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Original Research Article

Height of medical students and carrying angle: An investigative correlation in central India within Raigarh District of Chhattisgarh

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Abstract

Introduction: A medially created acute angle or laterally created obtuse angle between the long median axis of arm and long median axis of forearm when the arm is extended and the hand supinated, with the axis of the forearm deviating laterally can be said to be named as the carrying angle (CA). This angle permits the forearms to clear the hips in swinging movements during walking and is beneficial when carrying objects.

Aims & Objective: This conducted study evaluates significant interdependence between CA & height among males and females. We added a special reference on height and length of forearm which might affect CA along with any significant differences in comparison to right or left sided individual.

Materials and Methods: Our observational manuscript had 82 (30 male & 52 female) medical students (17–21 years) of Late Shri Lakhiram Agrawal Memorial Government Medical College Raigarh CG. For measurement of CA (in degrees), students were made to fully extend and supinate the arm in anatomical position and placing Goniometer over center of Cubital Fossa. Palpating anatomic Surface landmarks of Bicipital groove, biceps brachii tendon at its insertion and Palmaris Longus tendon at the wrist, median axes of the arm and the forearm was demarcated. The height, ages and sexes of the students were also recorded.

Results: The mean carrying angle (Left) among males & females has been recorded as 6.62° ±1.82 & 12.78° ±3.51 respectively. The same for right side has been 6.21° ±1.3 & 12.58° ±3.33 respectively. A significant positive correlation between height of students and carrying angle, p= 0.0001(<0.05), for both males and females had been observed. Additionally, variations of CA with respect to dominant hand and length of forearm were also documented. Our study determined height from obtained CA by linear regression equation models.

Conclusion: The present study correlated CA with height, hand dominance & length of forearm. The results of linear regression equations to predict height from CA, can be a source of judgement in forensic Anatomy and anthropology. The measurements of our study contribute for Orthopaedicians and radiologists in management of elbow displacement / fractures / condylar disorders including cubital fossa deformities.

Keywords: Hand dimension, Gender, Sexual dimorphism, Sectioning point, Central India

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1. Introduction

Superior extremity, in anatomic orientation (fully extended & supinated forearm)[2] forms an acute angle medially at the elbow between the long axis of the humerus and the long axis of the ulna, defined as, “Carrying angle” (CA).[1] Several Anatomical causes have been proposed as the reason for CA.

1. Medial edge of trochlea of humerus party responsible as it projects nearly 6 mm below the lateral edge & the obliquity of the superior articular surface of the coronoid process which is not set at right angle to the shaft of ulna.[3]
2. Axis of the elbow joint is set obliquely at nearly 84° of both the humerus & ulna.[4,5]

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3. Obliquity of trochlea to the shaft of the humerus.[6]
4. Trochlear groove being vertical anteriorly but on the posterior aspect it runs obliquely distally & laterally, forming CA in extension wherein posterior aspect of the oblique groove makes contact with the trochlear notch of ulna.[7]
5. Presence of curved ridge joins the prominence of the coronoid & olecranon process in Ulna, articulating with the groove in the trochlea of the humerus.[8]
6. Obliquity of the shaft of ulna.[8]
7. Inner lip of trochlea of humerus has a ridge (groove) which is much deeper distally anteriorly so that ulna (with the forearm) is deflected in full extension by this ridge.[9]

CA is somewhat greater in female than in male,[1,10] (as females have smaller shoulder and wider pelvis, demanding a more acute CA),[11] preventing the forearm in contacting hips in swinging movements during walking and carrying objects.[12] The average angle in men is about 5° whereas in women it is about 10° to 15° (170° in males and 163° -167° in females, laterally).[1,11]

An increase or decrease in CA is referred to as cubitus valgus and Cubitus varus respectively.[13-15] Knowledge of varying degrees of CA including pathological unilateral increase[14,15] is vital in elbow dislocations, fractures, epicondylar diseases and elbow reconstruction[16-17] for Anatomists, Orthopaedicians and Radiologists. Dominant limb shows a pronounced CA than non-dominant limb of both sexes, advocating presence of natural forces over elbow joint[14,17] along with developmental, ageing and racial parameters as modifiers of CA.[18]

CA has been considered as a secondary sexual characteristic.[19,20] Literature review has focused on cause of formation of carrying angle, along with it's differences in sex and age. Nonetheless, fragmented observation has been paid in correlating carrying angle with various parameters, along with existent debate about the carrying angle of males and females, forming the framework of the current study, to reinvestigate CA, correlating height of the individual and length of forearm as differentiating parametres with notable significance to side.

