



## MORPHOMETRIC STUDY OF CARRYING ANGLE OF ELBOW IN PRE PUBERTAL AND POST PUBERTAL GIRLS AND ITS CLINICAL IMPLICATION

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### ABSTRACT

**Introduction:** Carrying angle (CA) is the angle formed between fully extended arm with fully extended and supinated forearm. Study of carrying angle is helpful in evaluation of different deformities around the elbow joint. This study is aimed to construct morphometric data of carrying angle in pre pubertal and post pubertal girls and to establish its relationship with change in height & length of forearm. **Aim & Objectives:** To show morphometric differences of carrying angle between pre & post pubertal girls & to establish its relation with changes in length of forearm & also to show its clinical significances. **Material & Methods:** Carrying angle was measured in 94 healthy subjects including both pre pubertal and post pubertal girls with the help of goniometer. Height is measured with the help of stadiometer in normal anatomical position while length of forearm is measured with the help of measuring tape in extended and supinated forearm. Pre Pubertal subject were selected from pediatric OPD, while Post Pubertal subjects were selected from MBBS students coming to RGKMC & H. **Result:** Present shows a significant increase in carrying angle from pre pubertal to post pubertal age group. It also showed a positive correlation between change in height & length of forearm with change in carrying angle. **Conclusion:** Any deviation from normal CA can affect day to day activity. Study of carrying angle is helpful in management of valgus and varus deformity, elbow displacement and fracture, and other clinical conditions.

**KEYWORDS :** CA, Pre-pubertal & post pubertal age, elbow, goniometer.

### INTRODUCTION:

The carrying angle clinically defined as the angle made by longitudinal axis of the arm and the fore arm in full extension with the elbow supinated<sup>(12)</sup>. Study of carrying angle of both elbow is very important because any deviation of carrying angle from its normal value can affect our day-to-day activity. Studying of carrying angle also helps in evaluation of deformities around the joints which may guide in management of various clinical conditions, e.g. valgus and varus deformity of elbow. The result of study could be useful in management of elbow displacement, fracture, surgical planning for elbow reconstruction.<sup>(11)</sup>

The bones which contribute in formation of elbow joints are Humerus, Radius, and Ulna. The elbow joint is a synovial joint of hinge variety. It is uniaxial joint and has only one degree of freedom. The movement occurring at joint are Flexion and Extension. The joint is formed by articulating the upper end of both radius and ulna between the lower end of humerus<sup>(13)</sup>. The elbow is made up of three articulations.

**1. RADIO-HUMERAL JOIN:** Here the capitulum of humerus articulates with radial head.

**2. ULNO-HUMERAL JOINT :** In it trochlea of humerus articulates with the trochlear notch of the ulna.

**3. RADIO-ULNAR JOINT :** Here the radial head articulates with radial notch of ulna<sup>14</sup>.

The carrying angle is formed in part by the projection of medial trochlear ridge 6mm below its lateral edge, and in part by the obliquity of the coronoids superior articular surface. The inclination of the humeral and the ulnar articular surface is nearly equal so that when the two bones enters in same plane, the carrying angle disappear at maximum flexion.

In female carrying angle is 10°-15°. Cubitus vulgus is the condition if the angle is >15° where as if the angle is decreased below normal range, it is called cubitus varus deformity. The carrying angle allows forearm to clear hip while swinging, during walking and also essential when carrying objects<sup>1</sup>

increases gradually and is highest in 15-16 yrs age group. The elbow is slightly varus at birth, then increase in carrying angle continues until it reaches stabilization of skeletal development and growth at around 15 yrs of age.

It is very important to study carrying angle in children because it is routinely used during treatment of fracture around elbow. Increase in carrying angle is referred to as cubitus valgus and decrease in carrying angle as cubitus varus deformity. Cubitus varus deformity is one of the common complication of supra condylar humeral fracture, lateral condylar fracture and transphyseal fracture in children.

The carrying angle is also known as the acute angle created by the arm's median axis and that of the forearm which is completely extended and supinated. So, we can say that it measures the lateral obliquity. The angle is best observed when the forearm is in full extension, elbow in supination and the external rotation of the shoulder is there.

