ORIGINAL RESEARCH

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CARRYING ANGLE AND ITS CO-RELATION WITH DIFFERENT PARAMETERS HEIGHT, LENGTH OF FOREARM, AND AGE

[1]Pooja A. Shah
[*2]Waqar M. Naqvi

ABSTRACT

Background: The carrying angle is known as the acute angle created by the arm's median axis and that of the forearm, which is completely extended & supinated, and thus measures the forearm's lateral obliquity. This angle is best observed when the forearm is in full extension, elbow in supination, and the external rotation of the shoulder. The purpose of the research is to study the co-relationship between carrying angle and various parameters of height, forearm length, and age.

Methods: A total of 106 asymptomatic, healthy students were selected from 18-22 years of age at Ravi Nair Physiotherapy College, DMIMS, Sawangi Meghe, Wardha. The carrying angle was measured with a goniometer. A measuring tape was used to measure the overall height of the subject and length of the subject's forearm.

Results: The p-value was found $p< 0.05$ on comparing carrying angle with height and forearm length, which suggests significant co-relation. Thus the person's height is inversely related to the carrying angle. The forearm length & height are directly related to each other; hence the forearm length is also related to the carrying angle. The p-value was found $p > 0.05$ on comparing carrying angle with age, which is non-significant. Thus there is no significant variation in carrying with age since the subjects were within a limited age range.

Conclusion: The carrying angle depends on the bone's length in the forearm. If the bone length is significantly greater, the angulation of the proximal articulation of the proximal articular surface is lower, hence the carrying angle is lower and vice versa.

Keywords: Height, age, carrying angle, forearm length.

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CORRESPONDING AUTHOR

[*2]Waqar M. Naqvi

Department of Community Physiotherapy, Ravi Nair Physiotherapy College, Datta Meghe Institute of Medical Sciences, Wardha, Maharashtra -442001, India.
Email: waqar.naqvi@dmimsu.edu.in

[1]BPT, Final year student, Ravi Nair Physiotherapy College, Datta Meghe Institute of Medical Sciences, Wardha, Maharashtra-442001, India.
E-mail: poojashah2198@gmail.com

INTRODUCTION

The elbow joint is a synovial joint of hinge variety. It is uniaxial and has only one degree of freedom. The movements occurring at the joint are flexion and extension [1]. The joint is formed by articulating the upper ends of both radius and ulna between the lower end of the humerus. The long axis of the extended forearm is found to be at an angle to the long axis of the arm [2]. The carrying angle is defined as the angle made by the arm's median axis and forearm [3], which is fully extended and supinated and measures the forearm's lateral obliquity [4]. This angle is best found when the elbow is in full extension, forearm in supination, and the shoulder in external rotation [5].

The ' carrying angle ' is formed in part by the projection of the medial trochlear ridge 6 mm above its lateral edge, and in part by the obliquity of the coronoid's superior articular surface. The inclination of the humeral and ulnar articular surfaces is nearly equal so that when the two bones enter the same plane, the carrying angle disappears at maximum flexion [4]. The line of the upper arm and forearm becomes straightened out when the forearm is in the usual working position of almost full pronation [6]. The carrying angle allows the forearm to clear the hips while swinging during walking and is also essential when carrying objects [7]. It is observed that the normal carrying angle in males is 5°-10°. In females, it is slightly more generous, being 10°-15°. Cubitus valgus is the condition if this angle is > 15°, whereas if the angle is < 5°, it is called cubitus varus.

The carrying angle pathophysiology varies by age, gender, elbow joint overextension, dominant side upper extremity, anthropometric features like height, and distance between the trochantres. It may be due to ligamentous laxity, fractures, traumatic injury sequel, and the occurrence of upper limb congenital deformity, positive results for rheumatic, inflammatory, or genetic diseases [8]. This may also cause a marked difference in the right and left side [9]. The carrying angle varies between individuals and is found to be higher in females compared to males. It is also considered a secondary sexual character [10,11]. On average, women have smaller shoulders and broader hips than their male counterparts, which may be one of the reasons why they have an acute carrying angle [2,12]. The carrying angle in the non-dominant extremity is less than in the dominant extremity of both genders, which states that the forces of nature alter the carrying angle [13].

The current study has, therefore, focused on the correlation between carrying angle and age, height, and forearm length. There have been very few studies that correlate the carrying angle with different parameters. Consequently, an attempt was made to determine the connection between the carrying angle and forearm height, age, and total body length.

MATERIAL AND METHOD

The participants of this study were from Ravi Nair Physiotherapy College, DMIMS, Sawangi Meghe, Wardha.

