

Carrying Angle Among School Children And Young Adult In Enugu, Nigeria: A Normative Study.

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ABSTRACT

Previous studies on the carrying angle have created some controversies and disparities in the reported cases. The lack of consistent reports may be traced to the limitations and definitions of the specific measurement techniques as well as individual variations in the specimens and subjects. Methods used in the past include, simple protractor goniometer, X-ray images, CT-images, MRI-images, etc. In this study carrying angle is measured using a semi-circle manual goniometer on both left and right elbows in 2298 subjects (1,181 males, and 1,117 females). The age ranges from 5-19years and then young adults from 20years to 38years. The carrying angle is found to be higher in females than males in all age groups (females :L=3.19;R=12.31, males: L=8.78;R=7.78). The mean left carrying angle was also observed to be higher than the right carrying angle in all the age groups (females: L=13.19;R=12.31, males: L=8.87;7.78). However, statistically significant results were observed in a few age groups. The study confirms that the clinical carrying angle correlates best with age up to 9years, following which there was an irregularity in variation of the angles. The angle equally correlated well with height, weight and the upperlimb length. The revealed differences between the carrying angles in males and females can be considered as a secondary sex character. The recorded measurements also might be useful in the elbow and its reconstruction of fractures. The reproductivity of measuring the carrying angle by the simple technique used in this study makes the researchers propose that this may be used in actual clinical practice.

Key Words: Carrying Angle, Goniometer, Images, MRI and CT-scan.

INTRODUCTION

Carrying angle which is defined as the angle formed by the axes of the arm and the forearm when the elbow is completely extended has been used as an index for assessing various body features and characters.

It is also a common knowledge that a number of reports (Akpa, 1991, Zampagni et al, 2008, Shunsuk et al, 2009, Mehmez tukanmenz et al, 2002) have established influence of age, gender and ethnic differences on anthropometric- metabolic relationship. However, the predictive power of some anthropometric indices have been proved to be population dependent. This study therefore was designed to determine the normal carrying angle values among various age groups in children and young adults in Enugu, South-East of Nigeria.

MATERIALS AND METHODS

A total of 2,298 subjects were recruited for

this work. They were selected from university of Nigeria secondary school, Enugu Campus, College of The Immaculate Conception (CIC), Holy Rosary College (HRC), Enugu, University Primary School, Enugu Campus and Medical Students of University of Nigeria(UNEC).

A simple random sampling method was employed and the subjects were between the age of 5 to 38years. The interval of the birthday used was +_ 6months.

The exclusion criteria were children less than 5years, people with history of clinical evidence of fracture of the upperlimb bones, dislocation of the elbow joint or its disease condition; upperlimb amputees, the blind, deaf and dumb individuals.

The instrument used was the protractor goniometer. All the measurements were done by the authors either in the classroom, department of Anatomy or halls of residence of the undergraduates.

The work was analysed with SSPP version 15.

RESULTS

Table 1 shows a breakdown of the number of subjects studied by age and sex.

A total of 2,298 subjects were measured and the age range was 5-38years. For comparative purposes, the 20-38years old were grouped together as young adults. All the subjects were Nigerians.

Age	Number of males	Number of females	Total
5	64	48	112
6	67	78	145
7	61	55	116
8	48	56	104
9	83	44	127
10	70	42	112
11	53	53	106
12	61	34	95
13	97	67	164
14	50	207	257
15	99	138	237
16	52	94	146
17	33	58	91
18	35	70	105
19	20	19	39
20-38	288	54	342
Total	1,181	1,117	2,298

Table 2 : The mean, standard deviation, minimum and maximum deviations for the RCA of both males and females by age.