In full extension the coronoid process is received by coronoid fossa and the radial head is received by radial fossa on the superior surface of humerus. In full extension, the olecranon process is received by the olecranon fossa on the posterior aspect of the humerus.

If there is increase in carrying angle there is possibility of elbow instability and it may result in pain during exercise or in throwing activity of sports and may predispose to increased risk of elbow dislocation and distal humerus fracture while falling on outstretched hand.

The rate of increment in carrying angle in boys and girls is 0.42 and 0.60 per year respectively<sup>15</sup>.

Some study also states that carrying angle is greater in short persons compared to taller persons and lesser in relation to fore arm bone length, greater the carrying angle will be.

The carrying angle can be measured as external angle between humerus and ulna. The average value of external angle is about 165° in adult female and 175° in adult male. The angle can be measured as small internal angle of deviation of ulna from long axis of humerus. Average is 14° male and 16° in female.

It has been found that the mean carrying angle is lowest at birth and is

In present study I will follow internal angle of deviation which is 2°-26°

in male and  $2^{\circ}$ - $22^{\circ}$  in female.



**Fig 1:-** Humerus Of Right Side (ANTERIOR VIEW)



**Fig 2:-** Humerus Of Right Side (POSTERIOR VIEW)



**Figure 3-** Anterior view of upper end of ulna (right side)



**Figure 4-** Anterior View Of Radius Of Right Side



**Figure 5-** Posterio View Of Radius Of Right Side



**Figure 6-** Top View Of Radius Of Right Side



**Figure 7:** Radio-ulnar Joint Of Left Side



**Figure 8:** Skeleton Of The Elbow Joint Of Right Side (Posterior View)



**Figure 9 :** Skeleton Of The Elbow Joint Of Right Side (Lateral View)

#### Methodology:

After informed consent, corresponding age group was identified. 94 subjects (47 in each group) were selected. Pre Pubertal subject were selected from pediatric OPD of RGKMCH, while Post Pubertal subjects were selected from MBBS students coming to dept. of Anatomy, RGKMCH. MBBS students and subjects from pediatric OPD were selected because of easy availability. All subjects were female. The subjects were divided in two groups. The first group, belongs to pre pubertal age group, in which 47 female subjects were chosen of 8-10 yrs age range. The second group, belongs to post pubertal age group, in which 47 female subjects were chosen of 18-20 yrs age range. All measurements were done in well illuminated room and warm atmosphere in Department of anatomy and Pediatric Out Patient Department of R.G.Kar Medical College, Kolkata, West Bengal. Every measurement was taken twice by same examiner and recorded in corresponding form. A third reading was taken if initial two measurements showed a large discrepancy, and closer reading was taken. All measurements were recorded in duly filled up proforma.

**Study Design:** The present study will be descriptive and analytic study.

**Study Population:** 94 subjects (47 in each group) were selected. Pre Pubertal subject were selected from pediatric OPD, while Post Pubertal subjects were selected from MBBS students of RGKMC &H.

#### Exclusive Criteria:

1. Subjects with congenital bone deformity.
2. Subjects with acquired deformities in upper limb.

**Study Area:** RG Kar Medical College, Kolkata, W.B.

- Dept. of Anatomy.
- Dept. of Pediatric.
- Dept. of Orthopedic.

**Measuring Carrying Angle:** During measurement of carrying angle the arm was kept extended and supinated. The carrying angle was measured between the long axis of arm and the long axis of forearm with the help of goniometer. The normal outward deviation of extended and supinated forearm is defined as the carrying angle. Carrying angle of both arms were noted.

#### 1) Study Tool:

- (a) Goniometer
- (b) Digital Vernier Caliper
- (c) 5 meter collapsible measuring Steel tape
- (d) 5 meter measuring plastic tape

- (d) 30 cm transparent Faber Castle Scale
- (e) Canvas / Plastic table

### Subjects Were Identified And Were Divided Into Two Groups:

- (a) Pre Pubertal girls (Age 8 - 10 yrs)
- (b) Post Pubertal girls (Age 18 - 20 yrs)

After taking consent, clinical history were taken. H/O of trauma was taken and clinical examination of elbow joint were done to exclude congenital deformity around elbow joint. The carrying angle of both elbow were measured with extended and supinated from in a well illuminated room. The X - Ray films were also collected who suffered from any orthopedic ailment around elbow joint.

