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ORIGINAL RESEARCH

A Correlative Study on Carrying Angle and Body Height in the Male Population of Uttar Pradesh: An Observational study.

Anand Kumar Mishra[1], Mohd. Yameen[2], Akhil Sathyan[3], Vibhash Kumar Vaidya[4], Sagun Shukla[5],Ujjawal Singh[6]

[1]Assistant professor, Department of Anatomy, United Institute of Medical Science, Prayagraj, U.P
[2]Assistant professor, Department of Anatomy, TSM University, Lucknow, U.P
[3]Assistant professor, Department of Anatomy,VarunArjun Medical College &Rohilkhand Hospital, Banthara, Shahjahanpur, U.P. - 242307
[4]Assistant professor, Department of Anatomy,VarunArjun Medical College &Rohilkhand Hospital, Banthara, Shahjahanpur, U.P. – 242307
[5]Assistant professor, Department of Anatomy,VarunArjun Medical College &Rohilkhand Hospital, Banthara, Shahjahanpur, U.P. – 242307
[6]Tutor, Department of Anatomy,VarunArjun Medical College &Rohilkhand Hospital, Banthara, Shahjahanpur, U.P. – 242307

Corresponding author:
Dr. Vibhash Kumar Vaidya
Assistant professor, Department of Anatomy,VarunArjun Medical College &Rohilkhand Hospital, Banthara, Shahjahanpur, U.P. – 242307, Email id: vibashc455@gmail.com

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Abstract

Introduction: The carrying angle refers to the angle formed between the arm and forearm when the elbow is fully extended. This angle varies based on factors such as sex, age, and race, and can also be influenced by different morphological characteristics.

Aim and objectives: To analyze the correlation between carrying angle degrees and body height among male students at the UIMS, Prayagraj and VAMC & RH, Shahjahnpur.

Materials & Methods: In this cross-sectional study, the carrying angle of 500 healthy male students from UIMS, Prayagraj, and VAMC & RH, Shahjahanpur, aged between 17 and 35 years, was assessed. The study also examined the correlation between the carrying angle and participants' height. The carrying angle (measured in degrees) was determined using a manual goniometer, aligning two drawing axes of the arm and forearm in the anatomical position at the measurement point. The arm's axis was defined by the lateral border of the cranial surface of the acromion to the midpoint between the lateral and medial epicondyles of the humerus. Statistical analysis included standard deviation, t-tests, P-values, and correlation calculations. A p-value of $0.05 < P < 0.10$ was considered suggestively significant, while a p-value of $P \leq 0.001$ was regarded as highly significant.

Observation and Result: In this present cross-sectional study, the mean bilateral range for participants aged 17, 18, 19, and 20-35 years was 10.1˚-13.4˚, 13.1˚-15.1˚, 13.9˚-14.1˚, and 9.2˚-9.2˚, respectively. The carrying angle on the left side was greater in 18-year-old participants, whereas the right-side angle was greater in 19-year-old participants. A significant bilateral difference was observed for height, right carrying angle (RCA), and left carrying angle (LCA) ($p \leq 0.05$). The mean RCA and LCA values were nearly equal, with no significant difference, except in the 17-year-old and 20-35-year-old groups, where significant differences were noted.

Conclusion: The straightforward method used in this study to measure the carrying angle is recommended for future research and clinical practice due to its simplicity and effectiveness. Additionally, the values obtained may aid in the management of elbow disorders, while the significant differences observed between males and females could serve as a valuable reference in forensic medicine for sex differentiation.

Key words: Angle, Acromian, Gonio, LCA, RCA

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Introduction:

