

**Original Article****Morphometric measurements of carrying angle of elbows and its association with gender and height among Kashmiri population: A cross-sectional study**

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Sheikh Mohd SaleemEmail: saleem.900@gmail.com, Contact: +91-7006806993**Abstract****Background:** *The carrying angle is defined as the acute angle made by the median axis of the arm and that of fully extended & supinated forearm & thus it measures the lateral obliquity of the forearm.***Objectives:** *The objectives of the study were to estimate the male female difference in the carrying angle among Kashmiri population and to find out any correlation of carrying angle with different parameters like gender and height.***Methods:** *We included an arbitrary sample of 200 students both male and female from the sampling frame using convenient sampling method. The socio-demographic characteristics and anthropometry data were recorded on a pretested, predesigned proforma. The measurement of carrying angle was done using an improvised instrument goniometer.***Results:** *A total of 200 participants were included in the study, among whom 53% were females and rest were males. The mean height of all the participants was 168.14±6.41 Cms. The carrying angle ranged from 7 -19 Degrees in the study participants among both the sexes. The association of the gender and height of the participants with carrying angle was found to be statistically significant for both right and left extremities with p-values < 0.05.***Conclusion:** *The present study concludes that the carrying angle is greater in females than in males and it can be regarded as the secondary sexual characteristic in females. Furthermore, height of an individual is inversely proportional to its carrying angle.***Keywords:** *Carrying Angle, Carrying angle and Gender, Height and Carrying angle Kashmiri Population.***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^[1]. When the arm is extended forward, the humerus and forearm are

not perfectly aligned or when the forearm is completely extended and supinated, as in carrying an object, it is not in line with the arm but is deflected laterally. These deflections or deviation which occurs laterally towards the long axis of the arm, are referred as the "carrying angle" or cubital angle^[2,3].

The carrying angle may also be defined as the acute angle made by the median axis of the arm and that of fully extended & supinated forearm & thus it measures the lateral obliquity of the forearm^[4]. 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. 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 with the elbow joint fully extended^[3], the axis of the forearm deviates laterally, distally, from the axis of the humerus. An improvised instrument goniometry is used to measure the carrying angle of the upper extremities. The procedure of the measurement of carrying angle is discussed in other sections of this paper. This deviation, the carrying angle, has been quoted as 10 to 15 degrees in males, and up to 25 degrees in females^[5].

It is well documented that the women on an average have smaller shoulders and wider hips than men, which may be one reason for more acute carrying angle in them. This intersex disproportionate nature of the carrying angle is popular among researchers and is regarded as one of the promising secondary sexual characteristic^[3]. Furthermore, the clinical anatomy of the carrying angle is related to handling and monitoring of traumatic lesions that affect the pediatric elbow, increased carrying angle may lead to elbow instability, pain during exercise, reduce elbow flexion, dislocation and fractures. It is 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^[3].

In view of the clinical importance of the carrying angle and lack of sufficient literature on the said topic among Kashmiri population, we conducted this study with an aim to estimate the normal carrying angle among Kashmiri population. The objectives of the study were to estimate the male female difference in the carrying angle among Kashmiri population and to find out any correlation of carrying angle with different parameters like gender and height. The results of the study may be useful to orthopedic surgeons for correction of cubitus varus deformity occurring after malunited supracondylar fracture of humerus.

Material and Methods

Study design and Setting: This cross-sectional study was carried out by the postgraduate Department of Anatomy, Government Medical College, Srinagar among undergraduate medical students of the college.

Inclusion Criteria: We included the undergraduate students for the study as they are selected via a common medical entrance test and come from different parts of Kashmir valley. They represent diverse inter-geographical and socio-cultural variations and represent whole of the Kashmir valley in one or the other forms. At first the students were explained about the objectives of the study and those who gave written informed consent were included in the study.

Exclusion criteria: The students were asked about their medical history including a report of trauma, fracture, or disablement of the upper limb and were excluded from the study as these could influence the results of our research.

Sampling Method: We included an arbitrary sample of 200 students both male and female from the sampling frame using convenient sampling method.

Sample collection: The socio-demographic characteristics and anthropometry data were

recorded on a pretested, predesigned proforma. The measurement of carrying angle was done using an improvised instrument goniometer. The participants were asked to stand up straight, roll his/her shoulders back and gently rotate his palms to face forward. The goniometer was placed on the elbow joint and was straightened. The two arms of the goniometer were straightened so that the readout on the plate shows 0 or 180 degrees. The goniometer's measurement plate was placed at the fulcrum of one elbow. One arm of the goniometer was placed along the middle of participant's upper arm. The other arm of the goniometer was moved until it lines along the middle of the participants forearm. The readout angle was recorded from the measurement plate. The recorded angle was then subtracted from the initial reading readout between 0 or 180 degrees. The final number was taken as the carrying angle for that particular arm. The process was repeated for both the elbows using the procedure mentioned supra.