SEX	AGE	No.	MEAN	S D	MIN	MAX
MALE	5.00	64.00	6.28	2.03	2.00	10.00
	6.00	67.00	6.58	2.10	2.00	11.00
	7.00	61.00	7.03	2.66	4.00	16.00
	8.00	48.00	8.21	2.15	4.00	13.00
	9.00	83.00	9.72	2.89	4.00	15.00
	10.00	70.00	9.47	2.84	1.00	15.00
	11.00	53.00	7.85	2.28	4.00	11.00
	12.00	61.00	10.02	2.35	4.00	16.00
	13.00	97.00	9.84	3.18	4.00	18.00
	14.00	50.00	10.50	4.30	3.00	22.00
	15.00	99.00	11.70	9.00	2.00	78.00
	16.00	52.00	10.31	2.89	4.00	15.00
	17.00	33.00	9.91	3.28	4.00	17.00
	18.00	35.00	12.77	3.46	5.00	20.00
19.00	20.00	13.80	4.89	8.00	25.00	
20-38	288.00	8.78	2.32	1.00	15.00	
FEMALE	5.00	48.00	6.56	2.44	3.00	12.00
	6.00	78.00	6.90	2.37	2.00	15.00
	7.00	55.00	6.60	2.23	2.00	10.00
	8.00	55.00	8.54	2.74	4.00	15.00
	9.00	44.00	10.89	3.19	4.00	17.00
	10.00	42.00	10.40	2.83	5.00	15.00
	11.00	53.00	12.00	5.11	2.00	25.00
	12.00	34.00	13.09	3.01	9.00	20.00
	13.00	67.00	11.58	3.96	4.00	22.00
	14.00	207.00	10.41	4.08	4.00	21.00
	15.00	138.00	8.49	3.69	2.00	26.00
	16.00	94.00	9.40	4.99	3.00	24.00
	17.00	58.00	13.62	3.56	8.00	22.00
	18.00	70.00	14.39	4.19	5.00	25.00
19.00	19.00	16.00	4.77	5.00	21.00	
20-38	54.00	12.31	5.20	3.00	25.00	

Table 3: Comparison of means of Right Carrying Angle of both males and females by age.

Age	MALE			FEMALE			P – value
	No.	Mean	S D	No.	Mean	S D	
5.00	64.00	6.28	2.03	48.00	6.56	2.44	0.51
6.00	67.00	6.58	2.10	78.00	6.90	2.37	0.40
7.00	61.00	7.03	2.66	55.00	6.60	2.23	0.35
8.00	48.00	8.21	2.15	55.00	8.54	2.74	0.50
9.00	83.00	9.72	2.89	44.00	10.89	3.19	0.04
10.00	70.00	9.47	2.84	42.00	10.40	2.83	0.10
11.00	53.00	7.85	2.28	53.00	12.00	5.11	0.00
12.00	61.00	10.02	2.35	34.00	13.09	3.01	0.00
13.00	97.00	9.84	3.18	67.00	11.58	3.96	0.00
14.00	50.00	10.50	4.30	207.00	10.41	4.08	0.90
15.00	99.00	11.70	9.00	138.00	8.49	3.69	0.00
16.00	52.00	10.31	2.89	94.00	9.40	4.99	0.05
17.00	33.00	9.91	3.28	58.00	13.62	3.56	0.00
18.00	35.00	12.77	3.46	70.00	14.39	4.19	0.05
19.00	20.00	13.80	4.89	19.00	16.00	4.77	0.16
20-38	288	8.78	2.32	54	12.31	5.20	0.00

In males, the mean right carrying angle increased from the 5-years old (6.28⁰) to the 9-years old (9.72⁰) and then from 18-years old upwards to reach 13.80⁰.

In females, the mean right carrying angle increased from the 5year old 6.56⁰ ± 2.4 to the 9years old 10.89⁰ ± 3.19 then 11-12years old

before another significant rise from the 17-years old to attain 16.00⁰ ± 4.77 at the 19-year old.

The females showed higher carrying angle than males but statistically significant differences were observed only at 11-13years-old, 15, 17-years old and in young adults (20-38 years)(p<0.05).

Table 4: Comparison of means of Left Carrying Angle of both males and females by age.

