



Journal of Anatomical Sciences

Email:anatomicaljournal@gmail.com

J Anat Sci 11 (1)

Carrying angle of the elbow among Ukwuani children in South-South Nigeria

Eboh DEO and Akpoyibo EE

Department of Human Anatomy and Cell Biology, Faculty of Basic Medical Sciences, College of Health Sciences, Delta State University, Abraka, Nigeria

Corresponding Author: Eboh DEO

Email: deebboh@delsu.edu.ng; drebohdenis@gmail.com; +2348033872254.

ABSTRACT

The obliquity of the ulnar shaft to the trochlea notch which fits the trochlea and the tilted inferior sharp ridge of the medial trochlea of the humerus are the cause of the carrying angle. This study was undertaken to determine the normal carrying angle of the elbow joint among Ukwuani children in the South-South Nigeria. It involves Ukwuani children in primary and secondary schools in Ukwuani Local Government Area, Delta State, South-South Nigeria. The sample had 427 males and 429 females subdivided into 6-11 years old, 12-14 years old and 15-17 years old, using the stratified random sampling technique. The carrying angle of the elbow joint was measured in degrees using the digital goniometer while body height was measured in centimetres using anthropometer. The SPSS 20 was used for the data analysis. The statistics used were the t-test, Pearson's correlation and the one-way analysis of variance. The statistical significance was fixed at $p < 0.05$. The carrying angle in females was significantly greater than in males in all the age groups. Carrying angle on the right was significantly greater than on the left in all the age groups. The carrying angle at 12-14 years and 15-17 years were significantly greater than in 6-11 years on both sides, but there was no significant difference between the carrying angle at 12-14 years and 15-17 years. Correlation between height and carrying on both sides showed varied outcomes in all the age groups. The findings will be useful to the Physical anthropologists and the clinicians.

KEYWORDS: Age, Carrying angle, Children, Elbow, Height.

INTRODUCTION

One of the features of anatomically modern human is that, the forearm is laterally deviated from the upper arm at the elbow, if in the anatomical position. The axes of these segments form an angle called the carrying angle (CA) of the elbow. This enables the arms to swing during walking without the medial surface of the forearm hitting the lateral surface of the thigh.

The carrying angle is caused mainly by the obliquity of the ulnar shaft to the trochlea notch which fits the trochlea of the humerus¹. To a lesser extent, it is also caused by the tilted inferior sharp ridge of the medial trochlea of the humerus^{1,2}. It has been stated that in health, carrying angle may be influenced among other factors, by age³, sex^{4,5}, height^{6,7} and forearm length⁶.

The study of carrying angle has received attention in some populations, using either the direct (clinic) method^{6,8} or the radiographic method⁹. In Nigeria, studies on carrying angle include those conducted in adults^{6,10,11} in adults, in adults and children⁸ and in adolescents¹².

Studies conducted in India include those in adults^{9,13,14}, in adolescents¹⁶, in children^{5,17} and in mixed categories^{18,19,20}. Similar studies have also been conducted in Malaysia among young adults²¹ and in

Brazil in subjects 1 to 18 years of age²².

Despite the studies on carrying angle in different populations of the world, the focus on children is low. Indeed, among Ukwuani people of Southern Nigeria, studies of this parameter are lacking. Hence, this study to close the gap in literature.

The findings of this study will be useful to the surgeons involved in the management of paediatric elbow injury or disorder that requires reconstruction of that part of the body. Knowledge of the variation of this parameter will also be relevant in designing elbow prostheses. In addition, the findings will be useful in population variation studies, which is relevant to anthropology.

The purpose of this study was to determine the normal carrying angle of the elbow joint among Ukwuani children in the South-South Nigeria, and to:

- verify if there is a significant gender difference in carrying angle;
- determine if there is a significant side difference in carrying angle;
- determine the correlation between body height and carrying angle.

MATERIALS AND METHODS

Study Design and Population: It was a cross-sectional study of Ukwuani children in primary and secondary schools, aged 6-17 years, in Ukwuani Local Government Area, Delta State, South-South Nigeria.

Sample and Sampling Technique: The study involved 856 subjects (427 males and 429 females) who were subdivided into three age groups made up of subjects in the Primary School (6-11 years old), Junior Secondary School (12-14 years old) and Senior Secondary School (15-17 years old), using the multistage sampling technique.