2. Materials and Methods

Present study has been conducted among 82 (50 female & 32 male) willing participants (with prior informed consent) of MBBS batch 2023 (100 students in age group between 17-22 yrs), of Late Shri Lakhiram Agrawal Memorial Government College (C.G.). CA and height were measured, obtaining ethical approval from the Institutional Ethics Committee.

2.1. Inclusion criteria

Students providing informed consent without bony deformities or accidents or surgical procedures involving limbs and belonging to Chhattisgarh region (central India) were included under the study.

2.2. Exclusion criteria

Students belong to other part of India (all India central pool quota), who did not provide cfonsent to participate, individuals with congenital anomaly of limb(s) and vertebral column, contractures, missing limbs, history of trauma to hand and foot, with features suggestive of dysmorphic syndromes, chronic illness, hormonal therapy were not included.

2.3. Study tools

Standard universal manual goniometer evaluating range of motion (ROM) of joints having fixed and movable arms and wall mounted stadiometer with analogue scale.

2.4. Study methods

Height was measured in centimeters (vertex to heel, with bare foot, as recommended by International Biological Program 7) using wall mounted stadiometer, with individual standing erect on a horizontal resting plane with heels together, palms turned towards the side of thigh and the finger pointing downwards (**Figure 1**).

For measurement of CA (in degrees), students were made to fully extend and supinate the arm in anatomical position and placing Goniometer over center of Cubital Fossa. The fixed arm of Goniometer is placed in median axis of arm and movable arm of Goniometer is placed in the median axis of forearm. Anatomic Surface landmarks of Bicipital groove, Biceps Brachii tendon at its insertion and Palmaris Longus tendon at the wrist were contemplated to demarcate the median axes of the arm and the forearm respectively. **(Figure 2**)

All measurements were repeated twice (and mean obtained) with the same instrument to reduce intra observer errors. Obtained data were computerized and statistically justified. Standard student t-test performed and p-value <0.05 is considered significant.

A previous pilot study using 20 volunteers was carried out by the same researcher. All the parameters measured were not statistically significant ($p> 0.05$). This was an indication that the measurements were valid and reliable.

Figure 1: Height with stadiometer

Figure 2: Carrying angle and goniometer

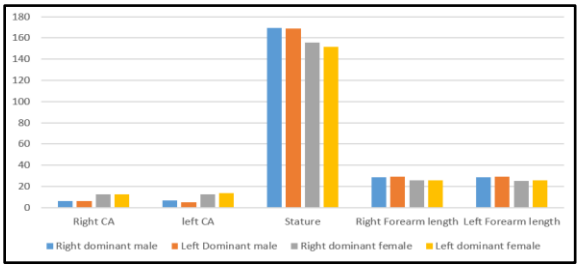

Chart 1: Carrying angle, length of forearm and statu among males and female as per dominant and non-dominant upper limbs

3. Results

The study included 82 individuals (50 female & 32 male). We attempted to identify correlation between carrying angle with sex and height. Significance of CA in dominant and non-dominant limb and height has also been studied. The participating individuals were found to be belonging to both right hand and left-hand dominant group.

A. Variation of carrying angle values between boys and girls. (**Table 1**)

1. Mean carrying angle among boys and girls is 6.42±1.56 and 12.68±3.42 degrees respectively.
2. Mean carrying angle among boys (Right side) is 6.21°±1.3.
3. Mean carrying angle among boys (Left side) is 6.62°±1.82.
4. Mean carrying angle among girls (Right side) is 12.58°±3.33.
5. Mean carrying angle among boys (Left side) is 12.78°±3.5.