The carrying angle is the angle formed between the axis of the arm and the forearm when the elbow is fully extended. This angle varies based on factors such as sex, age, race, and different morphological characteristics [1]. It can be measured in vitro using various techniques, including a goniometer, X-rays, CT scans, and MRI. However, only a few studies have focused on measuring this angle in vivo [2]. In the anatomical position, the upper arm and forearm do not align in the same plane. Due to the lateral angulation of the forearm, its medial border does not make contact with the lateral surface of the thigh [3]. This lateral deviation at the elbow is attributed to the shape of the trochlea at the lower end of the humerus. The carrying angle is caused partly by the medial flange of trochlea edge, about 6mm beyond its lateral edge and partly by the obliquity of the superior articular surface of the coronoid which is not orthogonal to the shaft of the ulna [3]. But get masked by pronation of the extended forearm. The value of carrying angle might vary between the sexes as well as presence with different height. However, when the arm is extended in the anatomical position, the longitudinal axis of the upper arm and forearm form a lateral (valgus) angle at the elbow joint which is the angle of deviation (approximately 50 in males and between 100 and 150 in females) on the medial side [4]. The level of the elbow joint is situated 2cm below a line joining the two epicondyles. Which slopes downward and medially from its lateral extremity and this obliquity produces another angle on the lateral side of the elbow which is also regarded as the carrying angle by many authors [5, 6]. This angle is approximately examined on 165 degrees in the female and 175 degrees in the male [3]. These two angles however disappear on full flexion of the elbow, when the shafts of the ulna and humerus come to lie in the same plane, and is also obscured in full pronation of the forearm. The difference in the carrying angle in male of various age groups is a long debated issue in anatomy and anthropology [7, 8, 9]. Several studies showed variability in carrying angle among different age group of both sexes. Snell [10] obtained carrying angle of 170 degrees and 167 degrees for males and females, respectively. Variability is expected become of the variability of the measurement methods.

Carrying angle apparently develops in response to supination of the forearm and keeps the swinging upper extremity away from the side of the pelvis during walking [11, 12]. Degrees of carrying angle may vary in both the sexes, between 163-175 degrees towards the body. If it is more when measured away from the body it is called as cubitus valgus and if less, it is Cubits varus [13, 14]. But studies have been mentioned that there is a gradual increase in the carrying angle with skeletal maturation. A more recent study concluded that carrying angle is a suitable secondary sexual characteristic for the individual. The olecranon-coronoid angle shows high sexual dimorphism and it may be one of the causes of sexual difference observed in carrying angle.

An increased carrying angle can contribute to elbow instability and discomfort during physical activities, increasing the risk of dislocation and fractures—particularly when falling on an outstretched hand or sustaining a distal humeral epiphyseal fracture. Considering these factors, this study aims to establish a correlation between height and the carrying angle of the right and left elbows in males. Understanding the normal range of the carrying angle is essential not only for radiologists but also for orthopedic surgeons, as it plays a crucial role in diagnosing epicondylar conditions, managing fractures, and performing elbow reconstruction procedures effectively.

Importance of the study- The carrying angle holds significant clinical importance in Medicine, particularly in Anatomy, Surgery (with a focus on Orthopaedics and Paediatrics), Rehabilitation, and Sports Medicine. It plays a crucial role in determining the types of fractures likely to occur, especially in younger individuals, including infants, children, and young adults. For instance, supracondylar fractures are commonly observed in children (Park et al., 2003). The carrying angle influences the nature of fractures sustained after a fall on an outstretched arm (Park et al., 2003). This study aims to establish baseline carrying angle values in this population, which may aid future research in identifying correlations between carrying angle and fracture patterns. Additionally, it has practical applications in the diagnosis and management of elbow disorders.

Materials & Methods:

In this cross-sectional study, the carrying angle of 500 healthy male students from UIMS, Prayagraj, and VAMC & RH, Shahjahnpur, aged between 17 and 35 years, was assessed. The correlation between carrying angle and height of participants were also done.

Inclusion criteria: Only healthy male students from 17-35 year of age were included as study participants.

Exclusion criteria: Participants with a history or clinical evidence of fracture of the upper limb bone(s), dislocation on injury to the elbow or any congenital conditions were excluded from the study.

Methodology:

The carrying angle (measured in degrees) is determined using a manual goniometer, aligning it

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with the anatomical position of the arm and forearm at the point of measurement. The arm's axis is defined by the lateral border of the cranial surface of the acromion to the midpoint of the lateral and medial epicondyles of the humerus. The forearm's axis extends from the midpoint of the lateral and medial epicondyles of the humerus to the midpoint of the distal radial and ulnar styloid processes[15].