Method of Data Collection: Two measurements were taken:

The axial angle of the elbow joint was measured in degrees using the digital goniometer (iGANG, China), with the subject standing in anatomical position. The fixed and movable arms of the instrument were positioned on the median axes of the volar surface of the arm and forearm respectively (Figure 1), as previously used ⁶. The average of the two measurements was recorded in each case, on both sides. Body height was measured in centimetres using anthropometer, with subject standing barefooted, from the vertex of the head to the sole of the foot.



Figure 1: .Measurement of carrying angle of elbow.

Only subjects without clinical evidence of trauma or other disorders of the elbow joint were included in the study. Prior to measurement, permission for the study was obtained from the various head of schools as well as informed consent in accordance with revised Helsinki Declaration ²³. The Research Ethics Committee of the Faculty of Basic Medical Sciences also approved the research methodology.

Data Analysis: The data were analysed with SPSS 20. Independent sample t-test was used to find out mean gender and side differences. Pearson correlation was used to assess the relationship between carrying angle and body height, while One-way analysis of variance (ANOVA) was used to determine significant age difference. The level of statistical significance was fixed at $p < 0.05$.

RESULTS

Figure 2 is the contribution of study subjects according to age group and gender. It showed that in 6-11 years (mean age= 8.00 years), 12-14 years (Mean age= 13.10 years) and 15-17 years (mean age= 15.80 years) group, males and females constituted 49.2% and 50.8%; 46.4% and 53.6%; and 55.6% and 44.4% respectively.

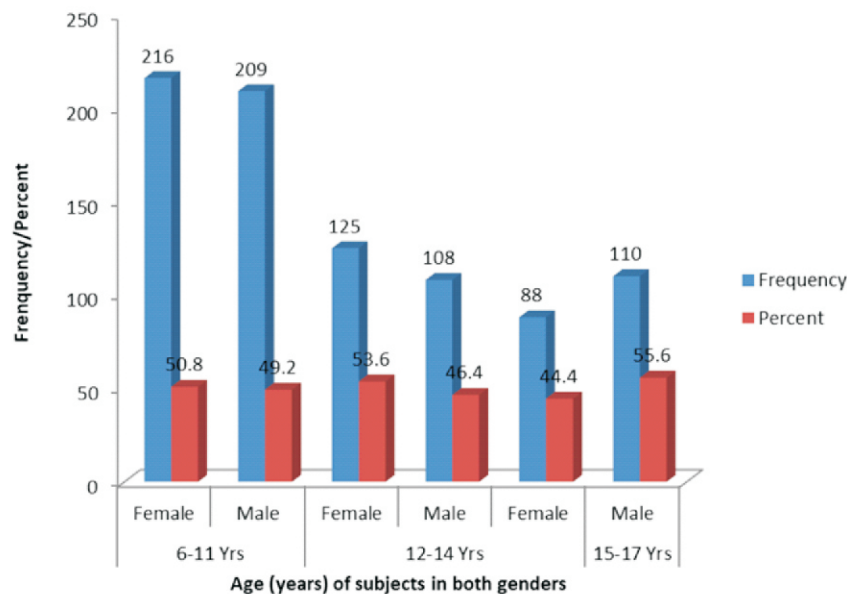


Figure 2: Frequency and percentage distribution of subjects in the different age groups.

Table 1 showed that in all the age groups, carrying angles in females were significantly greater than males on both sides. When compared, carrying angle in 12-14 years group was greater than that in 15-17 years group which was in turn greater than in 6-11 years group.

Table 1: Comparison of body height and carrying angle in both genders in different age groups.