Table 1: Carrying angle among males and females with respect to height

Results	Males			Females		
	Right CA In Degrees	**Left CA In Degrees**	**Height In Cm**	**Right CA In Degrees**	**Left CA In Degrees**	**Height In Cm**
Mean	6.21	6.62	169.7	12.58	12.78	155.58
Standard deviation	1.3	1.82	5.07	3.33	3.51	5.149
Range	5	6	24	14	14	21
Maximum	10	11	178.5	20	21	168
Minimum	5	5	154.5	6	7	142

Table 2: Mean carrying angle among males/females and height

Results	Males			Females		
	Right CA In Degrees	**Left CA In Degrees**	**Height In Cm**	**Right CA In Degrees**	**Left CA In Degrees**	**Height In Cm**
Mean CA(In degrees)	6.42°±1.56		-------	12.68°±3.42		-------

Table 3: Carrying angle among males and females with respect to length of forearm

Results	Males	Females

	Right CA In Degrees	Left CA In Degrees	Forearm length In Cm	Right CA In Degrees	Left CA In Degrees	Forearm length In Cm
Mean	6.21	6.62	28.68	12.58	12.78	25.47
Standard deviation	1.3	1.82	1.35	3.33	3.51	1.56
Range	5	6	5.5	14	14	6.6
Maximum	10	11	31.5	20	21	28
Minimum	5	5	26	6	7	21.4

Table 4: Carrying angle among males and females with respect to their dominant hand and height.

Male						Female					
Right Dominant			Left Dominant			Right Dominant			Left Dominant		
Mean CA	Mean Forearm length (cm)	Mean Height (cm)	Mean CA	Mean Forearm length (cm)	Mean Height (cm)	Mean CA	Mean Forearm length (cm)	Mean Height	Mean CA	Mean Forearm length (cm)	Mean Height (cm)
6.2°	28.8	169.7	5°	29.5	169	12.8°	25.5	155.7	13.6°	25.5	151.6

Table 5: Carrying angle, length of forearm and stature among males and female as per dominant and non-dominant

Male			Female	
Right Dominant		Left Dominant	Right Dominant	Left Dominant
Parameters	Mean value	Mean value	Mean value	Mean value
CA (Right side)	6.2	6	12.8	12.6
CA (Left side)	6.6	5	12.5	13.6
Stature	169.7	169	155.7	151.6
Length of forearm (Right side)	28.8	29	25.5	25.9
Length of forearm (Left side)	28.6	29.5	25.4	25.5

Table 6: Comparison of studies on Carrying angle with present study

Study	Sample size	Population	Mean CA Males	Mean CA Females	Mean height Males (cm)	Mean height Females (cm)
Potter HP et. al (1895)	185	Outside India	6.83°	12.85°	NA	
Ruparelia S et.al. (2010)	333	Gujarat India	6.9°	11.8°	166.87	153.94
Yilmaz E et. al (2005)	1275	Outside India	Right arm dominant group, right CA = 11.25° and left CA = 10.57° Left arm dominant group, right CA = 1Q.65° and left CA =12.93°		NA	
Thejeshwari HG et, al (2017)	150	South India	166.75°	168.1°	170.2	155.6
Paraskevas G (2004)	600	Outside India	12.88°	15.07°	NA	
Sharma K et. al (2013)	532 children	Nepal	5.79°	6.38°	142	130
Rajesh B et. al (2013)	60 adolescents	Pondicherry India	6.65°	13.6°	169.8	157.7
Rakesh Kumar Adhikari et. al (2017)	100 (adult & teenagers)	Nepal	Dominant UL* = 11.72 Non-dominant UL= 10.02	Dominant UL*= 13.7 Non-dominant UL= 11.74	NA	
Vaibhav Saini et. al (2022)	230	Haryana India	12.68° (Rural) 11.13° (Urban)	15.34° (Rural)	NA	

	Children & adults			13.50° (Urban)		
Present study	82 Young adults	Raigarh (CG) India	6.42°	12.68°	169.7	155.58