Study design: The participants of this study were from Ravi Nair Physiotherapy College, DMIMS, Sawangi Meghe, Wardha. It is a co relational- cross-sectional study which was conducted for one year. The sampling design was a simple random sampling method with a sample size of 106 students. The instruments used for this study were a universal goniometer and a measuring tape.

PROCEDURE

The institutional ethical committee clearance was obtained from (IEC Ref.No. DMIMS(DU)/IEC/2017-18/E549) DMIMS. Permission from the principal of Ravi Nair Physiotherapy College was taken, and the work was started. The targeted population was selected from Ravi Nair Physiotherapy College. The participants were chosen as per the criteria of exclusion and inclusion. The Inclusion criteria were 1st and 2nd-year physiotherapy students. The exclusion criteria were any musculoskeletal injuries of the upper extremity, fractures of the upper extremity, neurological involvement of upper arm, hyper-flexibility. The students have explained the whole procedure of the study. A universal Goniometer measured the carrying angle. The height of the subject and length of the forearm was measured using a measuring tape.

In the present study, 106 asymptomatic, healthy students of Ravi Nair Physiotherapy College, DMIMS, Sawangi Meghe, Wardha were selected with age ranged between 18 to 22 years.

After getting informed consent, 106 healthy physiotherapy students, 100 females and six males were considered for the study. Those subjects were assessed with carrying angle, height, age, forearm length.

The fixed axis of the instrument could be kept on the upper arm's median axis, the mobile arm adjusted to the forearm's median axis and the angle noted on the goniometer. At its insertion, the biceps brachii tendon, the bicipital groove, and the palmaris longus tendon at both the wrist were palpated and used as landmarks for demarcating the median axes of the arm and the forearm. The angle was taken with the forearm in full supination [14]. The carrying angle was taken both on the left and the right side to assess the difference on both sides, if any. It was measured in degrees [15].

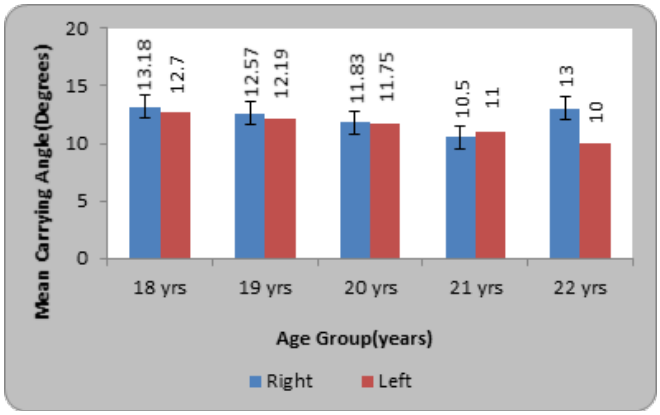
The height was calculated in a standing, erect, anatomical position with barefoot from the vertex to the heel using a measuring tape [16]. Similarly, forearm lengths were measured using tape. Ulna's medial epicondyle and styloid process are used as a landmark. Distance is recorded as the forearm length between these two points. All the parameters were measured in centimeters except the carrying angle, which was measured in degrees. Three consecutive readings were taken, and the mean was recorded along with age [17].

Data analysis was carried out using descriptive and inferential one-way ANOVA, paired and unpaired Student t-test and analysis software was SPSS 22.0 version and GraphPad Prism 6.0 version and $p<0.05$ as a norm of interpretation.

RESULTS

Age in years	n	Carrying Angle (Degrees)			
		Right		Left	
		Mean	SD	Mean	SD
18 yrs	37	13.18	2.10	12.70	2.29
19 yrs	52	12.57	2.82	12.19	2.89
20 yrs	12	11.83	1.74	11.75	2.09
21 yrs	4	10.50	1.73	11.00	1.41
22 yrs	1	13.00	.	10.00	.
Total	106	12.63	2.48	12.25	2.57
F-value		1.56		0.82	
p-value		0.19,NS		0.51,NS	

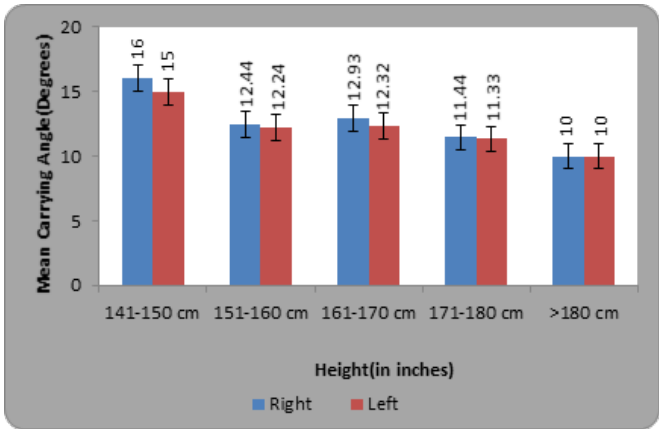
Table 1: Correlation of age in years with carrying angle (degrees)



