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THE CARRYING ANGLE OF ELBOW- A CORRELATIVE AND COMPARATIVE STUDY

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ABSTRACT

Background and Objectives: The angle formed by the axes of the arm and the axes of forearm when the elbow is fully extended and forearm is supinated that obtuse angle is known as "carrying angle". Carrying angle evaluation is important to identify deformities of elbow. The present study aimed Measure and correlation of carrying angle with various parameters in young males and females.

Materials and methods: The present study includes 220 (110 females & 110 males) healthy students of MBBS from KBNIMS, Gulbarga, belongs to Karnataka were selected and ages groups is 18 to 22 years. Goniometry is used for measurement of carrying angle. Height measured in normal anatomical standing posture and length of forearm measured with measuring tape. Measurements were documented and statistically analyzed. Spearman's correlation use to get relationship between parameters. **Result:** In females there was a significant positive correlation ($p<0.05$) of age with carrying angle of both sides, height was negatively correlated with carrying angle of both sides, no correlation between length of forearm with coring angle. In males Age and Height were not correlated with carrying angle but, the length of the forearm was significantly negatively correlated with carrying angle of both sides ($p<0.05$). Greater carrying angle was found in females.

Conclusion: Carrying angle increases with age and greater in females may be because Olecranon-coronoid angle exhibiting high sexual dimorphism may be one of the causes and it may also considered as secondary sexual characteristic. Carrying angle measurement helpful in reconstruction of elbow disorders observed after treatment of distal humerus fractures and evaluating praumatic elbow injuries.

Keywords: Carrying angle, Elbow joint. Sexual dimorphism, Trochlear angle

INTRODUCTION

The elbow joint is formed between the humerus in the upper arm and the radius and ulna in the forearm and allows the hand to be moved towards and away from the body. When the arm is extended forward, the humerus and forearm are not perfectly aligned a deviation occurs laterally towards the long axis of the arm, which is referred as the "carrying angle" (1).

The carrying angle apparently develops in response to pronation of the forearm and keeps the swinging upper extremity away from the side of the pelvis during walking (2). William et al suggested that the angle is formed by the medial edge of trochlea of humerus partly projects nearly 6 mm below the lateral edge & the oblique superior articular surface of the coronoid process which is not set at right angle to the shaft of ulna (3). Some studies showed that the inner lip of

trochlea of humerus is a ridge groove deeper in distally anteriorly so ulna is deflected in full extension by this ridge (4, 5).

Women on average have smaller shoulders and wider hips than men, which may be one reason for more acute carrying angle. A more recent study based on a sample size of 333 individuals from both sexes concluded that carrying angle is a suitable secondary sexual characteristic. The olecranon- coronoid angle shows high sexual dimorphism and it may be one of the causes of sexual difference observed in carrying angle (6).

The evaluation of carrying angle is also essential for handling and monitoring of traumatic lesions that affect the pediatric elbow (7). The increased carrying angle may lead to elbow instability and pain during exercise or in throwing sports and may reduce elbow flexion, dislocation, fracture when fall on outstretched hand and fracture of distal humeral epiphysis (8, 9, 10) and also important anthropologically for sex differentiation in skeletal remains and reduction of fractures complication of supracondylar fracture and may result in cosmetic deformity and for designing total elbow prosthesis (23).

Hence, the present study aimed to study the difference in carrying angle between sex (i.e., Male & female) and to find out any correlation of carrying angle with different parameters like age, height, length of the fore arm as this helps orthopedic surgeon for correction of cubitus varus deformity occurring after malunited supracondylar fracture of humerus.

MATERIAL AND METHODS

After informed consent, 220 (110 female & 110 male) asymptomatic, healthy students of M.B.B.S of Khaja Bandanawaz institute of Medical sciences, Gulbarga belonging to various regions of Andhra Pradesh, Karnataka were recruited for the study. There ages ranged between 18 to 22 years. Medical students of this age group were selected as subject because of easy availability. Demographical data was obtained from each subject including age. The students who had previous elbow injuries as well as congenital anomalies about the elbow were excluded from study. The study was designed to include subjects criteria was those with asymptomatic of any deformity, surgeries or fractures around the elbow joint and right handed individuals.

An improvised instrument goniometry was used to measure the carrying angle from both upper limbs of right and left side. The fixed arm placed on the median axis of the upper arm, the movable arm adjusted as to lie on the median axis of forearm and the angle read on the goniometer. Height was measured in standing, erect, anatomical position from vertex to heel with bare foot. Measuring tape was used to measure the length of forearm and technique used for measuring carrying angle is universally accepted. Measurements were documented and statistical analysis was done to get mean, and spearman's correlation Analysis was done to determine any possible relationship between age, height and length of forearm with carrying angle.

RESULTS

Table: 1 shows there was a significant difference in carrying angle of the two sides of the upper limbs both in males and females and a significant greater carrying angle was found in females. It was observed that the carrying angle of right limb was greater than left in both sexes. Similarly the right length of the forearm was significant than the left in both males and females.

In the present study we have done spearmen's correlation analysis to observe relationship between various parameters in both sexes.

Table: 2 shows there was a significant positive correlation ($p<0.05$) of age with carrying angle of both sides in females. Height was negatively correlated with carrying angle of both sides but not significant similarly there was no correlation between length of forearm with carrying angle in females.

In Males Age and Height were not correlated with carrying angle but, the length of the forearm was significantly negatively correlated with carrying angle of both sides ($p<0.05$) shown in **Table: 3**.

DISCUSSION

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 (11).