Clinical history was taken regarding any disturbance in the range of motion of elbow joint. H/O shoulder dislocation or h/o Supra clavicular fracture was also taken.

- Height was measured using stadiometer.
- Carrying angle of each individual was measured with the help of Goniometer.
- Lastly, a comparison was made between carrying angles of Prepubertal and Post pubertal girls. A correlation were made about changes in carrying angle with the height and length of the forearm.

### Parameters To Be Studied :

- Height of subject.
- Length of forearm.
- Carrying angle of elbows.

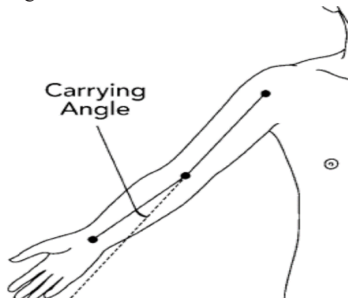
### METHODS:-

After taking consent and explaining procedure the required measurements i.e carrying angle, height and length of forearm, are take measured on both upper limb and are noted.

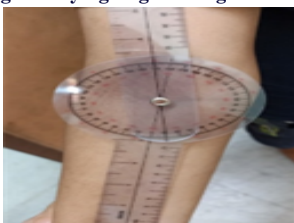
#### 1. Measuring Carrying Angle:-

During measurement of carrying angle the arm is kept extended and supinated. The carrying angle was measured between the long axis of arm and the long axis of forearm with the help of goniometer. The normal outward deviation of extended and supinated forearm is defined as the carrying angle. Carrying angle of both arm were noted.

The subject was asked to stand erect in anatomical position with arm extended, supinated and facing forward. The tip acromion was marked as "A". Now the midpoint between medial and lateral epicondyle was taken and was marked as "B". Now point "A" and "B" was joined by a skin pencil. This line (A-B) represents axis of arm. This line was extended further in same plane up to a point "C". Now for the measurement of axis of forearm, a point was taken at mid-point of styloid process of radius and ulna and it was marked as point "D". the point "B" and "D" was joined with skin marking pencil. The line (B-D) represents axis of forearm. The angle  $\angle CBD$  was measured with the help of goniometer which represents the carrying angle.



[Picture Showing Carrying Angle Of Right Hand  $\angle CBD$ ]



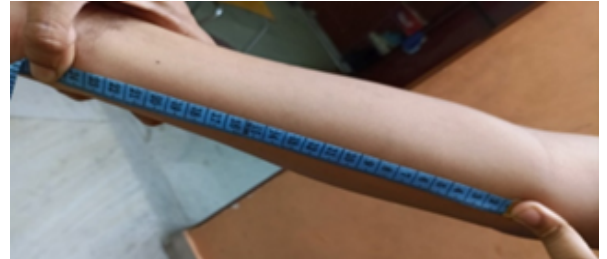
Picture Showing Measurement Of Carrying Angle

### Measuring Height:

Height was measured in standing, erect and in anatomical position. It was measured from vertex to heel with the help of 5meter steel tape. The subject was asked to stand against the stadiometer with bare feet. Body was kept in straight line. Height was measured from heel to vertex in centimeter and noted.

### Measuring Length Of Forearm:

The forearm is extended and supinated and extended. The medial epicondyle of humerus of both hand and styloid process of ulna of both hand is palpated and marked. The length of forearm is measured between these two points in both hands and is noted in centimeters.



Picture Showing Measurement Of Length Of Forearm

### Statistical Analysis:

For Statistical analysis, latest version of the IBM SPSS (Statistical Package for the Social Sciences) software has been used.

The following metric variable of Pre pubertal and post pubertal were compared and t-test performed and 'P' value found out.