Age (Year)	Parameter	Gender	N	Range	Mean (SD)	t	df	P-value
6-11years	Height (cm)	Male	209	106.50-155.00	129.00 (9.72)	1.78	423	0.08
		Female	216	106.70-157.00	127.15 (11.20)			
	a (°)	Total	425	106.50-157.00	128.04(10.53)	-	-	-
		Male	209	2.35-20.05	11.60 (3.65)	-3.47	423	0.001
	CAL ^b (°)	Female	216	2.55-47.25	13.00 (4.50)			
		Total	425	2.35-47.25	13.00 (4.16)	-	-	-
12-14years	Height (cm)	Male	209	3.60-27.10	14.27 (4.69)	-5.01	423	0.001
		Female	216	4.80-26.80	16.67 (5.14)			
	CAR ^a (°)	Total	425	3.60-27.10	15.49(5.06)	-	-	-
		Male	108	131.00-180.00	149.58 (10.18)	-3.17	231	0.002
	CAL ^b (°)	Female	125	129.00-175.40	153.37 (7.68)			
		Total	233	129.00-180.00	151.61 (9.10)	-	-	-
15-17years	Height (cm)	Male	108	2.65-20.00	13.59 (3.65)	-4.00	231	0.001
		Female	125	4.35-21.70	15.33 (3.03)			
	CAR ^a (°)	Total	233	2.65-21.70	14.52 (3.44)	-	-	-
		Male	108	4.05-25.30	15.78 (4.27)	-4.43	231	0.001
	CAL ^b (°)	Female	125	5.70-25.65	18.20 (4.05)			
		Total	233	4.05-25.65	17.08(4.32)	-	-	-
15-17years	Height (cm)	Male	110	140.50-180.00	165.00 (8.02)	5.06	196	0.001
		Female	88	146.00-178.80	159.64 (6.42)			
	CAR ^a (°)	Total	198	140.50-180.00	162.60(7.80)	-	-	-
		Male	110	2.75-26.10	13.47 (3.70)	-3.01	196	0.003
	CAL ^b (°)	Female	88	5.75-27.70	18.33 (4.38)			
		Total	198	2.75-26.10	14.15(3.61)	-	-	-
15-17years	Height (cm)	Male	110	4.30-30.85	16.20 (4.58)	-3.32	196	0.001
		Female	88	5.75-27.70	18.33 (4.38)			
	CAR ^a (°)	Total	198	4.30-30.85	17.14(4.61)	-	-	-
		Male	110	2.75-26.10	14.15(3.61)	-	-	-
	CAL ^b (°)	Female	88	5.75-27.70	18.33 (4.38)	-3.32	196	0.001
		Total	198	4.30-30.85	17.14(4.61)	-	-	-

^aCarrying angle of right elbow; ^b Carrying angle of left elbow; SD= standard deviation.

Table 2 showed the carrying angle was significantly greater on the left elbow compared to the right across all age groups. Table 3 shows that in each age group, there was significant correlation between carrying angle of the right and left elbow. The 15-17 years group had the greater correlation coefficient (0.636) while 6-11 years had the least (0.447).

Table 2: Paired Samples t-test between carrying angle of the right and left elbow based on age group.

Age (Yrs)	Parameter	Mean difference	t	df	p-value
6-11	CAR ^a (°) - CAL ^b (°)	-3.19	-13.402	424	0.001
12-14	CAR ^a (°) - CAL ^b (°)	-2.56	-10.271	232	0.001
15-17	CAR ^a (°) - CAL ^b (°)	-3.00	-11.647	197	0.001

Df= degree of freedom; ^a Carrying angle of right elbow; ^b Carrying angle of left elbow.

Table 3 showed a post hoc analysis of one-way analysis of variance of carrying angle in the three age groups. The carrying angle at 12-14 years and 15-17 years were significantly greater than in 6-11 years group on both sides. No significant difference between carrying angle at 12-14 years and 15-17 years.

Table 3: Post-hoc multiple comparison of One-way analysis of variance

Carrying angle	Post-hoc statistic	(I) Age (Yrs)	(J) Age (Yrs)	Mean Difference (I-J)	Std. Error	p-value
Right side	Tukey HSD	6-11 Yrs	12-14 Yrs	-2.22343*	0.31378	<0.001
			15-17 Yrs	-1.84719*	0.33121	<0.001
Left side	Tamhane	6-11 Yrs	12-14 Yrs	-1.58886*	0.37446	<0.001
			15-17 Yrs	-1.65266*	0.40916	<0.001

Std = standard.

The correlation between height and carrying angle is shown in Table 4. In 6-11 year old category, correlation at right elbow was positive and significant while on the left, it was negative and significant. In the 12-14 year old subgroup, correlation of height with the carrying angle of right elbow was negative and not significant while it was positive and significant on left side. Correlations were negative and significant for both sides in the 15-17 year-old. In general, the correlation was poor across the age groups.

Table 4: Pearson correlations between height and carrying angle of both elbows based on age group.

Age (Yrs)	Parameter	Statistic	CAR ^a (°)	CAL ^b (°)
6-11 Yrs	Height (cm)	Pearson Correlation	0.101	-0.041
		P-value	0.038	0.402
		N	425	425
12-14 Yrs	Height (cm)	Pearson Correlation	-0.011	0.136
		P-value	0.867	0.038
		N	233	233
15-17 Yrs	Height (cm)	Pearson Correlation	-0.170	-0.184
		P-value	0.017	0.010
		N	198	198

DISCUSSION

In the current study, the mean carrying angle in females was significantly greater than that in males in the three groups studied. Previous studies in sub adults also reported that females have a remarkably greater carrying angle compared to males^{5, 12, 22, 24, 25}. The result of this study is also in line with Sharma et al.¹⁷ as they reported that the carrying angle in females was greater than that in males on the left side. In contrast, they also observed that on the right side, the gender difference was not statistically significant.