*****UL= Upper limb

Table 7: Estimation of Stature from Carrying angle among females (Using regression equation, Y=a+bX.where, Y(Dependent variable) = Height (To be calculated), a= Regression Constant (Derived for this study), b(Independent Variable) = CA & X= Regression Co-efficient (Derived for this study))

	Female (Right side)			**Female (Left side)**		
S. No.	**CA**	**Stature Linear equation Y=157.6 + 0.1607 x X**	**Range**	**CA**	**Stature Linear equation- Y= 171.8 +1.292× X**	**Range**
1)	16	160.17	142-168 cms	10	184.72	142-168 cms
2)	14	158	142-168 cms	11	186.01	142-168 cms
3)	12	159.5	142-168 cms	16	192.4	142-168 cms
4)	10	159.2	142-168 cms	12	187.3	142-168 cms
5)	10	159.2	142-168 cms	8	182.1	142-168 cms
6)	11	159.3	142-168 cms	14	189.8	142-168 cms
7)	12	159.5	142-168 cms	9	183.4	142-168 cms
8)	8	158.8	142-168 cms	15	191.1	142-168 cms
9)	11	159.3	142-168 cms	17	193.7	142-168 cms
10)	19	160.6	142-168 cms	18	195	142-168 cms
11)	10	159.2	142-168 cms	15	191.18	142-168 cms
12)	11	159.3	142-168 cms	9	183.4	142-168 cms
13)	20	160	142-168 cms	11	186	142-168 cms
14)	8	158.8	142-168 cms	14	189.8	142-168 cms
15)	11	159.3	142-168 cms	12	187.3	142-168 cms
16)	15	160	142-168 cms	13	188.5	142-168 cms
17)	10	159.2	142-168 cms	15	191.1	142-168 cms
18)	9	159.04	142-168 cms	16	192.4	142-168 cms
19)	17	160.3	142-168 cms	13	188.5	142-168 cms
20)	8	158.8	142-168 cms	7	180.8	142-168 cms
21)	15	160	142-168 cms	11	186	142-168 cms
22)	12	159.5	142-168 cms	6	179	142-168 cms
23)	13	159.6	142-168 cms	16	192.4	142-168 cms
24)	10	159.2	142-168 cms	11	186	142-168 cms
25)	14	159.8	142-168 cms	12	187.3	142-168 cms
26)	15	160	142-168 cms	15	191.1	142-168 cms
27)	12	159.5	142-168 cms	11	186	142-168 cms
28)	20	160	142-168 cms	10	184.7	142-168 cms
29)	15	160	142-168 cms	18	195	142-168 cms
30)	6	158.5	142-168 cms	13	175.6	142-168 cms
31)	15	160	142-168 cms	8	182.1	142-168 cms
32)	13	159.6	142-168 cms	10	184.7	142-168 cms
33)	17	160.33	142-168 cms	12	187.3	142-168 cms
34)	10	159.2	142-168 cms	18	195	142-168 cms
35)	18	160.4	142-168 cms	20	197.6	142-168 cms
36)	15	160	142-168 cms	9	183.4	142-168 cms
37)	11	150.3	142-168 cms	7	180.8	142-168 cms
38)	10	159.2	142-168 cms	12	187.3	142-168 cms
39)	14	159.8	142-168 cms	11	186	142-168 cms

40)	12	159.5	142-168 cms	17	193.7	142-168 cms
41)	15	160	142-168 cms	13	188.5	142-168 cms
42)	19	160.6	142-168 cms	15	191.1	142-168 cms
43)	11	159.3	142-168 cms	11	186	142-168 cms
44)	15	160	142-168 cms	14	189.8	142-168 cms
45)	10	159.2	142-168 cms	10	184.7	142-168 cms
46)	15	160	142-168 cms	9	183.4	142-168 cms
47)	14	159.8	142-168 cms	10	184.7	142-168 cms
48)	15	160	142-168 cms	18	195	142-168 cms
49)	12	159.5	142-168 cms	12	187.3	142-168 cms
50)	20	160	142-168 cms	15	191.1	142-168 cms