### RESULT:

- The study shows that there is not a significant difference of carrying angle between the both right and left limbs in both pre pubertal and post pubertal age groups. In Pre pubertal age group the mean carrying angle of right elbow was 6.65 with SD of 1.18. While that of left elbow the mean carrying angle was 6.63 with SD of 1.18. It is seen that carrying angle is slightly more in right elbow as compared to the left elbow. In post pubertal age group the CA was almost same in both limbs. The mean was 13.93 with SD of 0.986 in both elbow. There is no significant difference in CA of right and left side ( $p$ -value  $> 0.05$ )
- It has been observed that there was a significant increase in carrying angle with age. If we observe CA of right side, it increases from 6.65 (mean) in pre pubertal age group to 13.93 (mean) in post pubertal age group. We can say that there is significant change in carrying angle from pre pubertal to post pubertal age in girls. The " $p$ "-value found is  $< 0.0001$ , which is significant.
- On comparing height with carrying angle between the two groups, we found a " $p$ "-value of  $< 0.0001$ , which is very significant. It indicates that carrying angle increases with increase in height from pre pubertal to post pubertal groups.
- We have also studied relation of carrying angle with length of forearm. The mean length of forearm on right side in pre pubertal age group was  $18.29\text{cm} \pm 1.38$ . It increases to  $24.87\text{cm} \pm 1.35$  in post pubertal girls. We found that the carrying angle is greater in girls with longer forearm ( $p$ -value  $< 0.0001$ ).

On seeing correlation between the length, we found, that there are mild correlations between length of each forearms and the respective carrying angles which found statistically significant for right side but not significant for left side (table 10).

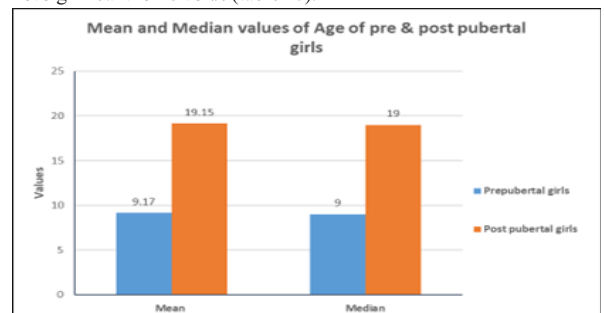


Fig 1: Bar diagram showing mean and median values of age of pre & post pubertal girls

**Table 1: Mean, Median And Range Of Age (years) Of Study Population Across The Two Groups.**

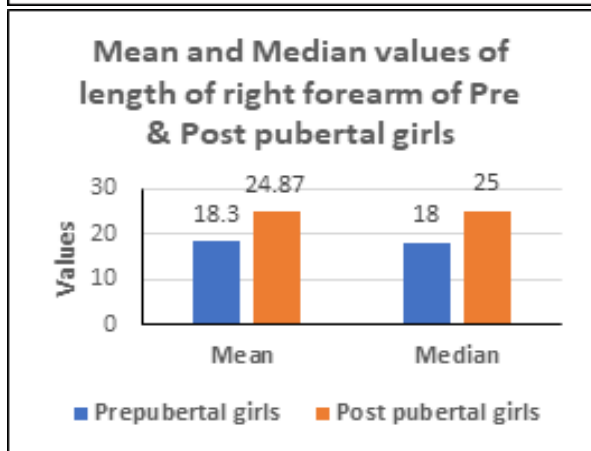
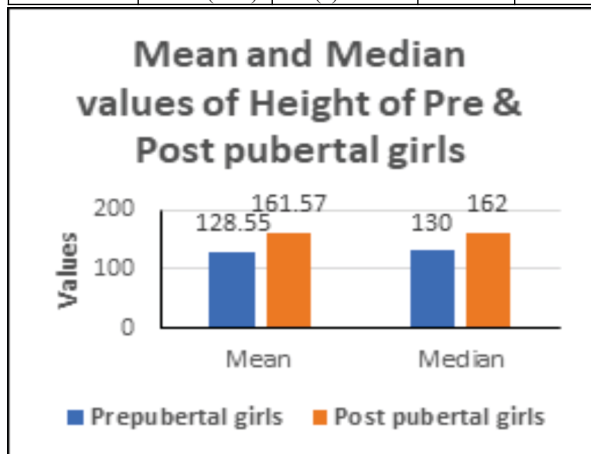
| Groups        | Mean (SD)    | Median (IQR) | Range   | P value |
|---------------|--------------|--------------|---------|---------|
| Pre-Pubertal  | 9.17 (0.82)  | 9 (2)        | 8 – 10  | 0.000   |
| Post Pubertal | 19.15 (0.78) | 19 (1)       | 18 – 20 |         |

