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Original Research Article

THE COMPARISON AND EVALUATION OF CARRYING ANGLE OF ELBOW WITH ANTHROPOMETRIC MEASUREMENTS IN BOTH SEXES

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ABSTRACT

Background: The carrying angle is defined as the acute angle made by the median axis of the arm with the fully extended and supinated forearm. It is important in walking, swinging and carrying objects. Various studies have been done on the cause of the formation of carrying angle. Variations in carrying angle have been reported with age groups, gender and race but little attention has been given to correlate the carrying angle with various anthropological parameters .Hence this study was done to co-relate the carrying angle with various anthropological parameters.

Material and Methods: The present cross sectional observational study was done on 226 students (122 males and 94 females) of age group 17-21 years. A written informed consent was taken. Ethical clearance was taken from institutional ethical committee. The carrying angle of the elbow was measured by goniometer. Height was measured using a stature meter. Arm and forearm length was measured using vernier caliper. Data was statistically analyzed by "paired- t" test to compare parameters in between paired observations and "unpaired- t" test to compare groups. The relation between the continuous variables was found by pearson 'correlation (r) test.

Results: Carrying angle, arm length and forearm length of right side was statistically significantly increased as compared to left side in both males and females. Right hand carrying angle showed no correlation with arm length, forearm length and height in females whereas left hand carrying angle of females and both side carrying angle of males showed negative correlation with arm length, forearm length and height.

Conclusion: Carrying angle was greater in females than males. The carrying angle was more on the right side than the left side in both sex. Carrying angle showed negative correlation with height and forearm length in both sex.

KEY WORDS: Arm length, Carrying angle, Elbow, Forearm length, Height, Sex.

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INTRODUCTION

The carrying angle is defined as the acute angle made by the median axis of the arm with the median axis of the fully extended and supinated

forearm. It measures the lateral obliquity of the forearm[1].The average carrying angle in males is about 5^0 whereas in females it is about 10-15^0 [2]. This angle is important in walking, swinging and carrying objects[2]. It permits the arm to swing without contacting the hips during walking[2].

Various studies have been done on the cause of formation of carrying angle. Some suggest that the valgus angulation of the forearm is a result of the configuration of the articulating surface of the humerus and ulna [1,2].Moreover in ulna a curved ridge is present between olecranon and coronoid process which fits the trochlear groove of humerus. The shaft of ulna is deflected by this ridge which accounts for most of the carrying angle [3,4]. But recent studies suggest that the medial edge of trochlea of humerus projects 6 mm below the lateral edge and the obliquity of the superior articular surface of the coronoid process may be responsible for the angulation [5].

Knowledge of carrying angle is important anthropologically for differentiation of sex in fragmentary remains and also to understand sexual dimorphism which is more common in bones [6]. It is important in the diagnosis of the disease of lateral and medial epicondyle [7]. It helps in the monitoring of traumatic lesions that affect the paediatric elbow [8]. Biomechanical engineers may require knowledge of the same for designing a total elbow prosthesis [9].

Developmental, aging and possibly racial influences add further to the variability of the carrying angle[6]. Most studies have focused on the cause of the formation of carrying angle. Many have reported variations in carrying angle with age groups, gender and race but little attention has been given to correlate the carrying angle with various anthropological parameters. Hence this study was done to correlate the carrying angle with various anthropometric measurements such as length of arm, length of forearm and height.

MATERIALS AND METHODS

The present cross-sectional observational study was done on 188 students (86 males and 82 females) of A.C.P.M Medical, Dental and Nursing college, Dhule of age group 17-21 years. A written informed consent was taken after explaining the aim of study in detail. Ethical clearance was taken from the institutional ethical committee. The mean age of the female subjects was 18.9 ± 0.7 years and male subjects was 19.1 ± 0.9 years

Exclusion Criteria: History of fracture of arm and / or forearm bones, deformity involving upper extremity, neuropathies, history of congenital anomalies, history of endocrine disorders, athletes.

Procedure:

Carrying angle: The carrying angle of the elbow of both hands was measured using a full circle goniometer made of flexible clear plastic with 35 cm long arms. Bicipital groove, Biceps brachi tendon at its insertion and Palmaris longus tendon at the wrist were palpated and marked as anatomical landmarks to demarcate the median axis of arm and forearm respectively. The measurement was taken by placing the goniometer's measurement plate at the fulcrum of one elbow. The fixed arm was placed on the median axis of the upper arm, the movable arm adjusted on the median axis of forearm. The arrow on the goniometer measurement plate indicated the angle.

