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Original Research Paper

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CARRYING ANGLE OF ELBOW IN INDIAN CHILDREN - WHAT IS THE NORM?

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ABSTRACT

INTRODUCTION: Knowledge of normal value of carrying angle is important while managing injuries around elbow. However there is paucity of literature documenting carrying angle in Indian children. Influence of various factors like age, sex, height, weight on carrying angle is still debated. With this study we tried to bridge this gap in knowledge.

MATERIALS AND METHODS: We conducted cross sectional study of 1893 children in the age group of 3 to 15 years. Student having history of previous fractures, orthopaedic deformities, neurological conditions were excluded. To assess the effect of the age, the patients were separated into five cohorts: 3 to 5, 5 to 7, 7 to 9, 9 to 11, 11 to 13 and 13 to 15. The carrying angle of elbow was measured using universal standard extendable goniometer. To avoid interobserver variability, all measurements were recorded by a single orthopaedic surgeon with 5 years postgraduate experience.

RESULT: Carrying angle was more in females 9.67 (SD 3.16) compared to males 8.33 (SD 2.63). . We observed increasing value of carrying angle with age. Pearson correlation coefficient showed carrying angle had positive correlation with age ($r= 0.5$, $P< 0.001$), height($r= 0.5$, $P< 0.001$). However BMI Z score, which is weight adjusted for age and sex did not show any correlation with carrying angle and no significant difference was noted between carrying angle on right and left side.

DISCUSSION: Finding of our study differed with available literature in respect to lower value of carrying angle in both males and females. We did not found changes in carrying angle on left or right side in contrast to previous studies showing larger carrying angle in dominant side. Further studies with larger sample size are required in this aspect.

KEYWORDS : Carrying Angle Of Elbow, Indian Children

INTRODUCTION:

Fractures around elbow joint like supra condylar humerus fracture are one of the common injuries occurring in children. These injuries affect carrying angle, which is an angle formed between forearm and arm with elbow fully extended and forearm fully supinated [1]. If these fractures are not properly managed, can lead to unsightly cosmetic appearance of the elbow [2]. While managing these fractures we need to know average value of carrying angle in a particular age group to avoid deformity. The carrying angle permits the arm to swing without contacting the hips [3, 4] .Women on average have smaller shoulders and wider hips than men, which may necessitate a more acute carrying angle [3]. There is, however, extensive overlap in the carrying angle of men and women, and a sex-bias has not been consistently observed in scientific studies[3,4,5]

There is paucity of literature documenting normal value of carrying angle in Indian children. Influence of various factors like age,sex, height,weight on carrying angle of elbow is still debated. Some articles describes that carrying angle increases with age while others have noted that carrying angle is more in females compared to males [6,7,8]. There are few studies observing no change in carrying angle in different genders [9,10,11]. We tried to address this problem with our study.

MATERIALS AND METHOD:

We conducted cross sectional study of 1893 children in the age group of 3 to 15 years. The study was conducted in school going children in urban area i.e. Mumbai. Necessary permission was taken from our institute and school authorities. All students studying from kindergarten to 10th standard were included. Student having history of previous fractures, orthopaedic deformities, neurological conditions were excluded. To assess the effect of the age, the patients were separated into five cohorts: 3 to 5, 5 to 7, 7 to 9, 9 to 11, 11 to 13 and 13 to 15. Age group wise distribution of participants is given in table 1.Body weight and heights were measured by a single person. For measuring of body weight - digital weighing scale with regular calibration was used while for height- wall mounted measuring tape was used with the patient in upright position.

The carrying angle of elbow was measured using universal standard extendable goniometer. All the measurements were recorded with the student sitting comfortably erect in armless chair with the back supported, thighs parallel and feet flat on the ground. The elbow was maintained at neutral, forearm in full supination and the wrist at neutral. The Hinge of goniometer was placed midway between the medial and lateral humeral condyles in the centre of the cubital crease as shown in fig 1. Lateral edge of the acromion and the midpoint of the radial and ulnar styloid are used as landmarks for proximal and distal arms of goniometer. Carrying angle was measured off the dial at the centre of the goniometer, to the nearest degree. To avoid interobserver variability, all measurements were recorded by a single orthopaedic surgeon with 5 years postgraduate experience.

