Research Article

Morphometric co-relation of carrying angle to height, sex, age and dominance in children- A quantitative study

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ABSTRACT

Introduction and Aim: The fracture around elbow is the second most common fracture in the paediatric age group. The carrying angle changes with age and height of the child. The knowledge of carrying angle is important for diagnosing, handling and management of paediatric elbows. The objective was to find the age, height, gender and dominant handedness difference in angle of children aged 5-18 years.

Materials and Methods: The carrying angle was measured by a goniometer in 290 healthy students of randomly selected schools. Various parameters; age, gender, height, dominance and length of arm and forearm were also measured. The results were statistically analysed and correlated.

Results: The mean carrying angle was 8.9° ± 3.6° on the right side and 8.5° ± 3.8° on the left side in females whereas in males it was 7.1° ± 2.9° and 6.4° ± 2.9° on right and left side respectively. The angle was more on the dominant side than on the non-dominant side.

Conclusion: The normative data of this study could be useful in management of elbow displacement, fractures and surgical planning of traumatic elbow injuries.

Keywords: Carrying angle, displacement, elbow.

INTRODUCTION

The fracture around the elbow is the second most common fracture in the paediatric age group (1). Malunion or inaccurate reduction of the fracture leads to disabling and unsightly cubitus varus deformity. The surgical planning to which the correction needs to be made for that particular age and sex requires accurate preoperative charting of the angle (2). Increased angle can lead to pain during exercise or elbow instability leading to increased risk of elbow dislocations or fractures of distal end of humerus (3).

Anatomically the carrying angle of the elbow is defined as the angle formed by the long axis of the arm and the long axis of the forearm in the frontal plane in a fully extended and supinated elbow. This angle is normally 14° in females and 11° in males and is obscured in full forearm pronation and elbow flexion (4). This angle not only varies with gender but it also varies with other parameters like age and height. Hence, an effort has been made to find out correlation of carrying angle with age, gender, height and dominance in children of 5-18 years of age. The normative data of this study could be therefore important for diagnosing, handling and management of paediatric elbows to prevent post - operative disability.

MATERIALS AND METHODS

Ethical approval for this study was obtained from the Institutional Ethics Committee. The carrying angle was then measured in 290 students of randomly selected schools in the year 2015-2018. Informed consent was taken from the guardians of the children involved.

Inclusion criteria:

- Normal children in the age group of 5-18 years.
- Children < 14 years whose guardians gave consent to participate in the study.
- For Children ≥14 years, both child and guardian gave consent to participate in the study.
- Exclusion criteria:
- Any history of fracture of upper limbs.
- Any congenital anomaly of upper limbs.
- Deformity of upper limbs.
- Refusal to enrol in the study.

METHODOLOGY

Height: Height was measured in centimetres from vertex to heel with bare foot using a height measuring scale.

Carrying angle: The child was made to fully extend and supinate both the elbows. The measurement was taken by placing the goniometer at the centre of the cubital crease. The fixed arm was placed on the median axis of the upper arm and the movable arm adjusted on the median axis of the forearm. The angle indicated by the arrow on the goniometer was noted in degrees as shown in figure1.

To reduce errors, all the measurements were taken twice by two separate observers and the average of the two readings was taken. The data collected was statistically analysed. Mean with standard deviation using Independent Student's t-test were calculated and p-value < 0.05 was considered as significant.

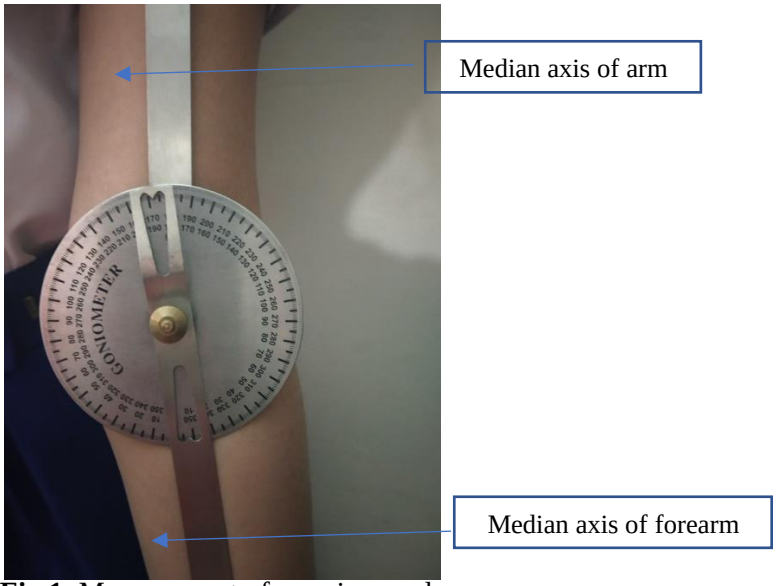

Fig.1: Measurement of carrying angle

RESULTS

A total of 580 elbows were measured in the study. Out of these 290 children, 147 were females and 143 were males. The results are shown in Table 1,2. In our study the right sided dominance was seen in 97.24% and left sided dominance was seen in 2.76% cases only. The angle was more on the dominant side as compared to the non-dominant side in both the cases (Table 1). The angle was seen to increase with age in both males and females as depicted in the graph (Fig.2). When comparing the height of the children with the carrying angle, strong positive correlation was found between them. It was statistically significant (r =0.652, n = 290, p = 0.001) on the right side and (r =0.566, n = 290, p = 0.001) on the left side (Fig. 3,4).