Arm length: The length of the arm was measured as the distance between the lateral border of Acromion and lateral border of head of Radius with forearm in pronated position using vernier caliper.

Forearm length: The length of the forearm was measured as the distance between the lateral border of the head of radius to styloid process of radius using vernier caliper.

Three consecutive readings of the above paramaters were taken and the mean was recorded .

Height: Measurement of height of students was done using a stature meter. Height was measured from vertex to heel of the individual with bare foot in anatomical position in centimeters.

The data was tabulated and statistically analysed. Comparison of mean of parameters in between paired observations was done by 'paired t' test. Comparison in between the groups was done by 'unpaired t' test. Correlation between the continuous variables was done

by Pearson's correlation (r) test. The statistically significance level of p<0.05 was considered for interpretation[10].

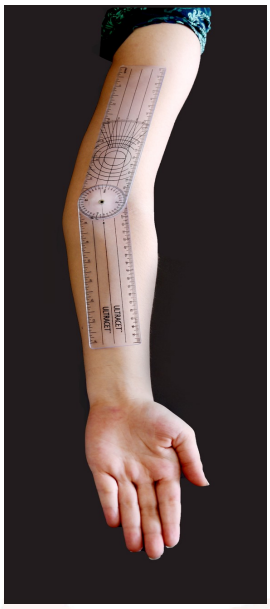

Fig. 1: Measurement of Carrying angle of elbow by using goniometer.

RESULTS

Table 1: Comparison of Carrying angle of elbow in males and females.

	Female (n=82)	Male (n=86)	Mean difference	p value
Right Carrying angle	11.05±2.012	8.03±1.718	3.014	<0.001
Left Carrying angle	10.26±1.858	7.09±1.733	3.163	<0.001
Mean carrying angle	10.65±1.829	7.56±1.673	3.088	<0.001

The mean carrying angle of female subjects was 10.65 ± 1.829 whereas in males was 7.56 ± 1.673. The carrying angle of female subjects was found statistically highly significantly increased as compared to males (P<0.001).

Table 2: Comparison of mean carrying angle, forearm and arm length in between two sides in both sex.

Gender	Parameters	Right Side	Left Side	P value
Female (n=82)	Carrying Angle (º)	11.05±2.012	10.26±1.858	<0.001
	Forearm Length(cms)	231.24±11.669	228.09±11.481	<0.001
	Arm Length (cms)	280.66±13.858	279.87±13.347	0.435
Male (n=86)	Carrying Angle (º)	8.03±1.718	7.09±1.733	<0.001
	Forearm Length(cms)	255.74±13.387	252.87±12.852	<0.001
	Arm Length (cms)	311.09±17.491	307.34±16.747	0.007

Carrying angle of the right side was statistically increased as compared to left side in both males and females. The forearm length and the arm length of right side was also found to be statistically significantly more as compared to left side in both males and females.

Table 3: Correlation of anthropometric parameters with carrying angle of elbow in females (n=82).

Carrying Angle		Carrying angle		Forearm length		Arm Length		Height
		Right	Left	Right	Left	Right	Left	
Right	r	1	0.786	-0.023	-0.086	0.048	0.168	-0.092
	p value		<0.001	0.84	0.441	0.666	0.131	0.411
Left	r	0.786	1	-0.177	-0.225	-0.068	-0.013	-0.151
	p value	<0.001		0.112	0.042	0.541	0.907	0.175

Table 3 Shows statistically highly significant (P<0.001) positive correlation of carrying angle of right and left side in females. Carrying angle of right side showed no correlation with forearm length, arm length and height in females. Shows statistically highly significant (P<0.001) positive correlation of carrying angle of right and left side in females. Carrying angle of right side showed no correlation with forearm length, arm length and height in females.

Table 4: Correlation of anthropometric parameters with carrying angle of elbow in males (n=86).

Carrying Angle		Carrying angle		Forearm length		Arm Length		Height
		Right	Left	Right	Left	Right	Left	
Right	r	1	0.88	-0.269	-0.236	-0.177	-0.053	-0.348
	p value		<0.001	0.012	0.028	0.102	0.63	0.001
Left	r	0.88	1	-0.301	-0.265	-0.17	-0.073	-0.328
	p value	<0.001		0.005	0.014	0.119	0.505	0.002

Table 4 Shows statistically highly significant (P<0.001) positive correlation of carrying angle of right and left limbs in males. Right limb carrying angle showed statistically significant (P<0.001) negative correlation with forearm length, arm length and arm length and height in males. Left limb carrying angle showed statistically significant (P<0.05) negative correlation with forearm length, arm length and height in males.