Table 8: Estimation of stature from carrying angle among males (Using regression equation, Y=a+bX.where, Y(Dependent variable) = Height (To be calculated), a= Regression Constant (Derived for this study), b(Independent Variable) = CA & X= Regression Co-efficient (Derived for this study))

	Male (Right side)			Male (Left side)		
S. No.	**CA**	**Stature Linear equation- Y=168+0.2731×X**	**Range**	**CA**	**Stature Linear equation- Y=171.8+1.292×X**	**Range**
1)	6	169.6	154.5-178.5 cms	5	169.4	154.5-178.5 cms
2)	5	169.3	154.5-178.5 cms	4	169.2	154.5-178.5 cms
3)	4	169	154.5-178.5 cms	5	169.4	154.5-178.5 cms
4)	4	169	154.5-178.5 cms	4	169.2	154.5-178.5 cms
5)	7	169.9	154.5-178.5 cms	6	169.5	154.5-178.5 cms
6)	5	169.3	154.5-178.5 cms	5	169.4	154.5-178.5 cms
7)	5	169.3	154.5-178.5 cms	5	169.4	154.5-178.5 cms
8)	6	169.6	154.5-178.5 cms	6	169.5	154.5-178.5 cms
9)	8	170.1	154.5-178.5 cms	8	169.9	154.5-178.5 cms
10)	8	170.1	154.5-178.5 cms	9	170	154.5-178.5 cms
11)	7	169.9	154.5-178.5 cms	5	169.4	154.5-178.5 cms
12)	5	169.3	154.5-178.5 cms	8	169.9	154.5-178.5 cms
13)	4	169	154.5-178.5 cms	6	169.5	154.5-178.5 cms
14)	6	169.6	154.5-178.5 cms	7	169.7	154.5-178.5 cms
15)	7	169.9	154.5-178.5 cms	8	169.9	154.5-178.5 cms
16)	5	169.3	154.5-178.5 cms	6	169.5	154.5-178.5 cms
17)	9	170.4	154.5-178.5 cms	8	169.9	154.5-178.5 cms
18)	10	170.7	154.5-178.5 cms	10	170.3	154.5-178.5 cms
19)	7	169.9	154.5-178.5 cms	7	169.7	154.5-178.5 cms
20)	11	171	154.5-178.5 cms	11	170.5	154.5-178.5 cms
21)	7	169.9	154.5-178.5 cms	7	169.7	154.5-178.5 cms
22)	6	169.6	154.5-178.5 cms	6	169.5	154.5-178.5 cms
23)	5	169.3	154.5-178.5 cms	5	169.4	154.5-178.5 cms
24)	5	169.3	154.5-178.5 cms	5	169.4	154.5-178.5 cms
25)	6	169.6	154.5-178.5 cms	6	169.5	154.5-178.5 cms
26)	4	169	154.5-178.5 cms	4	169.2	154.5-178.5 cms
27)	5	169.3	154.5-178.5 cms	5	169.4	154.5-178.5 cms
28)	5	169.3	154.5-178.5 cms	6	169.5	154.5-178.5 cms
29)	6	169.6	154.5-178.5 cms	4	169.2	154.5-178.5 cms
30)	4	169	154.5-178.5 cms	5	169.4	154.5-178.5 cms
31)	5	169.3	154.5-178.5 cms	6	169.5	154.5-178.5 cms
32)	6	169.6	154.5-178.5 cms	7	169.7	154.5-178.5 cms

Furthermore, mean CA (Right side) among girls is significantly greater than mean CA (Right side) among boys, p=0.001 (<0.05), and mean CA (Left side) among girls is significantly greater than mean CA (Left side) among boys, p=0.001 (<0.05).

B. Statistics of carrying angle left, carrying angle right with height and sex.

Table 1 and Table 2 shows a significant positive correlation between height of students and carrying angle, p=

0.0001(<0.05), for both males and females. Male students with greater height (mean = 169.7±5.07 cm) have lower carrying angle in comparison to females with lesser height (mean = 155.58±5.15 cm), suggesting an inverse proportionality.

C. A remarkable inter relation between carrying angle and length of forearm is detectable. The length of forearm and the carrying angle is inversely proportional. **(**

Table 3).