Table 1: Association of mean carrying angle with respect to gender and dominance

Carrying Angle	Variable	Details	Mean ± SD	P value
Right Carrying angle in degrees (Mean ± SD)	Gender	Female (n=147)	8.9±3.6	p=0.001
		Male (n=143)	7.1±2.9	
	Dominance	Right handed (n=282)	8.1±3.4	p=0.206
		Left handed (n=8)	6.5±3.4	
Left Carrying angle in degrees (Mean ± SD)	Gender	Female (n=147)	8.5±3.8	p=0.001
		Male (n=143)	6.4±2.9	
	Dominance	Right handed (n=282)	7.5±3.6	p=0.387
		Left handed (n=8)	6.4±3.3	

p<0.05 - significant

Table 2: Mean carrying angle with height in different age groups

Age	Height (cm)	Carrying angle in degrees (Mean ± SD)	
		Right	Left
5-8 years	100-120 (n=26)	3.8±1.3	3.8±1.6
	120-140 (n=15)	4.6±1.1	4.2±1.1
8-11 years	100-120 (n=4)	3.5±1.0	3.3±1.3
	120-140 (n=75)	6.3±2.5	5.9±2.6
	140-160 (n=11)	8.1±1.9	7.0±2.1
11-14 years	120-140 (n=25)	8.6±2.3	8.1±2.9
	140-160(n=51)	9.1±2.4	8.4±2.5
	>160 (n=6)	10.7±2.9	9.8±3.3
14-17 years	140-160 (n=46)	11.2±3.4	10.5±3.9
	>160 (n=31)	10.6±2.7	9.6±3.4

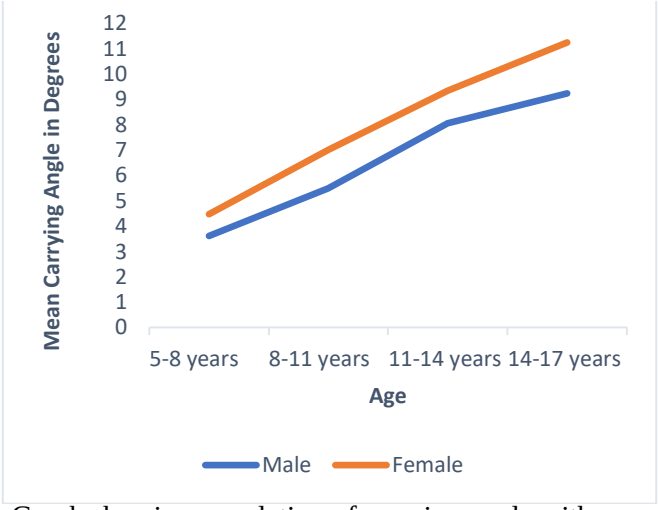

Fig.2: Graph showing correlation of carrying angle with age groups

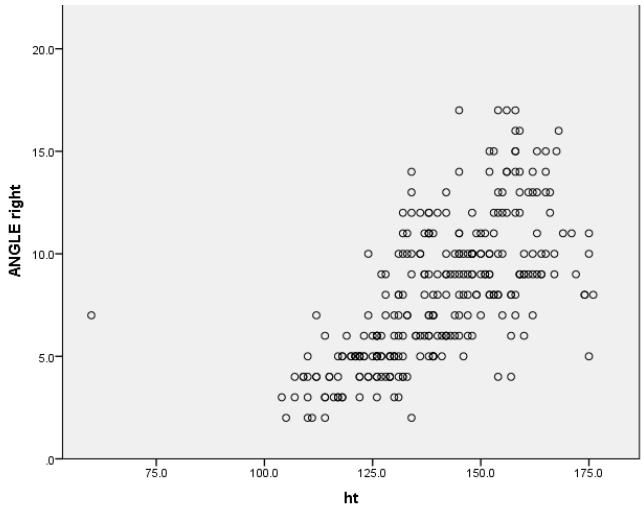

Fig.3: Scatter diagram showing correlation between height (ht) and left carrying angle