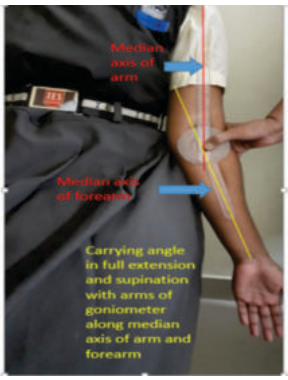

fig 1- position of elbow to measure carrying angle of elbow.

RESULT:

We studied carrying angle of elbow in 1893 children which included 983 males and 910 females in age group of 3 to 15 years (table 1, 2).

Table 1: Distribution of Study Subjects according to their Age Group (N = 1893)

Age (in Years)	No.	Percent
3-5	232	12.2
5-7	234	12.3
7-9	390	20.5
9-11	338	17.8
11-13	394	20.7
13-15	305	16.0
Mean (SD)	9.74 (3.42)	
Range	3.0-16.0	

Table 2: Distribution of Study Subjects according to the Gender (N=1901)

Gender	No.	Percent
Male	983	51.9
Female	910	48.1

Mean values categorised by age, gender and side are shown in table 3 and 4.

Table 3: Comparison of Parameters with Age (N=1893)

Age (Years)	Parameter	
	Carrying Angle (R) Mean (SD)	Carrying Angle (L) Mean (SD)
3-5	6.25 (2.33)	6.62 (2.20)
5-7	7.57 (2.34)	7.97 (2.49)
7-9	7.87 (1.97)	8.07 (2.03)
9-11	9.06 (2.72)	9.03 (2.85)
11-13	10.55 (2.93)	10.55 (3.05)
13-15	11.00 (2.58)	10.80 (2.56)
P Value	<0.001*	<0.001*
	ANOVA (Analysis of Variance)	

Table 4: Comparison of Parameters with Age and Gender (N=1893)

Age (Years)	Carrying Angle (R) Mean (SD)		Carrying Angle (L) Mean (SD)	
	Male	Female	Male	Female
3-5	6.18(2.33)	6.34 (2.35)	6.36 (2.30)	6.92(2.05)
5-7	7.09 (1.95)	8.10 (2.61)	7.46 (2.15)	8.52(2.73)
7-9	7.66(1.87)	8.14 (2.07)	7.75(1.90)	8.49(2.12)
9-11	8.21(2.26)	9.97 (2.88)	8.16(2.38)	9.97(3.02)
11-13	9.64(2.61)	11.34(2.98)	9.79(2.83)	11.20(3.09)
13-15	10.15(2.33)	11.91(2.52)	10.01(2.40)	11.63 (2.46)

The data was entered into Microsoft Excel (Windows 7; Version 2007) and analyses were done using the Statistical Package for Social Sciences (SPSS) for Windows software (version 22.0; SPSS Inc, Chicago). Data was checked for normality by using Shapiro-Wilk test .Continuous data are presented as means with the range or Standard deviation (SD). To know correlation between quantitative variables like age, height, weight with carrying angle, Pearson's correlation coefficient was calculated. To know correlation of qualitative variable i.e. gender with carrying angle, unpaired t test was used while we used paired t test to compare carrying angle of dominant and non-dominant side. ANOVA (Analysis of Variance) was used to compare carrying angle across different age groups. P value less than 0.05 considered significant.

Carrying angle was more in females 9.67 (SD 3.16) compared to males 8.33 (SD 2.63) with unpaired student t test showing this difference was significant with P value less than 0.001 (Table 5).