**Table 2: Distribution Of Study Population According To Their Age (years) Across Two Groups. (N=94)**

| Groups        | Age      | No. | %     |
|---------------|----------|-----|-------|
| Pre-Pubertal  | 8 years  | 12  | 25.50 |
|               | 9 years  | 15  | 31.90 |
|               | 10 years | 20  | 42.60 |
|               | Total    | 47  | 100   |
| Post Pubertal | 18 years | 11  | 23.40 |
|               | 19 years | 18  | 38.30 |
|               | 20 years | 18  | 38.30 |
|               | Total    | 47  | 100   |

**Table 3: Mean, Median And Range Of Height (cm) Of Study Population Across The Two Groups.**

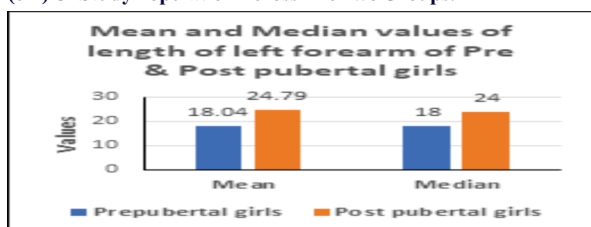
| Groups        | Mean (SD)     | Median (IQR) | Range     | P value |
|---------------|---------------|--------------|-----------|---------|
| Pre-Pubertal  | 128.55 (4.89) | 130 (6)      | 111 – 135 | 0.000   |
| Post Pubertal | 161.57 (6.07) | 162 (9)      | 148 – 176 |         |



**Table 4: Mean, Median And Range Of Length Of Right Forearm (cm) Of Study Population Across The Two Groups.**

| Groups        | Mean (SD)    | Median (IQR) | Range   | P value |
|---------------|--------------|--------------|---------|---------|
| Pre-Pubertal  | 18.30 (1.38) | 18 (2)       | 15 – 22 | 0.000   |
| Post Pubertal | 24.87 (1.19) | 25 (2)       | 23 – 28 |         |

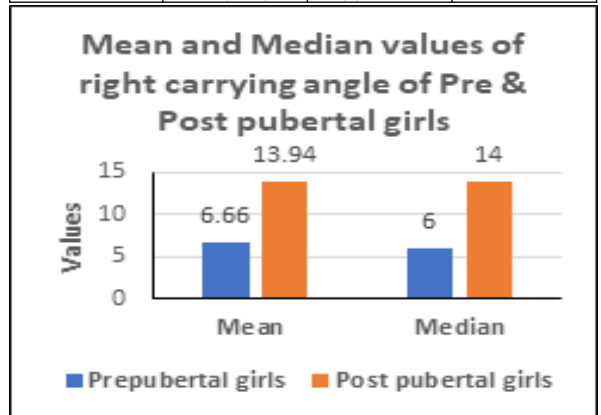
**Table 5: Mean, Median And Range Of Length Of Left Forearm (cm) Of Study Population Across The Two Groups.**



| Groups        | Mean (SD)    | Median (IQR) | Range   | P value |
|---------------|--------------|--------------|---------|---------|
| Pre-Pubertal  | 18.04 (0.72) | 18 (0)       | 16 – 20 | 0.000   |
| Post Pubertal | 24.79 (1.35) | 24 (2)       | 23 – 29 |         |

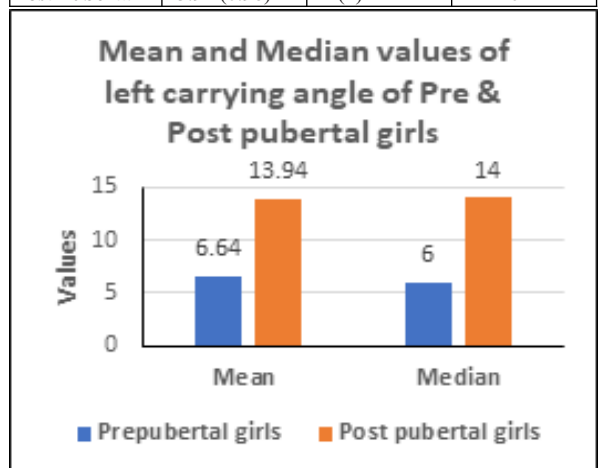
**Table 6: Mean, Median And Range Of Right Carrying Angle Of Study Population Across The Two Groups.**

| Groups        | Mean (SD)    | Median (IQR) | Range   |
|---------------|--------------|--------------|---------|
| Pre-Pubertal  | 6.66 (1.19)  | 6 (1)        | 5 – 10  |
| Post Pubertal | 13.94 (0.98) | 14 (2)       | 12 – 16 |