D. Variation of carrying angle in dominant and non-dominant limb. (**Table 4 & 5 & Chart 1**)

The carrying angle of right dominant males is less on the right side as compared to left CA. But the same is reverse for left dominant males. For females with right dominance, right carrying angle is more than left which is reverse for left dominant females. Additionally, the dominant forearm in each gender also shows more in length than the non-dominant forearm.

Table 6 gives a comparison of studies on Carrying angle with present study. The carrying angle, known to exhibit sexual dimorphism, has been widely studied across populations. Most prior research reports higher mean values in females, attributed to anatomical and hormonal differences. The present study aligns with these findings, showing comparable trends in gender-based variation. However, slight deviations in mean angles and range may reflect population-specific factors such as ethnicity, age distribution, and measurement technique. These differences underscore the need for regionally tailored anthropometric standards when using carrying angle for gender estimation.

Additionally, we framed liner regression to estimate and correlate height from carrying angle obtained from our sample. The results almost showed a cent percent accurate prediction in calculation of height **(Table 7 & 8)**. This diagnostic judgement can be a source of assistance in forensic Anatomy and anthropology.

This investigative study on 82 healthy boys and girls of ages between 17 to 22 years produced an evaluation of carrying angle as 6.42°±1.6 & 12.68°±3.42 among males and females respectively, bolstering the view that the carrying angle is a secondary sexual characteristic, as research have given the opinion of no variation of carrying angle in male & female of pubertal age.

4. Discussion

Potter[19] was the first to investigate gender variations of carrying angle, proposing higher carrying angle among females. Similar measurements were made by Mall.[3] Since then, a variety of enquiry on gender differences in carrying angle were performed using anthropometric and radiological procedures. This study intended to differentiate sexual variations of carrying angle with special reference to height and length of forearm. Similarities & differences were observed, compared to result obtained by other authors.[2,14,16,17,20,24]

The mean of right and left carrying angle of each gender, in the present study shows no significant differences as seen by Ruparelia S. et. al[2] Thejeshwari HG et. Al,[14], Sharma K et. al[18] and Rajesh B et.al.[20] The mean right carrying angle of right-side Vs left side among males and females' shows notable variations, as in both genders' females had a greater CA. This was in contract to findings of Sharma K et al[18] and Maria et. al[23] where the mean carrying angle of female on the right limb was 4.95 and the male was 4.55 degrees & mean carrying angle for women as 12.9 °and mean carrying angle for men as 12.39° respectively.

Carrying angle measured in our study has been found to be less from those of Sharma et al[18] and Vaibhav S, et al.[22] as we have not included children in present study.

Literature suggests a greater carrying angle in females than in males as this difference is considered as a secondary sexual characteristic[18,21,26] (olecranon coronoid angle is more in females).[18] Present study also adds the same as documentary evidence. Some workers are of the view that there is no difference in the carrying angle in male & female up to the puberty. But in the female, it is increased after puberty.[2]

Raj J et. al[25] shows that carrying angle appears to be not directly related to the height, weight or length of the ulna or humerus. However, the present study revealed that the elbow carrying angle is higher in girls who have a short forearm, which is similar to the findings of Rajesh et.[20] al and Khare et al.[26] The variables like height of the individual, length of the arm and width of the hip are not influencing the carrying angle.

The present study, also noted statistically significant correlative values between height and CA, which is congruence to findings of Thejeshwari HG et, al.[14] This can be conjectured that race and nutritional factors are vital in determination of degree of carrying angle. Thus, low degree of carrying angle should be pathological (trauma, inflammation etc.) rather than physiological. Non-traumatic ulnar neuropathy, at the elbow joint also contributes to carrying angle. Carrying angle in our study is also have found to be less as compared to CA of studies outside India,[14,17,21], which may put forward a racial background for development of CA.

Though no significant differences exist in our study in CA of each gender between right and left sides, but minute variations (in decimals) can be explained on the basis of dominant and recessive hands, suggesting ligamentous laxity at the medial elbow or asymmetrical bone growth. This

phenomenon is common in professional baseball players within the dominant elbow (Cubital Valgus) due to bone remodelling to adapt to stress.