The goniometer is used as follows: First, the fulcrum is aligned with the joint crease between the medial and lateral epicondyles of the humerus. Next, the stationary arm of the goniometer is positioned along the axis of the arm, while the moving arm is adjusted along the forearm's axis. The carrying angle is then recorded. Additionally, height was measured in meters from the vertex to the heel, with the subject standing barefoot. Each measurement was taken three times, and the average was calculated to minimize bias and improve accuracy.

Statistical analysis: Microsoft-Excel, Microsoft Disk Operating System and SPSS (version 15) were used for the statistical data analysis. Standard deviation, P-values and correlations were obtained. A p-value $0.05<P<0.10$ was considered suggestive significant and p-value $P\leq0.001$ was considered highly significant.

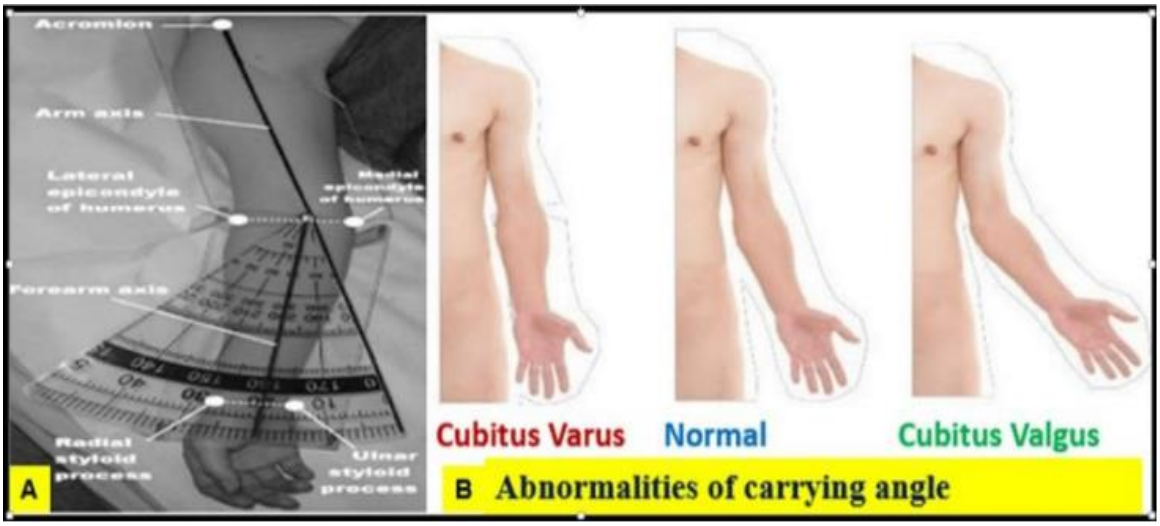

Figure 1: A. Manual Goniometer With Two Drawing Axes Of The Arm And Forearm In Anatomical Position At Point Of Measurement, B. Various Abnormalities Of Carrying Angle.

Results:

In this present cross-sectional study, the mean bilateral range for participants aged 17, 18, 19, and 20-35 years was 10.1˚-13.4˚, 13.1˚-15.1˚, 13.9˚-14.1˚, and 9.2˚-9.2˚, respectively. The carrying angle on the left side was greater in 18-year-old participants, whereas the right-side angle was greater in 19-year-old participants. A significant bilateral difference was observed for height, right carrying angle (RCA), and left carrying angle (LCA) ($p \leq 0.05$). The mean RCA and LCA values were nearly equal, with no significant difference, except in the 17-year-old and 20-35-year-old groups, where significant differences were noted. Descriptive analysis of height and carrying angle (both right and left) is presented in Tables 1 and 2, along with the corresponding p-values. Additionally, a descriptive statistics matrix of various parameters for the studied population is provided in Table 3.

Age	No.	Right		Left	
		Range	Mean ± SD	Range	Mean ± SD
17	70	4- 18 ˚	10.1 ± 4.4 ˚	5- 21 ˚	13.4 ± 4.1 ˚
18	72	5-19 ˚	13.1 ± 3.5 ˚	7- 22 ˚	15.1 ± 4.1 ˚
19	112	8-26 ˚	13.9 ± 5.9 ˚	4- 20 ˚	14.1 ± 4.9 ˚
20-35	246	1-16 ˚	9.2 ± 3.1 ˚	5- 18 ˚	9.2 ± 3.1 ˚

TABLE 1: showing range and mean with standard deviation of right and left side carrying angle of various age categories participants.

