

CARRYING ANGLE: A MORPHOMETRIC STUDY IN SOUTH INDIAN POPULATION

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ABSTRACT: Apes and humans are distinguished from other primate species in possessing carrying angle at the elbow. When the upper extremity is in the anatomic position, the long axis of the humerus and the long axis of the ulna form an acute angle medially at the elbow which is called the carrying angle. It is reported that carrying angles differ according to the sex and age. Study is comprised of 400 healthy volunteers belonging south Indian origin with an average age range: 18-38 years. The carrying angle was measured with a full circle manual goniometer. In the males, the right carrying angle was $13.8^{\circ} \pm 3.02^{\circ}$ and the left carrying angle was $12.2^{\circ} \pm 1.84^{\circ}$ ($P < .05$). In the females, right carrying angle was $18.4^{\circ} \pm 2.62^{\circ}$ and left carrying angle was $17.5^{\circ} \pm 2.84^{\circ}$ ($P < .05$). Knowledge of carrying angle is useful anthropologically for differentiation of sex in fragmentary skeletal remains but according to our study racial differences in carrying angle should also be taken into consideration. It is of immense help to the orthopedic surgeon for correction of cubitus varus deformity occurring after mal-united supracondylar fracture of the humerus and in pediatric elbow surgery.

KEYWORDS: Carrying angle, Cubitus varus, Goniometer, Humerus, Orthopedic surgeon.

INTRODUCTION: Apes and humans are distinguished from other primate species in possessing carrying angle at the elbow. The evolution of a carrying angle in apes is related to the need to bring the center of mass of the body beneath the supporting hand during suspensory locomotion as seen in lower limbs of humans in which the valgus knee brings the foot nearer the center of mass of the body during the single limb support phase of walking (Larson, 2000¹).

The lower part of the humerus and the upper part of the radius and ulna comes in the formation of the elbow joint. The elbow joint includes two articulations humero-ulnar- between trochlea of humerus and the ulnar-trochlear notch and humero-radial between the capitulum of humerus and the radial head. Hence it is a compound synovial joint. The trochlea is not a simple pulley as its medial flange exceeds its lateral, thus projecting to a lower level so that the plane of the joint is 2 cm distal to interepicondylar line.

When the upper extremity is in the anatomic position, the long axis of the humerus and the long axis of the ulna form an acute angle medially at the elbow which is called the carrying angle². Angle of deviation of the ulna from the long axis of the humerus forms the carrying angle of the elbow. This is an acute angle (approximately 14° in males [range 2° - 26°] and 16° in females [range 2° - 22°]). The carrying angle in this case is greater in females than in males.^{3,4} According to Mall⁵ the axis of the elbow joint is set obliquely at nearly 84° of both the humerus & ulna. Langer⁶ was of the opinion that the obliquity of trochlea to the shaft of the humerus is the cause. Kapandji⁷ explained that the angle is formed as a result of trochlear groove being vertical

ORIGINAL ARTICLE

anteriorly but on the posterior aspect it runs obliquely distally & laterally. This results in formation of carrying angle in extension when posterior aspect of the oblique groove makes contact with the trochlear notch of ulna & the angle is marked during flexion when trochlear notch lies on the vertical groove in the anterior aspect. Last⁸ suggested is that in the ulna a curved ridge joins the prominence of the coronoid & olecranon process which fits the groove in the trochlea of the humerus. The obliquity of the shaft of ulna to this ridge accounts for most of the carrying angle at elbow.

It is reported that carrying angles differ according to the sex and age. (Smith,⁹ 1960; Beals,¹⁰ 1976; Amis,¹¹ 1982; Tachdjian,¹² 1990). According to Khare et al (1999) the carrying angle is greater in shorter persons compared to taller persons and the lesser the forearm bone lengths the greater the carrying angle will be.

