

Study of Carrying Angle in Respect to Demographic Parameters of Medical Students

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Abstract

Background: An acute angle, at the elbow medially made by the long axis of the humerus and the long axis of the ulna in the anatomic position is known as carrying angle. The normal range of carrying angle is 5-10° in males and 10-15° in females. The aim of this study is to correlate the carrying angle with sex, height, length of forearm and dominant hand in North-west Indian medical students.

Materials and Methods: The study comprised of a total of 200 healthy subjects without any deformity of upper limb, including 100 males and 100 females. Goniometer was used for measuring the carrying angle. Stadiometer and measuring tape were used for the measurement of height and length of forearm.

Results: The mean carrying angle of right side was 11.88±1.32° and 14.80±1.97° in males and females, respectively. The mean carrying angle of left side was 11.53±1.20° and 15.38±1.87° in males and females, respectively. The carrying angle was significantly greater in females than males. Height and length of forearm were inversely related to carrying angle. It was found that non-dominant limb had a greater carrying angle.

Conclusion: Findings of present study is useful in the management of clinical conditions, such as, elbow dislocation, elbow deformities, elbow fractures and elbow reconstruction.

Keywords: Carrying angle, North-west Indian, Demographic parameters.

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Introduction

The elbow joint is most important joint of upper extremity. Daily living activities, work related tasks and recreational activities are affected severely due to loss of elbow functions. The arm and forearm form an angle at elbow; known as carrying

angle of the elbow, which is defined as an acute angle at the elbow medially made by the long axis of the humerus and the long axis of the ulna in the anatomical position [1]. The knowledge of carrying angle is important to understand sexual dimorphism

and also in anthropology where differentiation of sex is necessitated from remains of bony fragments [2]. The treatment of elbow fractures warrants the knowledge of pathological variations and values of carrying angle in different ethnic populations [3].

During extension the transverse axis of the elbow is directed medially and downwards; thus, an acute angle of about 13° is formed between the longitudinal axis of arm and forearm which disappears during full flexion and during pronation of the forearm, because then humerus and the ulna bones lies in the same plane [4].

The range of carrying angle is $5-10^{\circ}$ in males and $10-15^{\circ}$ in females. Greater carrying angle in females is attributed to wider hips and narrow shoulders [5], this is also permitted by joint laxity in females [6]. That's way carrying angle forms an important secondary sexual characteristic in females. In nature while we carrying objects anatomically it is required the forearm to swing freely without hitting the hips that body has managed through carrying angle [7]. So, alteration in carrying angle from the normal, results in clinical conditions, such as cubital valgus in which the angle is more than 13° and cubital varus in which the angle is less than 13° . These conditions may be caused after healing of certain fractures of elbow [8].

Thus, the aim of this study was to correlate the carrying angle with sex, height, length of forearm and dominant hand in young adults of North-west India.

Materials and Methods:

A cross-sectional descriptive study was conducted in the Department of Anatomy, Sardar Patel Medical College, Bikaner, Rajasthan. The sampling method done for the study was convenient sampling. A total of 200 sample size was taken, including 100 males and 100 females. Prior approval of the ethical committee and written informed consent of the subjects were taken.

Inclusion criteria: - Normal and healthy individuals with ages 17years and above, without any deformity of upper limb were included. Exclusion criteria: - Individuals with trauma, fracture and disablement of upper limb were excluded. Materials: - Universal goniometer, stadiometer and measuring tape.

Methodology: - Carrying angle was measured with the help of universal goniometer. Subjects were asked to stand in anatomical position, with forearm kept extended, supinated and fixed on the sides of the body. Olecranon process of ulna, head of radius, styloid process of ulna, styloid process of radius and medial and lateral epicondyles of humerus were palpated. The axis of arm (lateral border of the cranial surface of the acromion to the midpoint of the lateral and medial epicondyles of the humerus) and the axis of forearm (midpoint of the lateral and medial epicondyles of the humerus to the midpoint of styloid process of radius and ulna) were identified. Goniometer was places on the elbow, with the fixed arm on the axis of the arm and the movable arm on the axis of forearm. The readout plate was recorded from the measurement plate of the goniometer and the angle obtained was observed. Height of the individual was measured with the help of stadiometer. Subjects were asked to stand erect, looking forward, feet together with heels. Length of the forearm was measured using measuring tape, from the medial epicondyle of humerus to the styloid process of ulna. For all the measurements, three consecutive readings were taken and also their mean was recorded. All the measurements were measured in cm except for the carrying angle which was measured in degrees.

Statistical analysis: - All the measurements were recorded, tabulated and statistically analyzed. The data was entered into Microsoft excel and then analyzed for mean and standard deviation, a p-value of less

than 0.05 was taken to be statistically significant.

