manage and to follow up pediatric elbow related disorder, and by the biomedical engineers during designing elbow prosthesis.

Recommendation

Similar study can be done for long duration with large sample size selected from different parts of Bangladesh, for developing more acceptable standard carrying angle value to make the study fully representative. For increasing reliability of carrying angle measurement digital goniometry can be done.

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Contribution of author

UR- Conception, design, acquisition of data, interpretation of data, drafting and final approval.
 MA- Conception, design, manuscript writing and final approval.
 BB- Conception, data collection, critical revision and final approval.
 MH- Conception, manuscript writing, critical revision and final approval.
 RC- Conception, data collection, data analysis, manuscript writing and final approval.
 SS- Design, data collection, data analysis and final approval.

Disclosure

All the authors declared no competing interests.

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