DISCUSSION

Table 1 it was seen that the carrying angle of females was significantly more than males.This matched with the findings of Patil GV et al, Raichandani L et al, Manglaur V et al, Kumari LK et al [11-14]. The greater angle in females as compared to males is considered as a secondary sexual characteristic. As according to the study of some authors the increase is seen in females only after puberty [1,2]. Hence it can be due to hormonal influence [12]. It may be that the greater carrying angle develops in response to the broader pelvis in females to keep the forearm away from the side of the pelvis when the upper limb swings during walking [6].

But some authors contradicted this as the carrying angle is formed only when the forearm is fully supinated and extended at the elbow and during walking the forearm is pronated and elbow is slightly flexed. So the carrying angle is not present during walking [6].

According to some authors the apparent difference in gender may be due to increased joint laxity in females, permitting a greater degree

of extension which leads to more carrying angle [8]. Moreover when the forearm is pronated the proximal part angulates. Due to this the medial part of the trochlear notch moves more away from the humeral articular surface than the lateral part. As a result the medial lip of trochlea grows more distally than the lateral lip and also the valgus tilt of the distal humeral articulation with respect to the longitudinal axis of humerus is more in females leading to more carrying angle in them [8]. Olecranon coronoid angle exhibiting high degree of sexual dimorphism may be one of the cause of sexual differences observed in carrying angle. Inferior one third of the shaft of female humerus appears to have a slight radial deviation which may cause a more carrying angle in woman [12].

Table 2 shows increased carrying angle on right side as compared to left side in both males and females. It also revealed that arm and forearm length of right side was more as compared to left side in both males and females. This matched with the findings of Rajesh B et al, Manoranjitham R et al [2,6].

In contrast in studies done by Sharma K et al and Lim V et al it was seen that carrying angle of left side was more than the right side in both sex [7,8] .

Difference between the carrying angle of right and left sides may be due to ligamentous laxity at the medial elbow or asymmetrical bone growth [2]. The angle is greater in the dominant limb than in the non dominant limb of both sexes, suggesting that the natural forces acting on the elbow modify the carrying angle [2,6].

Table 3 Carrying angle of right side shows no correlation whereas left side carrying angle shows negative correlation with forearm length ,arm length and height in females.

Table 4 Shows negative correlation of right and left side carrying angle with forearm length, arm length, height in males. Similar findings were seen in the study of Ruparelia S et al, Sharma K et al, Kumari L K et al [1,7,14].

If the height of a person is less and therefore length of forearm (ulna) is lesser, then because of shorter lever arm, the proximal end has to angulate more in order to bring the hand in pronated position for routine work.Therefore in a 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 [6,7]. Greater the length of the forearm bones, lesser is the angulation of proximal articular surface and therefore lesser is the carrying angle [6]. The mean height of females in this study was 154.51 ± 5.892cm and in males was 169.00 ± 6.015 .The height of the females is less as compared to males. According to Table 1 the carrying angle of females is significantly more than males. The lesser height in females might have also contributed to greater carrying angle in them as compared to the males.

CONCLUSION

In the present study it was found that the carrying angle was significantly greater in females as compared to males. It may be due to hormonal influences or increased joint laxity in females. The increased growth of medial lip on trochlea as compared to lateral lip in females along with increased vagal tilt of distal humeral articulation with longitudinal axis of humerus also contributes for the increased carrying angle. It was also observed that the carrying angle on the right side was greater than left side which may be due to ligamentous laxity or asymmetrical bone growth. It was seen that the carrying angle in females on the right side did not show any correlation with the forearm length, arm length and height whereas the left side carrying angle in females and both sides carrying angle in males showed negative correlation with arm length, forearm length and height. Greater the height, greater is the forearm length, lesser in the angulation of proximal articulating surface and lesser is the carrying angle. Thus the value of carrying angle and its correlation with height, forearm length and sexual variation is of immense importance in the management of elbow dislocation, elbow deformities, elbow fractures and elbow reconstruction. As a deformity of carrying angle may result in non traumatic ulnar neuropathy,elbow instability,painful movement at elbow. This study can also help a forensic anthropologists to discriminate the sex of an individual from skeletal remains.

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Conflicts of Interests: None

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