Results:

The study included a total of 200 students, including 100 males and 100 females. The mean age of males was 21.48 ± 1.15 years and that of females was 22.09 ± 1.47 years. A p-value of 0.36 indicates, that the girls were slightly older than the boys. The mean carrying angle of right side was $11.88 \pm 1.32^\circ$ and $14.80 \pm 1.97^\circ$ in males and females, respectively. The mean carrying angle of left side was $11.53 \pm 1.20^\circ$ and $15.38 \pm 1.87^\circ$ in males and females, respectively. Both the above parameters were found to be statistically significant with a $p < 0.05$. The mean height of males and females was 173.99 ± 6.45 cm and 160.98 ± 6.43 cm, respectively. The mean of length of forearm of right upper limb was 27.33 ± 2.75 cm and 25.04 ± 1.52 cm in males and females, respectively. The mean of length of forearm of left upper limb was 27.63 ± 1.33 cm and 25.07 ± 1.48 cm in males and females, respectively. Out of the 100 males, 97 were right hand dominant and 3 were left hand dominant. Whereas, out of the 100 females, 90 were right hand dominant and 10 were left hand dominant.

On comparing right arm carrying angle with dominant hand in males, the mean of right carrying angle was found to be $11.87 \pm 1.32^\circ$ and $12.00 \pm 2.00^\circ$ for the right and the left hand dominant, respectively. On comparing right arm carrying angle with dominant hand in females, the mean of right carrying angle was found to be $14.76 \pm 1.98^\circ$ and $15.20 \pm 1.93^\circ$ for the right and the left hand dominant, respectively. On comparing left arm carrying angle with dominant hand in males, the mean of right carrying angle was found to be $11.53 \pm 1.15^\circ$ and $11.33 \pm 1.20^\circ$ for the right and the left hand dominant, respectively. On comparing left arm carrying angle with dominant hand in females, the mean of right carrying angle was found to be $15.21 \pm 1.82^\circ$ and $16.90 \pm 1.66^\circ$ for the right and the left hand

dominant, respectively. All the above parameters were found to be statistically significant with a p-value of less than 0.05.

In females, the mean of right and left arm carrying angles were found to be $14.80 \pm 1.97^\circ$ and $15.38 \pm 1.87^\circ$, respectively. The mean of length of forearm of right and left sides were found to be 25.04 ± 1.52 cm and 25.07 ± 1.48 cm, respectively. On correlating the right arm carrying angle with length of forearm of right and left sides, the above parameters were found to be significantly correlated with each other with a correlation coefficient of $r = 0.82$ and $r = 0.83$, respectively. On correlating the left arm carrying angle with length of forearm of right and left sides, the above parameters were found to be significantly correlated with each other with a correlation coefficient of $r = 0.85$ and $r = 0.84$, respectively.

In males, the mean of right and left arm carrying angles were found to be $11.88 \pm 1.32^\circ$ and $11.53 \pm 1.20^\circ$, respectively. The mean length of right and left side forearm was found to be 27.33 ± 2.75 cm and 27.63 ± 1.33 cm, respectively. On correlating the right arm carrying angle with length of forearm of right and left sides, the above parameters were found to be significantly correlated with each other with a correlation coefficient of $r = 0.83$ and $r = 0.84$, respectively. On correlating the left arm carrying angle with length of forearm of right and left sides, the above parameters were found to be significantly correlated with each other with a correlation coefficient of $r = 0.80$ and $r = 0.82$, respectively.

In males, the mean of right and left arm carrying angles were found to be $11.88 \pm 1.32^\circ$ and $11.53 \pm 1.20^\circ$, respectively. The mean of height was 173.99 ± 6.45 cm. On correlating the right arm carrying angle with height, both were found to be significantly correlated to each other with a correlation coefficient of 0.84. On correlating the left arm carrying angle

with height, both were found to be significantly correlated to each other with a correlation coefficient of 0.83.

In females, the mean of right and left arm carrying angles were found to be $14.80 \pm 1.97^\circ$ and $15.38 \pm 1.87^\circ$, respectively. The mean of height was 160.98 ± 6.43 cm. On correlating the right arm carrying angle with height, both were found to be significantly correlated to each other with a correlation coefficient of 0.80. On correlating the left arm carrying angle with height, both were found to be significantly correlated to each other with a correlation coefficient of 0.79.

Discussion:

The carrying angle is best observed when the elbow is supinated and forearm is in full extension and there is external rotation of the shoulder and carrying angle forms important secondary sexual characteristic feature [7]. An Indian study has recorded the value of carrying angle in a range of 10° in males and 13° in females. In cubital valgus, the carrying angle is more than 15° and in cubital varus, the carrying angle is less than 15° [12]. Present study was carried out to correlate carrying angle with parameters as sex, height, length of forearm and dominant hand in young adults of North India.

In present study the mean carrying angle of right upper limb was $11.88 \pm 1.32^\circ$ and left upper limb was $11.53 \pm 1.20^\circ$ in males. The mean carrying angle of right upper limb was $14.80 \pm 1.97^\circ$ and left upper limb was $15.38 \pm 1.87^\circ$ in females. For the right upper limb with a p-value of 0.001 in both males and females, it was found to be statistically significant. Similarly, for the left upper limb in both males and females, a p-value of 0.001 shows that the difference between the two was statistically significant.