In the present study we observed that carrying angle of females (13.54±6.44) is greater than males (12.09±4.66) our study was in line with studies like Khare GN *et al* (12) showed that carrying angle was more in females and they concluded that the carrying angle does not help in keeping the forearm away from the side of pelvis during walking, the forearm is pronated and carrying angle disappears in pronation of forearm. Fick (13) claimed that the external deviation of the forearm is because of two powerful muscles brachioradialis and extensor carpi radialis longus. These muscles as they located at the radial side abduct the forearm radially and contribute to the formation of the carrying angle. This ‘‘muscular theory’’ explains carrying angle fact that (a) in individuals of athletic and obese constitution, the angle is more as the muscles are well developed, and (b) in older individuals the angle is more as muscles are stronger. But, in many cases, the muscular theory cannot explained like the carrying angle is more obvious in women, in whom the muscles are less developed than in men. This may be inferior one-third of the shaft of the female humerus appears to have a slight radial deviation, which causes a more carrying angle in women (14). Aebi *et al*, Paraskevas G *et al*. (15,16) concluded that the brachial angle is similar in both sexes, but the ulnar angle of the elbow joint is smaller in women than in men, which causes a more carrying angle in women. Hubscher (14) noted that the angle is very similar in boys and in men, but varies in females with age, he explained that the hormonal factor may influence the carrying angle in women. Emami *et al* & Tukenmez *et al* (17, 18) found that carrying angle increases with age because of skeletal maturation and it is always greater on dominant side.

Our study was in contrast with studies like Beals *et al* (19) carrying angle increases with age, but same in each gender, but the study was done radiographically. Similarly, Dai *et al* (20) did not find any difference in carrying angle between boys and girls this variability may be because of different measurement techniques, races and number of cases.

Hence, Most of the studies have focused on cause of formation of carrying angle, difference in sex and age but little attention has given to correlate the carrying angle with various parameters. In the present study we made an effort to find out the correlation of carrying angle with age, height and length of forearm and found that in females the carrying angle significantly positively correlated with age, negatively but not significantly correlated with height and no correlation was found with length of forearm. In males the carrying angle was correlated with age and height but, negatively significantly correlated with length of forearm.

Our study was in agreement with study of Ruparelia et al (21) found that the height and forearm length both are more in males than females. In contrast to this average carrying angle is more in females than males, the findings similar to present study they explained that if height & length of ulna is lesser then in shorter person the medial part of trochlear notch of ulna goes more away from the medial flange of trochlea which can now grow more than in a

person with longer forearm, leading to greater carrying angle.

In present study in females there was no relationship of carrying angle with forearm length and in males the forearm length increases the carrying angle decreases we proposed an explanation that the carrying angle depend on greater the length of the forearm bone lesser is the angulation of proximal articulation of proximal articular surface, therefore lesser is the carrying angle. Shorter persons therefore have smaller carrying angles than taller persons.

The study of carrying angle has much clinical significance like extent of the carrying angle is used to determines the type of fracture that a child suffers when falling on an outstretched hand and also cubitus varus deformity can be prevented. The increased carrying angle may also leads to ulnar neuropathy. First, is it increase angulation of the ulnar nerve pathway and increase the tension & chronic stretching injury of the ulnar nerve at the elbow. Second, the ulnar nerve is angulates two heads of the flexor carpi ulnaris muscle by forward movement of the ulnar nerve resulting from forward movement of the medial head of the triceps brachii muscle in patients with cubitus valgus or cubitus varus deformity (22).

CONCLUSION

In our results are consistent with the literature that the carrying angle increases with age and carrying angle is greater in females because Olecranon-coronoid angle exhibiting high sexual dimorphism may be one of the causes of sexual dimorphism observed in carrying angle and it may be considered as secondary sex characteristic in female. The highest value of this angle in the female gender would be justified by the presence of ligamentous laxity also. Knowledge of the measurement of the elbow carrying angle and of its variations is important when evaluating traumatic elbow injuries in childhood and in adolescence and other elbow disorders that require reconstruction or arthroplasties. Increased carrying angle may be a risk factor for nontrauma- related ulnar neuropathy.

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Table: 1 Shows Demographic values and carrying angle of both sexes

Sex	side	Carrying angle (in degree)		Length of forearm (in cm)		Height (in cm)		Age	
		Range	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD
Male	Right	5-22	12.09±4.66	25-31	28.07±1.48	164-188	172.83±6.75	18-22	19.89±1.36
	Left	5-19	10.20±4.53	25-30	27.97±1.35				
Female	Right	4-27	13.54±6.44	23-29.5	26.12±1.45	148-170	159.18±6.42	18-22	19.88±1.37
	Left	4-25	11.90±5.61	23-29	25.81±1.57				

Table-2 Spearman's correlation coefficient Analysis of female group:

Variables	CORRELATION COEFFICIET (ρ)	p – VALUE
Age and carrying angle of right	0.249**	0.05*
Age and carrying angle of left	0.247**	0.04*
Height and carrying angle of right	-0.083	0.38
Height and carrying angle of left	-0.057	0.55
Forearm length of right and carrying angle of right	0.188	0.49
Forearm length of left and carrying angle of left	0.216	0.23

*** - Statistically significant, ρ = spearman's correlation coefficient**

Table-3 Spearman's correlation coefficient Analysis of Male group:

Variables	CORRELATION COEFFICIET (ρ)	p – VALUE
Age and carrying angle of right	0.017	0.85
Age and carrying angle of left	0.072	0.45
Height and carrying angle of right	0.014	0.88
Height and carrying angle of left	-0.030	0.75
Forearm length of right and carrying angle of right	-0.199*	0.03*
Forearm length of left and carrying angle of left	-0.198*	0.03*

*** - Statistically significant, ρ = spearman's correlation coefficient**