Ethical Clearance: Before the commencement of the study, permission was taken from the Departmental ethical committee who gave permission to conduct the study.

Statistical Analysis: Data was entered into Microsoft excel spread sheet 2013 and was analyzed using SPSS v.20.0. Outcome was expressed into measures of central tendency viz. mean and standard deviation where ever necessary. Categorical variables were analyzed

using chi-square test. A p-value of < 0.05 was considered significant at 95% confidence interval.

Results

A total of 200 participants were included in the study, among whom 53% were females and rest were males. The mean height of all the participants was 168.14±6.41 Cms. The range being 160-182.9 Cms. The mean height of the male participants was 173.58±4.64 Cms and the female participants was 163.32±2.98 Cms {Table 1}.

The association of the gender of participants with carrying angle of both the extremities is shown in Table 2. The carrying angle ranged from 7 -19 Degrees in the study participants among both the sexes. The right carrying angle in male participants ranged from 7-16 degrees while in female participants, it ranged from 9-18 degrees respectively. Similarly, the left carrying angle in male participants and female participants ranged from 7-15 degrees and 9-19 degrees respectively. The association of the gender with carrying angle was found to be statistically significant for both right and left extremities.

The height of the participants were grouped and compared with that of their carrying angles for both the extremities. The association of the height of both male and female participants were found to be statistically significant in both right and left extremities with p-values < 0.05. [Table 3 & 4]

Table 1: Description of Height of study participants

Trait	Frequency (%)	Mean	SD	S.E of Mean	Range
Height of all Participants	200 (100)	168.14 cms	6.41 cms	0.45 cms	160-182.9 cms
Height of Male Participants	94 (47)	173.58 cms	4.64 cms	0.47 cms	165.1-182.9 cms
Height of Female Participants	106 (53)	163.32 cms	2.98 cms	0.28 cms	160.0-170.2 cms

Table 2: Association of Gender of Participants with carrying angle of Right and Left extremities

	Sex	Carrying Angle (In Degrees)														Total	χ ² df	P value
		7	8	9	10	11	12	13	14	15	16	17	18	19				
Right Carrying Angle	Male	n	3	6	19	15	30	9	6	3	0	3	0	0	0	94	51.776 3	<0.001*
		%	3.2	6.4	20.2	16.0	31.9	9.6	6.4	3.2	0.0	3.2	0.0	0.0	0.0	100.0		
	Female	n	0	0	3	12	18	12	9	0	12	15	10	15	0	106		
		%	0.0	0.0	2.8	11.3	17.0	11.3	8.5	0.0	11.3	14.2	9.4	14.2	0.0	100.0		
Left Carrying Angle	Male	n	3	6	9	27	28	12	6	0	3	0	0	0	94	59.404 3	<0.001*	
		%	3.2	6.4	9.6	28.7	29.8	12.8	6.4	0.0	3.2	0.0	0.0	0.0	100.0			
	Female	n	0	0	3	12	24	3	12	3	9	12	13	12	3			106
		%	0.0	0.0	2.8	11.3	22.6	2.8	11.3	2.8	8.5	11.3	12.3	11.3	2.8			100.0

Table 3: Association of Height of Male Participant’s with their Carrying angle

Height (Cms)	Carrying Angle (In Degrees) Right Extremity									Total
	7	8	9	10	11	12	13	14	16	
165.1-170.0	3	0	0	0	0	0	3	0	3	9
170.1-175.0	0	3	13	9	18	0	0	0	0	43
175.1-180.0	0	3	3	3	12	3	3	3	0	30
180.1-185.0	0	0	3	3	0	6	0	0	0	12
Total	3	6	19	15	30	9	6	3	3	94
χ^2 12.400, df 4, p-value 0.015*										
Height (Cms)	Carrying Angle (In Degrees) Left Extremity									Total
	7	8	9	10	11	12	13	15	x	
165.1-170.0	3	0	0	0	0	3	0	3	x	9
170.1-175.0	0	3	3	9	22	6	0	0	x	43
175.1-180.0	0	3	3	12	3	3	6	0	x	30
180.1-185.0	0	0	3	6	3	0	0	0	x	12
Total	3	6	9	27	28	12	6	3	x	94
χ^2 33.049, df 4, p-value <0.001*										