Graph 1: Correlation of age in years with carrying angle (degrees)

Height in inches	n	Carrying Angle(Degrees)			
		Right		Left	
		Mean	SD	Mean	SD
141-150 cm	3	16.00	1.00	15.00	2.00
151-160 cm	50	12.44	2.50	12.24	2.78
161-170 cm	43	12.93	2.39	12.32	2.32
171-180 cm	9	11.44	2.12	11.33	2.29
>180 cm	1	10.00	.	10.00	.
Total	106	12.63	2.48	12.25	2.57
F-value		2.55		1.36	
p-value		0.044,S		0.25,NS	

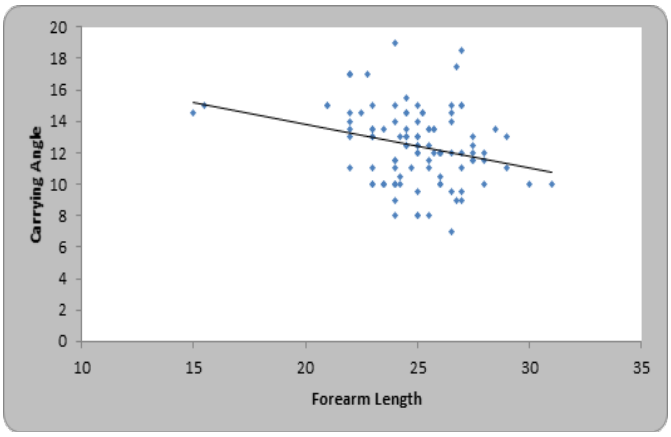
Table 2: Correlation of height (inches) with carrying angle (degrees)



Graph 2: Correlation of height (inches) with carrying angle (degrees)

The Pearson's Correlation Coefficient					
	Mean	Std. Deviation	N	Correlation 'r'	p-value
Forearm Length	24.88	2.35	106	-0.276	0.004,S
Carrying Angle	12.44	2.38	106		

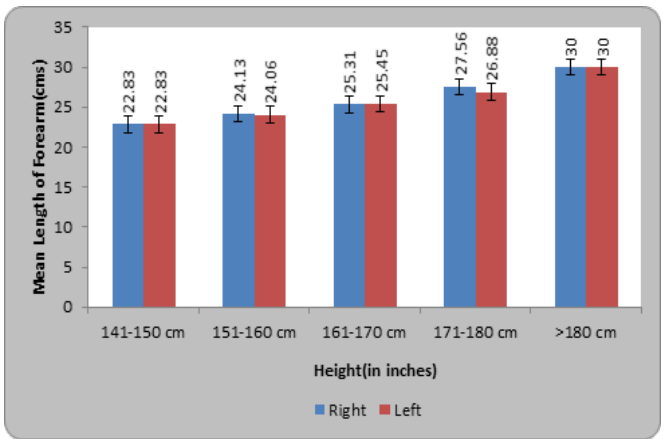
Table 3: Correlation between length of forearm and carrying angle



Graph 3: Correlation of forearm length with carrying angle

Height in inches	n	Length of forearm			
		Right		Left	
		Mean	SD	Mean	SD
141-150 cm	3	22.83	1.44	22.83	1.44
151-160 cm	50	24.13	2.73	24.06	2.24
161-170 cm	43	25.31	2.11	25.45	1.71
171-180 cm	9	27.56	2.39	26.88	2.35
>180 cm	1	30.00	.	30.00	.
Total	106	24.87	2.62	24.88	2.27
F-value		4.91		7.39	
p-value		0.001,S		0.0001,S	

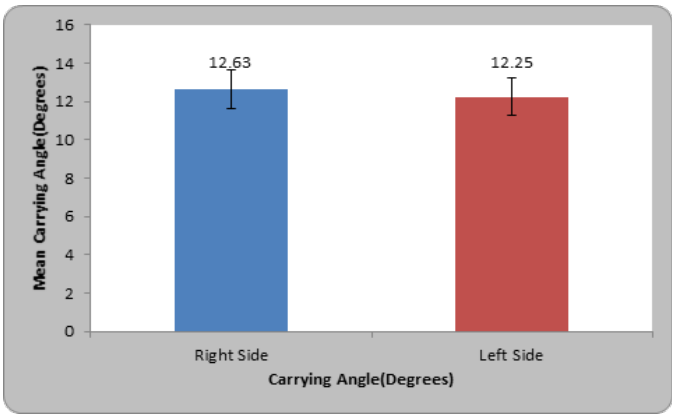
Table 4: Correlation of height (inches) with a length of arm