**Table 7: Mean, Median And Range Of Left Carrying Angle Of Study Population Across The Two Groups.**

| Groups        | Mean (SD)    | Median (IQR) | Range   |
|---------------|--------------|--------------|---------|
| Pre-Pubertal  | 6.64 (1.18)  | 6 (1)        | 5 – 10  |
| Post Pubertal | 13.94 (0.98) | 14 (2)       | 12 – 16 |



**Table 8: Comparison Between Mean, Median Of Right And Left Carrying Angle Across Pre And Post Pubertal Girls.**

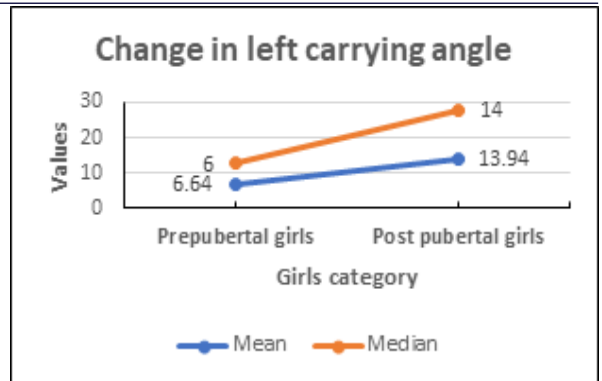
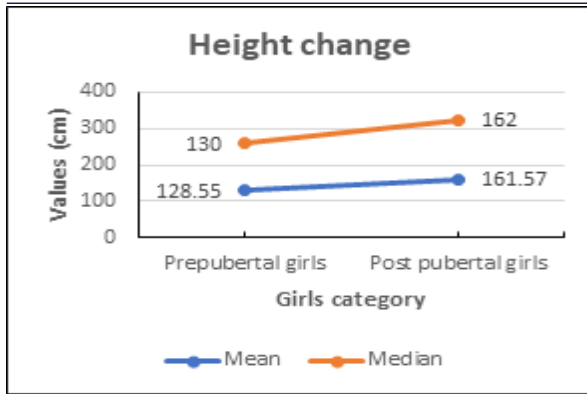
| Carrying Angle | Mean         |               | Median       |               | P value | Significance |
|----------------|--------------|---------------|--------------|---------------|---------|--------------|
|                | Pre-pubertal | Post-pubertal | Pre-pubertal | Post-pubertal |         |              |
| Right Side     | 6.66         | 13.94         | 6            | 14            | 0.000   | Significant  |
| Left Side      | 6.64         | 13.94         | 6            | 14            | 0.000   | Significant  |

**Comment:** This table shows that there is obvious change in carrying angle in both right and left upper limb among the study population after attainment of puberty, and the change is highly significant (p = 0.000) statistically also. (Test applied: Independent sample Mann-whitney U test for non-parametric distribution of data)

**Table 9: Comparison Between Mean Values Of Height And Carrying Angles Of Right And Left Upper Limbs.**

| Variables |        | Groups       |               | P value | Significance |
|-----------|--------|--------------|---------------|---------|--------------|
|           |        | Pre-pubertal | Post-pubertal |         |              |
| Means     | Height | 128.55       | 161.57        | 0.000   | Significant  |
|           | Rt CA* | 6.66         | 13.94         | 0.000   | Significant  |
|           | Lt CA  | 6.64         | 13.94         | 0.000   | Significant  |

\*CA = Carrying Angle



**Table 10: Correlation Between Change In Measurement Of Right And Left Carrying Angle Of Pre And Post Pubertal Girls And Their Change In Age, Height, Length Of Right And Left Forearm.**

| Variables                         | Change in Rt. CA* |         |                         | Change in Lt. CA* |         |                         |
|-----------------------------------|-------------------|---------|-------------------------|-------------------|---------|-------------------------|
|                                   | r                 | p value | Strength of correlation | r                 | p value | Strength of correlation |
| Age change                        | 0.17              | 0.242   | Mild                    | 0.15              | 0.300   | Mild                    |
| Height change                     | 0.41              | 0.004   | Moderate                | 0.42              | 0.003   | Moderate                |
| Change in Length of left forearm  |                   |         |                         | 0.27              | 0.064   | Mild                    |
| Change in Length of right forearm | 0.33              | 0.023   | Mild                    |                   |         |                         |