In the present study, carrying angle increased from age 6-11 years to 12-14 years, and 15-17 years. The differences between the carrying angle of primary school pupils, and junior secondary as well as senior secondary school students were statistically significant, but between junior and senior secondary school students, the difference was not significant. In a study by Terra et al.²², carrying angle was observed to increase from age 1 year to 18 years. In a previous study by Shiva et al.²⁴, it was observed that the carrying angle increased from age 5-12 to 13-18 years. This is similarly so for the study

Chinweife et al.¹² from 10 years of age to 19 years. Tukenmez et al.²⁶ also reported increase in carrying angle from age 6 years to 14 years. Also in a related report by Dey et al.²⁰, they noted that the carrying angle increased up to 15 years of age and remained so thereafter.

In comparison, between the right and left side, it was observed in the present study that the mean carrying angle on the left was significantly greater than the right side in the three age groups studied. Shiva et al.²⁴ reported carrying angle on the right side greater than that on the left side in both 5-12 years and 13-18 years groups. Chinweife et al.¹² studied the carrying angle in adolescents from 10 years to 19 years old and reported that in all the age levels, the carrying angle on the right were greater than those on the left side. The result of the present study is in tandem with that of Ozor et al.⁸ as they also reported that the carrying angle on the left is greater than the right side in children. In the study in 5-15 years old by Sharma et al.¹⁷, it was noted similarly that carrying angle of left elbow was greater than that of the right elbow.

On the relationship between height and carrying angle of elbow joint, 6-11 years old, there was a negative correlation on the right, while the left showed a positive correlation. The variability observed above in the correlation of height with carrying angle could be due to inherent factors related to the population. At 12-24 years old, the correlation was negative on the right side but positive on the left. Correlation of height with carrying angle was negative on both sides at 15-17 years of age. Various previous studies had also reported negative correlation of height with carrying angle^{6, 15, 22, 24}. Another study reported positive correlation between height and carrying angle¹². Sharma et al.¹⁷ in a study of carrying angle of 5-15 years old, reported a correlation of positive correlation with height on the right and negative on the left, in a similar pattern with 6-11 years old in the present study. Furthermore, Balasubramanian et al.⁵ in their study on children, noted that carrying angle did not correlate well with height. The varied results from various studies across the globe could be due to genetic, environmental, geographic factors as well as those affecting anthropometric measurements.

From the results, the carrying angle in females was significantly greater than in males on both sides in all the age groups. Carrying angle was significantly greater on the left elbow compared to the right across all the age groups. In each age group, there was significant correlation between carrying angle of the right and left elbow. The carrying angle at 12-14 years and 15-17 years were significantly greater than in 6-11 years on both sides, but there is no significant difference between the carrying angle at 12-14 years and 15-17 years. Correlation between height and carrying on both sides showed varied outcomes in all the age groups. The Physical anthropologists will find the findings in useful

population studies while the clinicians will use it as guide in the different age groups.