Graph 4: Correlation of height (inches) with length of arm Student's paired t test

	Mean	N	Std. Deviation	Std. Error Mean	t-value	p-value
Right Side	12.63	106	2.48	0.24	2.33	0.021,S
Left Side	12.25	106	2.57	0.24		

Table 5: Comparison of left and right side carrying angle(degrees)

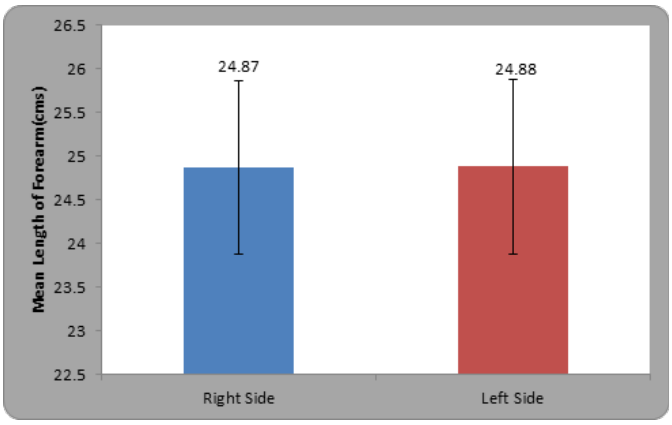


Graph 5: Comparison of left and right side carrying angle(degrees)

Student's paired t test

	Mean	N	Std. Deviation	Std. Error Mean	t-value	p-value
Right Side	24.87	106	2.62	0.25	0.07	0.94,NS
Left Side	24.88	106	2.27	0.22		

Table 6: Comparison of length of forearm (cm) left and right side



Graph 6: Comparison of length of forearm (cm) left and right side

DISCUSSION

Much research on the association of carrying angle with different parameters has been performed on human subjects—the number of researches aimed at the issue of carrying angle and gender difference. In a study done by Potter(2020) [18] and Atkinson & Elftman(1945) [19], it is stated that the carrying angle is more in females than in males. But in a study done by Beals(1976), it does not state any real difference between both the sexes [20].

G. Paraskevas et al. and Erhan Yilmaz(2005) [21] stated in their study that the angle on the dominant hand side is usually more extensive, and the reciprocal relationship between the carrying angle and the intertrochanteric diameter has also been confirmed [22].

The present study deals with the correlation between carrying angle and height, forearm length, and age.

The present study is almost similar to Srushti R et al. (2010) [17]. From the present study, we have observed that the length of the forearm is directly related to height. No significant difference is observed in the length of the forearm bones of the right and left side. No significant relation has been found between carrying angle and age.

An inverse relation is observed between forearm length, height, and carrying angle. This could be explained as follows: The carrying angle depends on the length of forearm bones. If the length of the bones of the forearm is more, then the angulations of proximal joint articulation of proximal articulating surfaces are less; hence the carrying angle is also less. For a shorter person, the medial portion of the ulna trochlear notch travels far from the trochlea's medial ridge, causing a more significant carrying angle.

It is also observed that due to the shorter lever arm, the proximal end angulate more to bring the hand into pronation for necessary activities when the overall height of the subject, as well as the length of the ulna, is lower. G N Khare(1999) [23] stated in his study, the angle is lesser in shorter subjects as compared to tall ones, which was found in this study also.

A study was done by Sharma(2015) [15] et al., The lowest carrying angle on the left and right limbs were found at 11 and 10 years of age, respectively, while the average carrying angle on the right and left limbs were found at 9 and 14 years of age respectively. which suggests direct relation of carrying angle with age. This cannot be found in our study as participants were within the limited age range(18-22 years)

The study of carrying angle is vital as a lot of pathologies are linked with it. The data is essential for surgeons and orthopedic as well as for pediatric to prevent deformity as well as to rule out any underlying pathology. An increase in carrying angle is a risk factor for non-traumatic ulnar nerve neuropathy as per a study done by Chein-Wei Chang(2008) [24]. A guesstimate of the carrying angle may help treat elbow injuries, such as fractures or epicondylar ailments, and elbow repair assessment [25].

CONCLUSION

According to this study, it is concluded that the height of the individual is inversely proportional to the carrying angle. It is evident from the present study that the height and forearm length is directly related to each other; therefore, the forearm length is also inversely related to the carrying angle.No significant variation is found in carrying with age subjects were within a limited range of age (18-22 years). No significant variation in lengths of the forearm of both the side.Non-significant variation in carrying angle of both the side. This research can be a method for testing the in

vivo carrying angle for orthopedic use, and the measures obtained may help treat elbow disorders and rehabilitation following fractures. This may also allow the orthopedic surgeon to correct the deformity of the cubitus varus that happens after supracondylar fracture of the humerus due to malunion.

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