Similarly, in the North Indian population-based studies conducted, showed the mean carrying angle of right and left upper limbs in males to be 11.44 ± 2.543 and 10.33 ± 2.289 , respectively; and in females, the mean carrying angle of right and left upper limbs was found to be 13.67 ± 2.673 and 12.74 ± 2.630 [13,14] (Table 1). Thus, the findings of the present study emphasize the fact that the carrying angle is greater in females than males and this difference has been considered to be a secondary sexual characteristic.

According to the present study and others Yadav SK et al [14] it was found that with an increase in height, there was a decrease in carrying angle (Table 1). Hence, males having a greater height than females, showed smaller carrying angle. The difference of above parameters was found to be having a p-value of less than 0.05, thus being statistically significant. Similarly, in Uttar Pradesh in India also found that on correlating height and carrying angle of left upper limb, were found to have a significant positive correlation with $r=0.08$ and $p=0.048$; whereas, when the carrying angle of right upper limb and height of the individual were correlated, the two were found to have a negative correlation with $r=-0.08$ and $p=0.058$ [3].

On correlating the carrying angle of left upper limb and dominant hand it was observed that carrying angle was greater in the non-dominant limb rather than the dominant limb except for the left-hand dominant females, which showed a greater carrying angle in their dominant hand. Similarly, findings reported in Uttar Pradesh population [3]. Whereas, in another study the carrying angle of dominant upper limb was found to be significantly higher than the non-dominant upper limb in both sexes [15].

Table 1: Comparison of different parameters among previous studies.

	No. of subjects	Carrying angle right arm(°)	Carrying angle left arm(°)	Height (cm)	Right forearm length (cm)	Left forearm length (cm)	
Present study (North India)	M	100	11.88±1.32	11.53±1.20	173.99±6.45	27.33±2.75	27.63±1.33
	F	100	14.80±1.97	15.38±1.87	160.98±6.43	25.04±1.52	25.07±1.48
Oladipo et al ⁹ (Nigeria)	M	100	9.31±1.67	8.99±1.53	181.09±4.76	-	-
	F	100	9.75±2.26	9.58±2.10	175±8.34	-	-
Ahmed SK et al ¹⁰ (Pakistan)	M	353	9.5±3.1	9±3.1	166.7±9.1	23.7±1.4	23.4±1.4
	F	142	14.4±3.2	13.8±3.2	154.2±7.1	22.3±1.4	22.1±1.4
Rethinasamy Met al ¹¹ (Tamil Nadu)	M	227	11.9	11.1	173.4±6.80	28.3	28.1
	F	333	14.7	13.6	157.8±9.32	25.2	25
Sharma SK et al ¹² (Uttar Pradesh)	M	120	11.5±3.70	10.7±3.1	170.3±5.60	27.8±2.30	26.6±2.30
	F	146	14.4±4.39	13.3±4.02	155.5±8.22	24.9±1.69	24.8±1.5
Bhat MA et al ¹³ (Kashmir)	M	91	12.25±1.49	10.50±1.39	-	-	-
	F	109	14.85±2.12	13.7±1.8	-	-	-
Yadav SK et al ¹⁴ (Lucknow)	M	200	11.27±2.54	10.33±2.28	170±6.45	26.38±1.58	25.84±1.55
	F	200	12.74±2.63	13.67±2.67	157.93±5.84	24.12±1.45	23.60±1.48
Kazi S et al ² (Maharashtra)	M	122	8.03±1.72	7.09±1.7	169.0±6.015	25.57±1.4	25.3±1.3
	F	94	11.05±2.01	10.26±1.85	154.51±5.89	23.24±1.5	22.80±1.15

M-Male, F- Female

In present study, on correlating both the right arm carrying angle and length of forearm in females were found to be directly correlated to each other with a correlation coefficient of $r = 0.82$ and a p-value of 0.01, Similarly, in males also, the above said parameters were found to be directly correlated with a correlation coefficient of $r = 0.83$ and a p-value of 0.01. According to the present study, with an increase in length of forearm there was a decrease in carrying angle. As in males, length of forearm was having a higher mean but the carrying angle in males was found to be smaller and in females, length of forearm was having a smaller mean but the carrying angle was higher.

Similar results were obtained by the study conducted on Maharashtra population in India [2], which showed the mean of right-side carrying angle and length of forearm in females to be $11.05^\circ \pm 2.012$ and 23.24 ± 1.5 cm, respectively. The mean of left side carrying angle and length of forearm in

females was found to be $10.26^\circ \pm 1.858$ and 22.8 ± 1.15 cm, respectively. In males, the mean of right-side carrying angle and length of forearm were $8.03^\circ \pm 1.718$ and 25.57 ± 1.4 cm, respectively. The mean of left side carrying angle and length of forearm were $7.09^\circ \pm 1.733$ and 25.3 ± 1.3 cm, respectively. Hence the above findings are in accordance with the findings of present study, that with an increase in length of forearm there will be decrease in carrying angle.

Conclusion:

The carrying angle was found to be significantly higher in females than males and also the carrying angle of non-dominant limb was higher. There is a negative correlation between carrying angle and height and length of forearm of the individual. The above values of correlation of carrying angle with sex, height, length of forearm and dominant hand of the individual are of immense importance in

the management of clinical conditions, such as, elbow dislocation, elbow deformities, elbow fractures and elbow reconstruction.

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