\*CA = Carrying Angle, r = Correlation co-efficient

**Comment:** The table shows mild correlation between change in age and change in measurement of carrying angles of both the upper limbs but these correlation is not statistically significant. The change in height of study population correlates moderately with change in measurement of carrying angles of both the upper limbs and it is found statistically highly significant. The table also shows that there are mild correlations between length of each forearms and the respective carrying angles which is found statistically significant for right side but not significant for left side.

**Table 11: Univariate Analysis Determining The Predicting Factors For Change In Carrying Angles Of Right And Left Side By Multiple Linear Regression.**

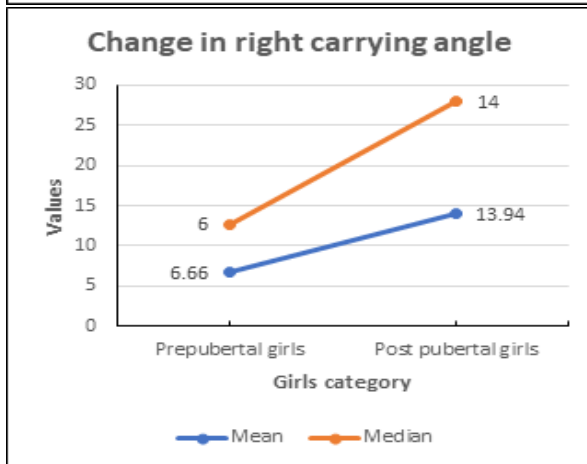
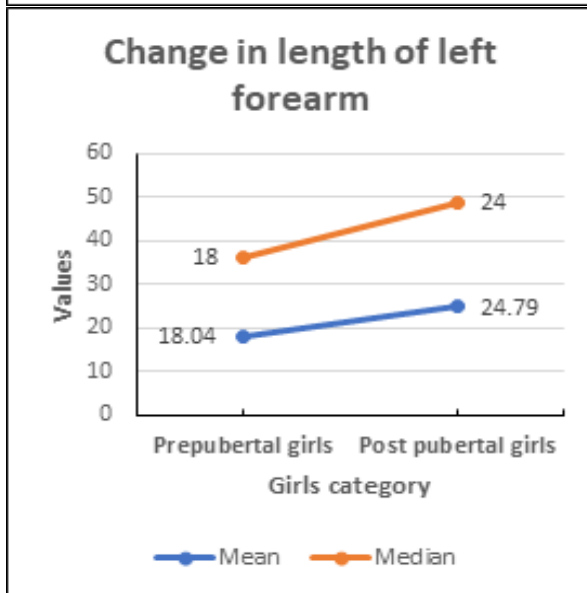
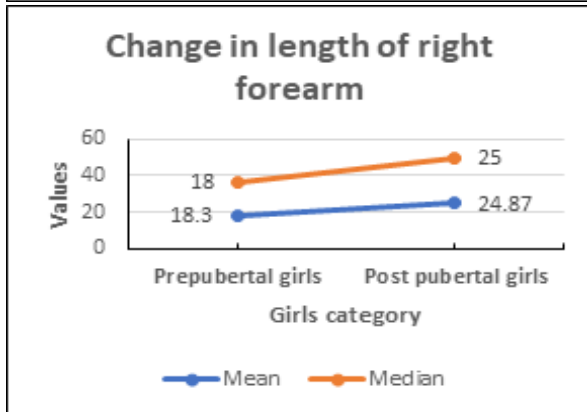
| Predicting factors                | Change in right carrying angle |                     |         | Change in left carrying angle |                     |         |
|-----------------------------------|--------------------------------|---------------------|---------|-------------------------------|---------------------|---------|
|                                   | B co-efficient                 | Confidence interval | P value | B co-efficient                | Confidence interval | P value |
| Change in height                  | 0.045                          | -0.011 – 0.101      | 0.11    | 0.057                         | 0.009 – 0.106       | 0.02*   |
| Change in age                     | 0.097                          | -0.273 – 0.466      | 0.60    | 0.145                         | -0.167 – 0.457      | 0.35    |
| Change in length of right forearm | 0.189                          | -0.069 – 0.448      | 0.14    |                               |                     |         |
| Change in length of left forearm  |                                |                     |         | 0.243                         | 0.014 – 0.471       | 0.03*   |

\* indicates statistical significance.