MATERIALS AND METHODS: This study is comprised of 400 healthy volunteers belonging south Indian origin with an average age range: 18-38 years. Informed, written, witnessed consent in vernacular of each subject was taken. Individuals with a previous history of fracture of arm and forearm bones or growth disturbance involving any one of the upper extremity were excluded from the study. The carrying angle measurements were performed first on the dominant extremity and then on the non-dominant extremity.

The carrying angle was measured with a full circle manual goniometer made of flexible clear plastic with 35 cm long arms. The measurement was taken by placing the goniometer's measurement plate at the fulcrum of one elbow. Lining one arm of the goniometer along the middle of the patient's arm the goniometer's other arm along until it lines up along the middle of the patient's forearm. Students' tests were used to compare the values of the carrying angles. P value <.05 was considered significant.

RESULTS: This study included 400 volunteers, 160 males (40 %) and 240 (60 %) females. Volunteers with right arm dominance were seen in 386 (96.5 %). Volunteers with left arm dominance were seen in 14 (3.5 %). In the males, the right carrying angle was $13.8^{\circ} \pm 3.02^{\circ}$ and the left carrying angle was $12.2^{\circ} \pm 1.84^{\circ}$ ($P < .05$) (table 1). in the females, right carrying angle was $18.4^{\circ} \pm 2.62^{\circ}$ and left carrying angle was $17.5^{\circ} \pm 2.84^{\circ}$ ($P < .05$) (table 1). Right and left carrying angles of females were found to be higher than carrying angles of males. The difference between males and females carrying angle was statistically significant ($P < .05$).

Gender	Right arm	Left arm	SD	P value
Male	$13.8^{\circ} \pm 3.02^{\circ}$	$12.2^{\circ} \pm 1.84^{\circ}$	3.54	$P < 0.05$
Female	$18.4^{\circ} \pm 2.62^{\circ}$	$17.5^{\circ} \pm 2.84^{\circ}$	2.64	$P < 0.05$

Table 1: Showing mean of carrying angle of males and females of south Indian population

DISCUSSION: Several authors have attempted to determine the variation of carrying angle with age and sex. Potter¹³ was the first to carry out an investigation on variation of carrying angle in male and female. He observed the greater carrying angle in females than in males.

ORIGINAL ARTICLE

The broad shoulders and narrow hips of the males, allow the arms to hang straight downwards with the long axis of the upper and lower segment approximately in the same straight line. Whereas in the females, the narrower shoulders and broader hips require a splaying out of the forearm axis in order that the hanging arms clear the hips. This observation made by Hooton¹⁴ (1946) became the basis for the theory of carrying angle.

According to Khare¹⁵ et al. (1999), the carrying angle does not help in keeping the forearm away from the side of pelvis during walking as during walk the forearm is pronated and carrying angle disappears in pronation of forearm. They found that carrying angle is inversely related to the height of a person, since the average height of females is lesser than the average height of males so average carrying angle is greater in females than males.

Different authors have found different values of carrying angle; this could be due to different methods from use of a simple goniometer to some complex radiological procedure, used by different authors and due to racial difference of the population studied.

Punia¹⁶ et al. (1994) mentioned that according to Moore¹⁷ (1985) knowledge of carrying angle is useful anthropologically for differentiation of sex in fragmentary skeletal remains but according to our study racial differences in carrying angle should also be taken into consideration.

CONCLUSION: Carrying angle is always higher in female than in male. Comparison with other studies shows wide regional variations, implying environmental and genetic factors during growth and development. Greater carrying angle in female is considered as secondary sex characteristic. It is of immense help to the orthopedic surgeon for correction of cubitus varus deformity occurring after mal united supra condylar fracture of the humerus and in pediatric elbow surgery. This study will assist the manufacturers preparing for elbow replacement implants. There is a high standard deviation when compared to the other studies as the population studied may have subjects belonging to different ethnic back grounds. Also lifestyle changes may affect the different groups in different possible ways.

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ORIGINAL ARTICLE

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