REFERENCES

1. Sinnatamby CS. *Last Anatomy. Regional and applied*. 12th edition. United Kingdom; Elsevier. 2011.
2. Jonhson D. Pectoral girdle and Upper limb. In: Standring S. Editor. *Gray's Anatomy. Anatomical Basis of Clinical practice*. 40th Edn. United Kingdom. Elsevier; 2008.
3. Beals RK. The normal carrying angle of the elbow. A radiographic study of 422 patients. *Clin Orthop Relat Res*. 1976;(119):194-6.
4. Zampagni ML, Casino D, Zaffagnini S, Visani AA, Marcacci M. Estimating the elbow carrying angle with an electrogoniometer: acquisition of data and reliability of measurements. *Orthopedics*. 2008;31:370.
5. Balasubramanian P, Madhuri V, Muliyl J. Carrying angle in children: a normative study. *J Pediatr Orthop B*. 2006;15:37-40.
6. Eboh DEO. Carrying angle of young adults in eight Nigerian ethnic groups. *Nig Res J. Clin Sci*. 2015;5(1):9-15.
7. Khare GN, Goel SC, Saraf SK, Singh G, Mohanty C. New observations on carrying angle. *Indian J Med Sci*. 1999;53:61-7.
8. Ozor II, Obikili EN, Anyanwu GE, Katchy AU. Carrying Angle among School Children and Young Adult In Enugu, Nigeria: A Normative Study. *J Expt Res*. 2016; 4(1):130-37.
9. Kumar B, Shakunthala PAI, Biswabina RAY, Snigdha M, Siddaraju KS, Pandey AK, Binu S. Radiographic study of carrying angle and morphometry of skeletal elements of human elbow. *Rom J Morphol Embryo*. 2010; 51(3):521-6.
10. Nwagbo GI, Emuobo H and Febresima O. A study of carrying angle of an adult Nigerian Population. *Afr. J. Intern. Med*. 2015; 3(10):301-3.
11. Mbagwu SI, Aligwekwe AU. Carrying angle of an adult Nigerian population. *International Journal of Research (IJR)*. 2014;1(4): 8-15.
12. Chinweife KC, Ejimofor OC, Ezejindu DN. Correlation of Carrying Angle of the Elbow in Full Extension and Hip-Circumference in Adolescents of Nnewi People in Anambra State. *Int J Scientific Res Pub*. 2014; 4(10):1-8.
13. Raichandani L, Sharma K, Kataria KS, Agarwal R, Joya H, Raichandani S. Goniometric Study of carrying angle and its correlation with various parameters In Western Rajasthan Population. *Int J Adv Res Review*. 2016; 1(5):139-46.
14. Kothapalli J, Murudkar PH, Seerla LD. The Carrying Angle of Elbow- A Correlative and Comparative Study. *Int J Cur Res Rev*. 2013; 5(07):71-6.
15. Ruparelia S, Patel S, Zalawadia A, Shah S, Patel SV. Study of carrying angle and its Correlation with various parameters. *National Journal of Integrated*

- Research in Medicine(NJIRM)*. 2010; 1(3):28-32.
16. Rajesh B, Reshma VR, Jaene RC, Somasekhar IT, Vaithilingam A. An evaluation of the carrying angle of the elbow joint in adolescents. *Int J Med Biomed Res* 2013;2(3):221-5.
17. Sharma K, Mansur DI, Khanal K, Haque MK. Variation of Carrying Angle With Age, Sex, Height and Special Reference to Side. *Kathmandu Univ Med J*. 2013;44(4):315-8.
18. Praveen K, Saranya R. Comparative study of carrying angle in a South Indian population. *Int J Anat Res*. 2016;4(4):3138-41.
19. Kumari KL, Sekhar RC. A Comparative Study of carrying angle between children and adult in Andhra population. *IOSR Journal of Dental and Medical Sciences*. 2016; 15(6): 33-36.
20. Day S, Mandal L, Kundu B, Mondal M, Sett TK. Carrying angle of the Elbow: It's Changes From Childhood to Adulthood: Morphometric Study in Eastern India. *Indian J Basic Appl Med Res* 2013;2(8); 823-30.
21. Vichard L, Natasha AJ, Mohamed FSG, DareenLim CW, Anita DK. An Anthropometric Study on the Carrying Angle of Elbow among Young Adults of Various Ethnicities in Malaysia. *National Journal of Integrated Research in Medicine(NJIRM)*. 2014; 5(6): 20-23.
22. Terra BB, Silva BCM, Carvalho HBF, Dobashi ET, Pinto JA, Ishida A. Evolution of the carrying angle of the elbow: a clinical and radiographic study. *Acta Ortop Bras*. 2011;19(2):79-82.
23. World Medical Association Declaration of Helsinki. Ethical principles for medical research involving human subjects. *Bull World Health Organ*. 2001;79:373-4.
24. Shiva PSS, Amardeep G, Manjappa CN. Evaluation of the carrying angle of the elbow joint in children's and adolescents and its correlation with various parameters. *Int J Orthopaed Sci*. 2017; 3(3): 996-9.
25. YilmazE, Karakurt L, Belhan O, Bulut M, Serin E, Avci M. Variation of carrying angle with age, sex, and special reference to side. *Orthopedics* 2005;28:1360–3.
26. Tukenmez M, Demirel H, Perçin S, Tezeren G. Measurement of the carrying angle of the elbow in 2,000 children at ages six and fourteen years. *Acta Orthopaedica et Traumatologica Turcica*. 2004;38:274–6.