Age	MALE			FEMALE			P – value
	No.	Mean	S D	No.	Mean	S D	
5.00	64.00	6.28	2.39	48.00	7.25	3.17	0.07
6.00	67.00	7.25	2.45	78.00	9.94	2.63	0.00
7.00	61.00	8.13	2.87	55.00	7.07	2.18	0.03
8.00	48.00	9.02	2.05	56.00	10.80	3.39	0.00
9.00	83.00	10.53	2.78	44.00	11.36	3.15	0.13
10.00	70.00	10.29	2.67	42.00	10.93	2.88	0.24
11.00	53.00	8.81	2.91	53.00	13.60	4.18	0.00
12.00	61.00	10.43	2.98	34.00	14.65	3.84	0.00
13.00	97.00	11.03	3.78	67.00	13.31	4.62	0.00
14.00	50.00	12.38	5.26	207.00	11.96	4.54	0.57
15.00	99.00	12.28	5.67	138.00	8.62	4.32	0.00
16.00	52.00	12.06	3.70	94.00	9.85	5.32	0.01
17.00	33.00	12.39	3.59	58.00	14.88	3.31	0.00
18.00	35.00	14.66	3.64	70.00	15.90	3.71	0.12
19.00	20.00	13.60	5.07	19.00	15.58	4.22	0.19
20–38	288.00	8.64	2.44	54.00	13.19	5.73	0.00

In males, the left carrying angle increased from the 5-year-old, 6.28 ± 2.39 to 9-years-old, 10.53 ± 2.78 , then showed another increase from the 17-year-old to the 18-year-old (14.65 ± 3.63).

In females, there was an increase from the 5-year-old (7.25 ± 3.63) to 9-year-old (11.36 ± 3.14) then from 11- year-old to 12-year-old, then 17-year-old to the 18-year-old (15.57 ± 4.32).

. Table 5: Comparison of means of Left Carrying Angle of both males and females by age.

Age	MALE			FEMALE			P – value
	No.	Mean	S D	No.	Mean	S D	
5.00	64.00	6.28	2.39	48.00	7.25	3.17	0.07
6.00	67.00	7.25	2.45	78.00	9.94	2.63	0.00
7.00	61.00	8.13	2.87	55.00	7.07	2.18	0.03
8.00	48.00	9.02	2.05	56.00	10.80	3.39	0.00
9.00	83.00	10.53	2.78	44.00	11.36	3.15	0.13
10.00	70.00	10.29	2.67	42.00	10.93	2.88	0.24
11.00	53.00	8.81	2.91	53.00	13.60	4.18	0.00
12.00	61.00	10.43	2.98	34.00	14.65	3.84	0.00
13.00	97.00	11.03	3.78	67.00	13.31	4.62	0.00
14.00	50.00	12.38	5.26	207.00	11.96	4.54	0.57
15.00	99.00	12.28	5.67	138.00	8.62	4.32	0.00
16.00	52.00	12.06	3.70	94.00	9.85	5.32	0.01
17.00	33.00	12.39	3.59	58.00	14.88	3.31	0.00
18.00	35.00	14.66	3.64	70.00	15.90	3.71	0.12
19.00	20.00	13.60	5.07	19.00	15.58	4.22	0.19
20 – 38	288.00	8.64	2.44	54.00	13.19	5.73	0.00

This showed that females have higher left carrying angle than males of the same age, but few significant results were observed at 6, 8,11,12,13,15,17,18 and 20-38year-old, (p<0.05).

REGRESSION ANALYSIS OF DIFFERENT PARAMETERS:

$$RCA = AGE + RULL$$

$$RCA = \text{Constant} + (\text{constant} * AGE) + (\text{constant} * RULL)$$

$$RCA = 6.70 + (0.17 * Age) + (0.02 * RULL)$$

$$\begin{aligned} \text{RCA} &= \text{BMI} + \text{AGE} \\ \text{RCA} &= \text{Constant} + (\text{constant} * \text{BMI}) + \\ &\quad (\text{constant} * \text{AGE}) \\ \text{RCA} &= 7.44 + (-0.01 * \text{BMI}) + (0.19 * \text{AGE}). \end{aligned}$$

$$\begin{aligned} \text{RCA} &= \text{WEIGHT} + \text{AGE} \\ \text{RCA} &= \text{Constant} + (\text{constant} * \text{WEIGHT}) + \\ &\quad (\text{constant} * \text{AGE}) \\ \text{RCA} &= 7.33 + (-0.00 * \text{WT}) + (0.20 * \text{AGE}) \end{aligned}$$