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	Sex	HT(m)	RCA ˚	LCA ˚	P- Value
	Age group	1.75	9.89	13.1	0.02
18 year	17 year	1.68	12.8	15.2	0.4
19 year		1.76	13.5	14.3	0.7
20-35 year		1.70	9.1	9.2	0.002

TABLE 2: Displaying distribution of average of height, right carrying angle (RCA) and left carrying angle (LCA) of various age groups.

	Age	Height	RCA	LCA
AGE	1.00	.802(**)	.145(**)	.079(**)
Height	.808(**)	1.00	.231(**)	.213(**)
RCA	.151(**)	235(**)	1.00	.662(**)
LCA	078(**)	221(**)	652(**)	1.00

TABLE 3: Pearson's correlation matrix of various parameters studies population. ** Correlation is significant at the 0.01 level (2-tailed). Age: strongly correlates with all the parameters (p<0.01).

Discussion:

The **carrying angle** is the angle formed between the long axis of the arm and the long axis of the forearm in the frontal plane when the elbow is fully extended and the forearm is supinated. This angle plays a crucial role in positioning the hand by acting as a lever arm and serving as a fulcrum for forearm movement. In individuals using crutches, the carrying angle functions as a weight-bearing joint [16]. The development of the carrying angle is influenced by forearm supination and helps keep the swinging upper limb away from the pelvis during walking [17]. Interestingly, this angle is present even in utero and is fully developed at birth [14]. However, it varies significantly among individuals, making it more appropriate to compare the carrying angle with the contralateral limb rather than a universal standard [18]. The formation of the carrying angle is attributed to the trochlea of the lower humerus [19, 20], with the upper ulna also contributing to its structure [5]. A curved ridge in the deep trochlear notch of the ulna influences the angle, as the obliquity of the ulnar shaft relative to this ridge accounts for most of the carrying angle. Fractures of the lower humerus or ruptures of the collateral ligaments, which stabilize the bones, can disrupt this angle [19, 20]. Age-related variations in the carrying angle have been observed. A significant difference in the carrying angle appears at age 17, becoming non-significant between 18 and 19 years, but again showing significance in young adults (20–35 years) [21]. This pattern aligns with the complete development of secondary sexual characteristics by age 20 and beyond. Additionally, the left carrying angle tends to be greater than the right, which correlates with differences in upper limb length—longer limbs generally exhibit smaller carrying angles [22]. Sex-based differences have also been reported, with adult females typically exhibiting larger carrying angles than males [14]. However, in the present study, young adults displayed lower average carrying angles in both elbows compared to a younger population. This finding contrasts with Yilmaz et al. (2005). Despite these observations, high standard deviations across all ages and sexes indicate significant individual variability in carrying angles.

The carrying angle of the dominant arm was found to be significantly greater than that of the non-dominant arm, as previously reported by Yilmaz et al. (2005) [14]. However, the present study, which analyzed 246 participants, revealed that only 0.2% of the population was left-handed. Interestingly, among males, the average carrying angle of the left arm was higher than that of the right arm, contrary to the expectation that the dominant arm would exhibit a greater carrying angle. This suggests that carrying angle does not correlate with handedness, challenging the findings of previous research.

Additionally, the study observed that males appeared taller at ages 17, 18, and 19. This indicates that during adolescence and early adulthood, males tend to have a statistically significant height advantage over females. Chinonso (1991) noted that anatomically identical structures often exhibit size variations, which may explain the differences observed between right and left carrying angles. In this study, statistically significant values were particularly evident in the 17–19 age group and young adults, aligning with the period of pubertal development and adulthood [23, 24].

Conclusions:

The straightforward method used in this study to measure the carrying angle is recommended for future research and clinical practice due to its simplicity and effectiveness. Additionally, the values obtained may aid in the management of elbow disorders, while the significant differences observed between males and females could serve as a valuable reference in forensic medicine for sex differentiation.

Disclosures:

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