Length of the forearm in female is 22.7 cm on right side and 22.6 cm on left side where as in male this value is 24.9 cm on both sides, which is inversely related to the carrying angle. The present study correlates the parameters of height & length of the forearm to be directly related to each other. Similar results have been obtained by Ruparelia S. et. al.[2]

The present manuscript also depicts that, among each gender, difference of the length of forearm of right and left side is statistically insignificant, but difference in the length of forearm between male and female is statistically significant Average Right forearm length is 28.9 cm in male and 25.70 cm in female whereas on the left side this value is 29.05 cm in male and 25.45 cm in female. Additionally, this research reviews as males having greater height and forearm length, in contrast to average carrying angle being more among females, similar to Ruparelia S. et.[2] al and Rajesh et. Al.[20]

Ruparelia S. et al. have suggested a complementary relationship between the development of the carrying angle and pronation, which varies based on the length of the forearm bones. A longer forearm bone results in a reduced angulation at the humero-ulnar joint, leading to a smaller carrying angle. Pronation causes the upper part of the forearm to angle, resulting in a more significant deviation of the medial section of the trochlear notch from the humeral articular surface. Consequently, the medial flange of the trochlea does not undergo compression and grows more compared to the lateral flange. If a person's height and consequently the length of the ulna are shorter, the proximal end must angulate more during pronation due to the shorter lever arm, resulting in a greater displacement of the medial part of the trochlear notch of the ulna away from the medial flange of the trochlea, which can grow more than in individuals with longer forearms, ultimately leading to an increased carrying angle.

5. Conclusion

The present manuscript integrates carrying angle with correlates such as gender, forearm length, stature, and hand dominance. An inverse relationship between height and carrying angle was observed, suggesting taller individuals tend to exhibit smaller angles. Among males, right-dominant individuals showed reduced carrying angles on the right side, whereas left-dominant males exhibited the reverse. In females, right dominance corresponded with a greater right carrying angle, while left-dominant females showed a higher angle on the left. Dominant forearms were consistently longer across genders. Notably, a direct association was found between hand dominance and carrying angle magnitude—individuals with either right or left dominance exhibited greater angles on their dominant side, regardless of gender.

6. Relevance of the Study

The in vivo measurements emanated in present study can be a source of contribution for Orthopaedicians and radiologists in management and reconstruction of elbow displacement / fractures / condylar disorders including cubitus vera and cubitus valga deformities.

7. Limitations

1. The study results have been predicted for sample of 17 – 22 years of age and may not be valid beyond this range.
2. Comparison of multiple regression and linear regression analysis (used in our study) would probably be more significant.
3. The measurements may not be beneficial to populations of different ethnicity, race or a different geographical region.
4. Estimation of stature in our region may not be clinically comparative in subjects with congenital or nutritional or elbow disorders or having a previous history of injury to upper limb.
5. Diurnal variations may be taken into consideration.
6. Comparative study of carrying angle in living and dead may give a better probability.
7. Our study has drawback of relatively small sample size. Future studies involving large samples of varied ethnic groups within variety of state of India are awaited.

8. Ethical Permission Letter Number

S. No./Med./Ethics Commi./2024/01 Dated 23rd February 2024.

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10. Conflict of Interest

The authors declare that there is no conflict of interest, financially or otherwise regarding the publication of this manuscript.

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12. Author Contributions

Dr Surajit Kundu and Dr Richa Gurudiwan, being the guide and co-guide respectively for Dr Nidhi (PG Student), conceived the original idea and designed the theoretical model of the manuscript and were instrumental in final writing of the paper and encouraging the post graduate student. They were in charge of overall direction and planning.

Dr Nidhi communicated and prepared the subjects, obtained consent, collected data, performed analysis, interpreted calculations and took the lead role in framing the draft of the paper, obtaining inputs and consulting all the authors.

Dr Gireesh and Dr Seema helped in preparation of the subjects, overall supervision of the paper and provided critical feedback.

All authors commented on the critical points and helped to shape the research, analysis and manuscript to its present form.

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