$$\begin{aligned} \text{RCA} &= \text{HEIGHT} + \text{WEIGHT} \\ \text{RCA} &= \text{Constant} + (\text{constant} * \text{HEIGHT}) + \\ &\quad (\text{constant} * \text{WEIGHT}) \\ \text{RCA} &= 2.02 + (4.84 * \text{HT}) + (0.01 * \text{WT}) \end{aligned}$$

$$\begin{aligned} \text{RCA} &= \text{AGE} + \text{HEIGHT} \\ \text{RCA} &= \text{Constant} + (\text{constant} * \text{AGE}) + \\ &\quad (\text{constant} * \text{HEIGHT}) \\ \text{RCA} &= 4.60 + (0.13 * \text{AGE}) + (2.25 * \text{HT}) \end{aligned}$$

$$\begin{aligned} \text{LCA} &= \text{AGE} + \text{LULL} \\ \text{LCA} &= \text{Constant} + (\text{constant} * \text{AGE}) + \\ &\quad (\text{constant} * \text{LULL}) \\ \text{LCA} &= 5.72 + (0.08 * \text{AGE}) + (0.07 * \text{LULL}) \end{aligned}$$

$$\begin{aligned} \text{LCA} &= \text{BMI} + \text{AGE} \\ \text{LCA} &= \text{Constant} + (\text{constant} * \text{BMI}) + \\ &\quad (\text{constant} * \text{AGE}) \\ \text{LCA} &= 8.00 + (0.04 * \text{BMI}) + (0.15 * \text{AGE}) \end{aligned}$$

$$\begin{aligned} \text{LCA} &= \text{WEIGHT} + \text{AGE} \\ \text{LCA} &= \text{Constant} + (\text{constant} * \text{WEIGHT}) + \\ &\quad (\text{constant} * \text{AGE}) \\ \text{LCA} &= 8.09 + (0.03 * \text{WT}) + (0.10 * \text{AGE}) \end{aligned}$$

$$\begin{aligned} \text{LCA} &= \text{HEIGHT} + \text{WEIGHT} \\ \text{LCA} &= \text{Constant} + (\text{constant} * \text{HEIGHT}) + \\ &\quad (\text{constant} * \text{WEIGHT}) \\ \text{LCA} &= 2.89 + (4.71 * \text{HT}) + (0.01 * \text{WT}) \end{aligned}$$

$$\begin{aligned} \text{LCA} &= \text{HEIGHT} + \text{AGE} \\ \text{LCA} &= \text{Constant} + (\text{constant} * \text{HEIGHT}) + \\ &\quad (\text{constant} * \text{AGE}) \\ \text{LCA} &= 3.33 + (4.33 * \text{HT}) + (0.05 * \text{AGE}) \end{aligned}$$

Using formulae derived from the regression analysis tables either RCA, LCA, HEIGHT, WEIGHT, BMI, RULL and LULL can be calculated when two other parameters are supplied. These formulae are summarized thus:

- $\text{RCA} = 4.60 + (0.13 * \text{AGE}) + (2.25 * \text{HT})$
- $\text{RCA} = 2.02 + (4.84 * \text{HT}) + (0.01 * \text{WT})$
- $\text{RCA} = 7.33 + (-0.00 * \text{WT}) + (0.20 * \text{AGE})$
- $\text{RCA} = 7.44 + (-0.01 * \text{BMI}) + (0.19 * \text{AGE}).$
- $\text{RCA} = 6.70 + (0.17 * \text{Age}) + (0.02 * \text{RULL})$
- $\text{LCA} = 2.89 + (4.71 * \text{HT}) + (0.01 * \text{WT})$

Various methods of measuring carrying angle have been reported (Zampagni et al, 2008). Considerable differences existed which were noted to be due to different definitions and methodologies. In this study, the carrying angle definition adopted was as the outward angulation of the supinated forearm with the elbow in full extension. It is found even in-utero and is completely developed in a newborn. It exhibits considerable individual variations, as a result, carrying normal standard (J.A Harring, 2002). This is important especially when both limbs are measured by the same individual, with the same instrument under the same environment. This method presented an simple and easy usability, fast and accurate evaluation of the carrying angle. The carrying angle values obtained by our method for 2298 subjects were comparable with those found in previous studies.