Table 4: Association of Height of Female Participant’s with their Carrying angle

Height (Cms)	Carrying Angle (In Degrees) Right Extremity										Total	
	9	10	11	12	13	15	16	17	18	x		x
160.0-165.0	0	6	15	12	6	3	9	10	9	x	x	70
165.1-170.0	3	6	3	0	3	3	6	0	3	x	x	27
170.1-175.0	0	0	0	0	0	6	0	0	3	x	x	9
Total	3	12	18	12	9	12	15	10	15	x	x	106
χ^2 11.959, df 3, p-value 0.008*												
Height (Cms)	Carrying Angle (In Degrees) Left Extremity											Total
	9	10	11	12	13	14	15	16	17	18	19	
160.0-165.0	3	6	18	3	9	0	9	3	10	6	3	70
165.1-170.0	0	6	6	0	3	0	0	6	3	3	0	27
170.1-175.0	0	0	0	0	0	3	0	3	0	3	0	9
Total	3	12	24	3	12	3	9	12	13	12	3	106
χ^2 13.608, df 3, p-value 0.003*												

Discussion

Knowledge regarding the measurement of the elbow carrying angle and of its variations is of prime importance when doctors evaluate severe traumatic elbow injuries especially in children^[6]. The information is also required for other elbow disorders that require reconstruction or arthroplasties^[7,8]. The main factor that influenced and determined the performance of this study was that we do not have reference values for carrying angle established for the Kashmiri population. Many researchers have documented studies on carrying angle and its value in relation to different parameters most notably age, gender, and handedness, due to its anatomical, physiological, and clinical implications. Several studies have addressed age-dependent changes in the carrying

angle. In general, it is agreed that carrying angle increases with age because of skeletal growth and development^[9-11]. In regard to gender, carrying angle is usually greater in females than males; however, this tendency cannot be generalized because of large inter-individual differences^[12]. In this study we have documented the range of carrying angle and its relation to gender and height among undergraduate medical students of Government medical college, Srinagar, who represent diverse inter-geographical and socio-cultural variations and represent whole of the Kashmir valley in one or the other forms. A total of 200 undergraduate medical students were included in the study using convenient sampling method among which 106 were female participants and rest were males. The mean height

of all the participants was 168.14 ± 6.41 Cms. The range being 160-182.9 Cms. The mean height of the male participants was 173.58 ± 4.64 Cms and the female participants was 163.32 ± 2.98 Cms. In this study, we found that the male participants were having more height than that of the female participants. These results are in accordance with studies conducted by Raj J et al and Khare GN et al respectively^[13,14]. In their study they also demonstrated the mean height of the male participants was greater than the mean height of the female participants.

On measuring the carrying angle among the participants, it ranged from 7 -19 degrees in the study participants among both the sexes. The right carrying angle in male participants ranged from 7-16 degrees while in female participants, it ranged from 9-18 degrees respectively. Similarly, the left carrying angle in male participants and female participants ranged from 7-15 degrees and 9-19 degrees respectively. The association of the gender with carrying angle was found to be statistically significant for both right and left extremities. Similar findings were reported by Potter et al^[15], Atkinson and Elftman^[16] and R purkait et al^[17] who stated that the carrying angle value in the female participants was greater than that of male participants and the relationship was found to be statistically significant. They also documented that the carrying angle can be considered as a secondary sexual character especially in females where its value is usually higher than males. The differentiation in carrying angle can help identify females. Similar finding were reported by Khare GN et al^[18]. On comparing the height of the participants with their carrying angles, it was found that the carrying angle value in female participants were more than male participants and the association was statistically significant. The greater carrying angle value in females is due to more angulation of proximal part of the forearm in pronated position. Whereas the medial part of the trochlear notch moves more away from the articular surface of the humerus making the value of angle more in

female participants as documented by various studies^[19,20]. Bhaskar S et al^[20] and Zampagni ML et al^[21], also documented that the carrying angle is developed in response to the pronation of the forearm & is dependent on the overall length of the forearm bones. Length of the forearm bone is inversely proportional to the angulation of proximal articulation of proximal articular surface, therefore lesser is the carrying angle. As males have longer forearm bones than females, that's why they have lesser value of carrying angle.

The present study concludes that the carrying angle is greater in females than in males and it can be regarded as the secondary sexual characteristics in females. Furthermore, height of an individual is inversely proportional to its carrying angle.

What this study adds to the Literature

This cross-sectional study is the only study describing the morphometric measurements of carrying angle among Kashmiri population. The study provides new information on the carrying angle and its association with gender and height among Kashmiri population. The results of this study are clinically important for the examination and management of elbow fractures in orthopedics and may help in the prediction of race in forensic medicine. Further research is warranted that shall include more racial groups and larger populations to further confirm the influence of other factors on carrying angle.

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