**Comment:** Change (increase) in height, age and length of right forearm across puberty are not significant predictors for change in measurement of right carrying angle across puberty, while change (increase) in height, and length of left forearm across puberty are the significant (p value = 0.02 and 0.03 respectively) predictors for change in measurement of left carrying angle across puberty.

#### DISCUSSION:

The present study was aimed to establish a relation of carrying angle



with the age and height of the subject and its association with the length of forearm. Here the study group was pre pubertal (8-10 yrs) and post pubertal (18-20 yrs). All subjects are female. It has been observed that the mean carrying angle of post pubertal age group is higher than the pre pubertal group, as shown in table 1 – table 10. We also found that the CA of right side is more in pre pubertal group (p value is 0.000), while it is same in both elbow in post pubertal group (p value is 0.000). Ozor et al<sup>9</sup> in his study also found that there is significant increase in carrying angle from pre pubertal to post pubertal age. While Pooja shah and Wakar M Naqvi in their study<sup>13</sup> found that there is no significant relation between the carrying angle and age. Paraskevas G et al<sup>28</sup> reported that carrying angle was significantly greater in right upper limb than the left. They found a CA of  $16.52 \pm 4.230$  in right and  $15.36 \pm 3.230$  in left upper limb. He also reported that in right handed subject, the CA is significantly greater in right upper limb. The difference between the carrying angle of right and left side may suggest ligamentous laxity at the elbow or asymmetrical bone growth<sup>11</sup>.

In present study it was found that carrying angle increases from pre pubertal to post pubertal stage in girls with the increase in height (p value 0.000), increase in length of forearm and age. It was also observed that carrying angle is directly related to forearm length.

ZULFIQAR ULLAH, AHMADZEB and others in their study on “Mean Carrying Angle of Elbow in Children Less Than Ten Years of Age”<sup>29</sup> found a significant association of carrying angle with height, forearm length and limb dominance ( $p \leq 0.05$ ) while no significant association of carrying angle was observed with gender and age.

Pooja shah and Wakar M Naqvi in their study<sup>13</sup> found an inverse relation between forearm length, height and carrying angle.

The study of carrying angle is very important to understand lots of clinical conditions. The data is essential for orthopedic surgeons and pediatricians to prevent deformity as well as to rule out any underlying pathology around elbow joint. An idea of carrying angle helps to treat some clinical ailments such as supra condylar fracture, fracture around elbow joint, vulgus and varus deformity. An increase in carrying angle is also a risk factor for non-traumatic ulnar nerve neuropathy according to study done by Chein-Wei Chang (2008)[24]<sup>6</sup>.

## CONCLUSION:

As shown in Table 10, we found that there is mild positive correlation between change in age and change in measurement of carrying angles of both the upper limbs. It means that the carrying angle increases with age. But these correlations are not statistically significant, i.e. age has not much influence over carrying angle.

This study showed a positive correlation between the change in height with change in carrying angle of both upper limbs. The change in height of study population correlates moderately with change in measurement of carrying angles of both the upper limbs and it was found statistically highly significant (Table 10). This study also showed that there were mild correlations between length of each forearm and the respective carrying angles which was found statistically significant for right side but not significant for left side.

From this study It has been concluded that Change (increase) in height, age and length of right forearm across puberty are not significant predictors for change in measurement of right carrying angle across puberty, while change (increase) in height, and length of left forearm across puberty are the significant (p value = 0.02 and 0.03 respectively) predictors for change in measurement of left carrying angle across puberty.

## Ethical Consideration:

Ethical clearance has been obtained from the “Institutional Ethical Committee (IEC)” of the R. G. Kar Medical College & Hospital, Kolkata, W.B.

## Conflict Of Interest: None.

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