Table 5: Comparison of Parameters with Gender (N=1893)

	Gender		P Value
	Male (n=983) Mean (SD)	Female (n=910) Mean (SD)	
Carrying Angle (R)	8.28 (2.60)	9.62 (3.23)	<0.001*
Carrying Angle (L)	8.37 (2.65)	9.72 (3.09)	<0.001*
Unpaired t Test, P Value *Significant			

We observed increasing value of carrying angle as the age increases. ANOVA test showed this association was significant with P value less than 0.001(Table 3). Pearson correlation coefficient showed carrying angle had positive correlation with age (r= 0.5, P< 0.001) (table 6.1), height(r= 0.5, P< 0.001) (table 6.2) and weight(r= 0.5, P< 0.001) (table 6.3).

Table 6.1: Pearson Correlation between Age and Other Parameters (N=1893)

Age (in Years)	Correlation Coefficient	P Value
Carrying Angle (R)	0.536	<0.001*
Carrying Angle (L)	0.478	<0.001*

Table 6.2: Pearson Correlation between Height and Other Parameters (N=1893)

Height	Correlation Coefficient	P Value
Carrying Angle (R)	0.527	<0.001*
Carrying Angle (L)	0.470	<0.001*

Table 6.3: Pearson Correlation between Weight and Other Parameters (N=1893)

Weight	Correlation Coefficient	P Value
Carrying Angle (R)	0.513	<0.001*
Carrying Angle (L)	0.462	<0.001*

However no significant difference was noted between carrying angle on right and left side (table 7).

Table 7: Comparison of Parameters between right and left side (N=1893)

	Side		P Value	Correlation
	Right Mean (SD)	Left Mean (SD)		
Carrying Angle	8.92 (2.99)	9.02 (2.95)	0.005*	0.877
Paired t Test				

DISCUSSION:

We studied normal values of carrying angle of elbow in different age groups. We tried to analyse effects of various variables like age, gender, height and weight on these values. We also analysed whether these values varies between right and left side of an individuals or not. Our study was conducted on large sample size with even distribution of age and gender, thus representative of general population and minimising selection bias.

We observed that mean value of carrying angle was more in females (mean 9.67, SD 3.16) compared to males (mean 8.33, SD 2.63). We also observed increasing value of carrying angle as the age increases. These findings were seconded by previous studies[12,13,14,15]. Since girls have higher carrying angle to start with, they will be less likely to develop cubitus varus deformity. The changes in carrying angle with age would also mean that a deformity might regress faster in girls than in boys. However these postulates needs to be verified with longitudinal studies as our observations are based on cross sectional study.

Most of the literature till date states that carrying angle is inversely proportional to height of an individual. However recently few literature in Indian subcontinent contradicts this observation. Sharma k et al [12] in their study of 532 children found that height is not inversely proportional to carrying

angle. Dr. Shiva Prakah SS et al [13] in their study of 120 children in Karnataka found that there was positive correlation between carrying angle and height. In our study also we found that there is positive correlation between height and carrying angle. Most of these literature have smaller sample size compared to present study. We need further studies with large sample size to analyse correct correlation of height and carrying angle.

We noticed no difference in carrying angle on right and left sides. Bernardo et al [14] had similar findings as our study while Soumedhik dey et al [15] , Tükenmez M et al [16] and Mohammed Z. Allouh [17] found that carrying angle was larger on dominant side. Sharma K et al [12] found that carrying angle was greater on non-dominant side. Golden et al[18] noticed that carrying angle was more on left side irrespective of hand dominance. May be, not labelling any side as dominant or non- dominant, may have avoided observer bias in our study.

Mean carrying angle observed in our study was lower in both females (mean 9.67, SD 3.16) and males (mean 8.33, SD 2.63) compared to previous studies done in Indian children [1,2,5]. Most of these studies had small sample size. To the best of our best knowledge largest study in Indian population so far as done by Soumedhik dey et al [15] who studied 360 children. We included 1893 children in our study. Due to large sample size our study, selection bias might have been eliminated.

There are some shortcomings of this study. Design of this study was cross-sectional in nature. Longitudinal studies carried over years over same individuals will validate our findings in different age groups. All measurements were taken by single observer, thus we do not know what will be inter-observer reliability of measurements. We had used only clinical measurements to document carrying angle. Radiological study would have been better inter-observer reliability but would have led to unnecessary radiation exposure.

CONFLICTS OF INTEREST: Nil

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