This work seems to be among the few ones to include children from 5years in this part of the world.

TABLE6: Comparative data on CA of males and females as reported by some authors.

Country	Authors	Year	Age	Angle measured	No.	Mean (degree)	S D	No.	Mean	S D
Varanasi	Khare et al	1999	Adults	Medial		13.56			16.92	
	Mohammed Omar	2009	Adults	Medial	45	9.29	2.98	45	18.47	4.12
	Alsubel et al									
	Shinsuk et al (CT Scan)	2009		Medial		19.8			22.1	
	Simple (radiograph)	2009		Medial		14.9			18.3	
	Snell	2004	Adults	Lateral		170			167	
	Potter	1895	Adults	Lateral	95	178.17		90	167.35	
	Steal et al, kates Clark,	1958	Adults	Lateral		165			155	
	De Plessis, Grants and	1966	“	“		“			“	
	Hamilton	1971	“	“		“			“	
		1975	“	“		“			“	
		1980	“	“		“			“	
		1987	“	“		“			“	
		1974	“	“		“			“	
	Perot	1974	Adults							
Frazier	1665	Adults			105					
Zampagni et al	2008	Adults			128	10.81	2.71	160	11.6	2.60
Van Roy et al	2005	Adults (25yrs)			10	11.6	3.2	10	16.7	2.6
Greece	Paraskevas et al	2004	Adults			12.88	4.27		15.07	4.95
	Chang et al	2008								
	Balasubramianian et al	2006								
Nigeria	Chinonso et al	1991		Lateral	280	161		220	161	
Nigeria (Efik/Yoruba Tribe in Lagos State).	Emeanu A.	1991	10-30	Lateral	120	160		120	160	

In this study carrying angle increased from 5years in both sexes, fall after 9years to 10years. This spurt corresponds to adolescent growth spurts and osseous development of the elbow joint (Khare et al, 1999). This is similar to what was documented in the literature. Our observation about the variation in the value of carrying angle of left and right elbow is in keeping with observation of many literatures.

Hence, the left was more than the right (L = 13.19; R= 12.31 and L = 8.78; R = 7.78; for females and males respectively).

The carrying angle of young adults was less than the children in this study. This is in disagreement with the findings of Yilmal et al (2005). However, high value of standard deviation (SD) were obtained at all ages in both sexes. From regression analysis, formulae

derived could be used as shortcuts in clinical practice.

RCA or LCA, RULL, LULL, Height, Weight, BML or Age can be calculated when two parameter are supplied.

CONCLUSION

This study has attempted to define carrying angle clearly and has included children as young as 5years. To reduce errors the same instrument were used and all the measurements were done by the authors. An age related increase in carrying angle up to 9years was observed (female = 7.25- 11.3; male = 6.28-10.53). The LCA was more than the RCA in both sexes (Female, L = 13.19, R = 12.31; Male, L = 8.87, R = 7.78).

However, a lower value of carrying angle was observed in young adult group. The study demonstrated also that the CA is significantly greater in females than in males, so can be considered as a secondary sex character. Although this information has been documented in previous studies, it produces normative values that could be useful in the clinical setting. There are some limitations regarding the cross – sectional nature of the subjects and inequality in the number of subjects across different age groups. However, their information may be useful for the assessment in comparison to pathologic conditions as well as in management of disorders of the elbow joint and its reconstruction after fractures.