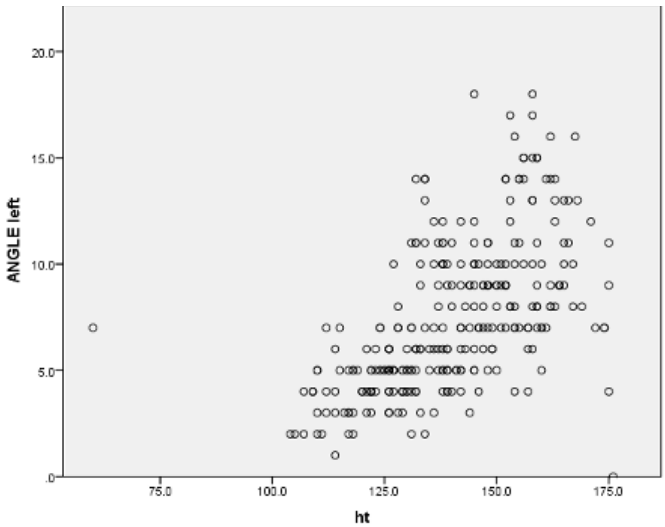

Fig.4: Scatter diagram showing correlation between height (ht) and right carrying angle

DISCUSSION

The arm and forearm are not aligned in humans which is most obvious when the elbow is straight and forearm fully supinated (5). The configuration of the humero-ulnar joint, between the trochlea and the trochlear notch of the ulna and the distal prolongation of the medial edge of the trochlear pulley, tilts the ulna, forming 'carrying angle'. Langer was of the opinion that the obliquity of trochlea to the shaft of the humerus is the cause of carrying angle (6). It slopes downwards and medially from its lateral extremity resulting in carrying angle. Knowledge of the measurement of carrying angle and its variations is

important when evaluating traumatic elbow injuries in childhood and adolescence. Sharma K *et al.,* compared the carrying angle in both sexes and found that the carrying angle was greater in females (7). Ruparelia S *et al.,* reported carrying angle to be 11.8° in females and 6.9° in males (8). Our study also showed remarkable difference and higher value in females as compared to that in males. In our study the mean carrying angle in females was 8.9° ± 3.6° on the right side and it was 8.5° ± 3.8° on the left side whereas in males, it was 7.1° ± 2.9° and 6.4° ± 2.9° on right and left side respectively. On reviewing the literature (4), it was seen that carrying angle varied from 6.7° to 20° in males and 11° to 25° in females these been consistent with our findings. Wider hips and narrow shoulders can be a reason for more acute carrying angle in females and is therefore deemed as one of the secondary sexual characters (9). Lim *et al.,* in their study concluded that difference in gender may be due to increased joint laxity in females permitting a greater degree of extension (4).

On comparing the carrying angle with age it has been reported that it shows a progressive increase with skeletal maturation in a predictable manner (10). In present study also carrying angle was seen to increase with age in both males and females on both the sides (Fig. 2). The mean carrying angle and standard deviation of this study for different age groups will help us determine what the cosmetically acceptable limit of deformity is for any particular age.

There was a strong positive correlation found between the height and carrying angle. So, carrying angle increased not only with age but also with the height meaning thereby that taller individuals are likely to have higher carrying angle than the shorter individuals. The values for different heights in an age group will provide the initial reference range.

On comparing the dominance, it was seen that in the dominant right sided children (n=282) the right carrying angle was 8.1°±3.4° as compared to the left angle which was 7.5°±3.6°. In the 8 children in our study who had left sided dominance, the right angle was 6.4° ±3.3° and the left angle was 6.5° ±3.4°. So, in the left sided dominant children it was observed that the angle was more on the dominant side. A study done by Yilmaz *et al.,* also found that mean carrying angle was significantly greater in dominant arm than the non-dominant arm in both sexes (11). In their study in the right arm dominant group, right carrying angle was 11.25°±3.73° and left carrying angle was 10.57°±3.63° while in the left arm dominant group, right carrying angle was 10.65°±3.99° and left carrying angle was 12.93°±4.22°. The higher values in their study could be attributed to difference in age studied; 2-91 years in their study and 5-18 years in ours. Our results were similar to that of Tükenmez *et al.,* and their age group was 6-14 years which was similar to our age group (10). Paraskevas G *et al.,* observed that carrying angle on the right side was more than on the left side but in the left-handed subjects, the values were greater in left upper limbs in both sexes (12). These findings are consistent with our study. A study on the athletes also showed that thirty percent of professional baseball players have an increased carrying angle in the dominant elbow (10-15 degrees), which can be attributed to bone remodelling due to stress (13). Increased carrying angle in the dominant limb means that natural forces act on the elbow and they modify the carrying angle.

CONCLUSION

In our study, we found that the carrying angle was more in females as compared to that in males which can be attributed to laxity of ligament and female secondary sexual characters. The study also found statistically significant positive correlation between the height and carrying angle. The increase in carrying angle with age and greater angle in the dominant arm indicates the skeletal maturity and stress modify the angle. In supracondylar fracture, the most common complication is loss of or increase in carrying angle. The knowledge of exact carrying angles in different age groups will be helpful to orthopedicians in selecting correct elbow prosthesis and managing reconstruction (8) or arthroplasties (14). This can prevent post-operative cosmetic deformity and pain on movement. Thus, it will help in pre-operative surgical planning of traumatic elbow injuries in childhood. It can also be important anthropologically for differentiation of sex and age in fragmentary skeletal remains.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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