REFERENCES

Akpa AO, (1991). *Anthropometrical study of the carrying angle in Nigeria*. Pp 102–103.
 Barasubramanian P, Madhuri V, Mulizil J, (2006). *Carrying angle in children: A normative study*. Journal of paediatric orthopaedics part B. 15(1); 37–40.
 Beals RK (1976). *The normal carrying angle of the elbow. A radiographic study of 422 patients*. Clinical Orthopaedics. Related research, 119: 194 – 196. Direct link.
 Chang CY, Wang and Chu C, (2008). *Increased carrying angle is a risk factor for non – traumatic ulnar neuropathy at the elbow*. Clinical orthopedic research 466: 2190–2195. Direct link.
 Chen AL (2007). *Carrying angle of the elbow – excessive overview*. University of Maryland, Medical Center. <http://www.umm.edu/ency/article/002316.htm>.
 Clark EN, (1963). *Tissue of the body* 3rd Edition, Wolf Medical Pub. 1983. pp182.
 Day HM, (1965). *Instruments used in measuring fossil bone*. Illustrated by A Oxehun London, 1969. pp 40–42.

Du Plessis, DJ, (1975). *A synopsis of surgical Anatomy*. 11th Edition, John Wright Son Ltd., Wright – Bristol, UK, ISBN 0723603847, pp: 485–489.
 Flatt AE, (1963). *Reconstructive plastic surgery*. Philadelphia. 3rd Edition. Pub. Cambridge University Press, (1979). pp49–51.
 Hamilton JW, (1984). *Textbook of Human Anatomy*. 2nd Edition, London macmilan. pp: 101–102.
 Haring JA, Tachdjian's *paediatric orthopaedics*, Vol 3. 3rd Edn. Philadelphia pa ; WB Saunders co; (2002): 2164–2168.
 Keats TE, Teeshrink R, Diamong AE, Williams JH. *Normal axial relationship of the major joints*. Radiology 1966; 87:904–908.
 Keith L, Moore and Arthur F, Dalley (2006). *Clinically Oriented Anatomy*. 5th Edn. Lippincott Williams and Wilkins, Philadelphia. ISBN 0 – 7817 – 36 – 39 – 0, pp:
 Khare GN and Rai SK, (1998). *Carrying angle in boys and girls of eastern part of India*. Indian J. Orthopaedics, 32: 7–14. Direct link.
 Khare GN, Goel SC, Saraf SK, Singh G and Mohanty C, (1999). *New observations on carrying angle*. Indian J.med. Sci,53: 61–67. Direct link.
 Mc Minn RMH, (1994). *Last's Anatomy, Regional and Applied* 9th Edn. Churchill Livingstone, London ISBN; 0–443–04903–3, pp53–145.
 Mohammed Omar Alsubael and Abdelmonem Awad M. Hegazy, (2009). *Radiographic Evaluation of the normal Elbow Carrying Angle in Adults*.
 Obikili EN (1991). *An Anthropometric study of body proportion of Nigerians*. Pp 80–81.
 Paraskevas G, Papadopoulos A, and Pawaziogas B (2004). *Surgical and Radiologic Anatomy*. Study of carrying angle of the human elbow joint in full extension; a morphometric analysis. 26(1) : 19–23 (pubmed).
 Potter HP, (1895). *The obliquity of the arm of the female in extension. The relation of the forearm with the upper arm in flexion*. JAnat. Physiol, 29: 488–491.
 Purkait R, and Chandra H, (2004). *An anthropometric investigation into the probable cause of information of carrying angle. A sex indicator*. JIAFM, 26: 14–19.
 Snell RS, (2004). *Clinical Anatomy*. 7th Edn. Lippincott Williams and Wilkins, Newyork, London, ISBN : 0–7817–4315–x, pp:455–590.
 Steel FLD and Tomlinson JDW, (1958). *The Carrying angle in man*. Zampagni, ML, Casino D, Martelli S, A. Visani and Marcarci M, (2008). *A protocol for clinical evaluation of the carrying angle of the elbow by anatomic landmarks*. J. should Elbow surg. 17:106–112. Direct link.
 Susan Standing (2005). *Grays Anatomy, The Anatomical Basis of Clinical Practice*. 39th Edn, Elsevier Churchill Livingstone.
 Van Roy P, Bacyens JP, Fauvart D, Lanssiers R and Clarijs JP, (2005). *Athrokinesematics of the elbow : study of the carrying angle*. Ergonomics, 48:1645 – 1656. Cross Ref/Direct link.