

A Morphometric Study of Carrying Angle in Garhwal Region of Uttarakhand

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Abstract

Context: The Carrying angle is defined as the angle between the median axis of arm and that of fully extended and supinated forearm. It is generally greater in females than in males and ranges from 2°-21° in males and 2°-26° in females. The Carrying angle also shows variation with age and various anthropometric parameters. Racial and regional influences add further to its variability. Thus, knowledge of carrying angle is useful for Orthopaedicians in their clinical practice, Biomechanical engineers for preparing elbow implants, Forensic experts and Anthropologists during prediction of sex and race of an individual. **Aims:** To determine the normal Carrying angle of individuals belonging to Garhwal region of Uttarakhand and to compare these values with those reported by other authors in different ethnic groups. **Materials & Methods:** A cross sectional study was conducted among 400 healthy individuals of both sexes of age group 18-40 years of Garhwal region of Uttarakhand using Goniometer and the data was analysed statistically. **Results:** The mean right Carrying angle was found to be 8.71°±2.54° in males and 12.31°±2.53° in females. The mean left Carrying angle was found to be 8.06°±2.77° in males and 11.76°±2.73° in females. The values are significantly different from those reported by other authors in different ethnic groups. **Conclusions:** This study has established data on the Carrying angle of Garhwal population of Uttarakhand. The carrying angle shows wide regional and racial variations.

Keywords: Carrying Angle; Elbow; Goniometer.

Introduction

The Carrying angle is defined as the angle formed by the long axis of arm and the long axis of forearm in the frontal plane, when the elbow is fully extended and the forearm is fully supinated [1]. The external angle formed between the long axis of arm and forearm is an obtuse angle [2], which is normally 175° in males and 165° in females [3]. Whereas the internal angle formed between the arm and forearm is an acute angle. This angle is usually greater in females than in males [4] and the difference has been considered to be a secondary sexual characteristic [5]. It ranges from 2°-21° in males and 2°-26° in females [6].

The level of the elbow joint is situated 2 cm below a line joining the two epicondyles. It slopes downwards and medially from its lateral extremity, and this obliquity produces the Carrying angle. The angle is also caused partly by the projection of the medial trochlear edge about 6 mm beyond its lateral edge and partly by the obliquity of the superior articular surface of the coronoid process of ulna, which is not orthogonal to the shaft of ulna [3].

The angle is usually greater in the dominant limb than in the non-dominant limb of both sexes, suggesting that the natural forces acting on the elbow modify the Carrying angle [7]. It is inversely proportional to the height of a person and length of forearm [8]. It also shows a direct relationship with the width of pelvis [9]. Development, ageing and racial influences add further to the variability of the Carrying angle [7]. It also shows wide regional variations, which might be due to effect of environmental and genetic factors during growth and development of an individual [10].

Increased Carrying angle may lead to elbow instability and pain during exercise [11]. It may predispose to dislocations [12] and increase chances of fracture around elbow when falling on an

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outstretched hand. The type of fracture a child sustains is determined by the value of Carrying angle [4]. Sometimes after healing of certain fractures of elbow, the Carrying angle may increase or decrease abnormally, i.e. Cubitus valgus or Cubitusvarus respectively [13]. A case of Cubitus valgus may lead to gradual stretch of ulnar nerve behind the medial epicondyle and may cause ulnar nerve palsy [14].

Thus, the knowledge of Carrying angle is useful for Orthopaedicians in their clinical practice for management of various elbow disorders, like fractures, dislocations and in elbow reconstructions [15], for Biomechanical engineers for preparing elbow replacement implants [11] and for Forensic experts and Anthropologists during prediction of sex and race of an individual especially in fragmentary skeletal remains [16].

So, this study was conducted to determine the range of normal values of Carrying angle of individuals belonging to Garhwal region of Uttarakhand, and to compare these values with those reported by other authors in their studies done in different ethnic groups.

Materials and Methods

A cross-sectional study [8] was conducted among healthy individuals of both sexes of age group 18-40 years belonging to Garhwal region of Uttarakhand. A total of 400 individuals were selected using Stratified random sampling method [17].

The age range was selected to minimise the confounding factor where Carrying angle has been documented to alter with age [14]. Individuals with clinical evidence of any trauma, disease condition, or undergone any surgery involving upper limb were excluded from the study.

The study was approved by the College Ethics Committee, in accordance with the International ethical standards. Informed, written, witnessed consent in vernacular of each participant was taken prior to their examination.

A full circle universal manual metallic protractor Goniometer was used to measure the elbow Carrying

angle of individuals [17]. The subjects were asked to stand in anatomical position on a flat ground. The hinged Goniometer has two arms- fixed arm and mobile arm, the two joined at a hinge. The hinge was placed on the volar aspect of elbow joint of the individual, in midline about 2cm below a line joining the medial and lateral epicondyles. The fixed arm was aligned with the median axis of arm and the mobile arm aligned at first in straight line with the fixed arm. Then the mobile arm was re-adjusted to align with the median axis of forearm. Bicipital groove, biceps brachi tendon at its insertion and palmaris longus tendon at the wrist were used to demarcate the median axis of arm and forearm [8]. An angle was formed between the two axis on the medial aspect of elbow [4], which was read out as the Carrying angle. Measurements were made in degrees and taken on both upper limbs. Each side was measured three times, average of the three readings calculated and rounded off to the nearest whole number.

Statistical Package for Social Sciences 17 [SPSS 17] and Smith’s Statistical Package [SSP] were used for data analysis. Independent sample t-test was used to compare the mean values among various groups. A p-value<0.05 was considered significant and p-value<0.01 highly significant.

Results

Mean right Carrying angle [RCA] and Mean left Carrying angle [LCA] of males and females are shown in Table 1.

Discussion

In this study, the mean right Carrying angle was found to be 8.71°±2.54° in males and 12.31°±2.53° in females. The mean left Carrying angle was found to be 8.06°±2.77° in males and 11.76°±2.73° in females.

Similar values of Carrying angle in females were found in the studies conducted by Terra BB et al. [18], Ruparelia S et al. [8] and Zampagni ML et al.[19].

Table 1: Mean Carrying angle

Angle	Males [n-201]	Females [n-199]
RCA	8.71°±2.54°	12.31°±2.53°
LCA	8.06°±2.77°	11.76°±2.73°

RCA: Right Carrying Angle,LCA: Left Carrying Angle,n: Number

The results of the present study were compared with those reported by other authors in different ethnic groups of India [Table 2, Graph 1] and world [Table 3, Graph 2].

Table 2: Comparison of Carrying angle of both males and females found in this study with those reported by other authors in different ethnic groups of India

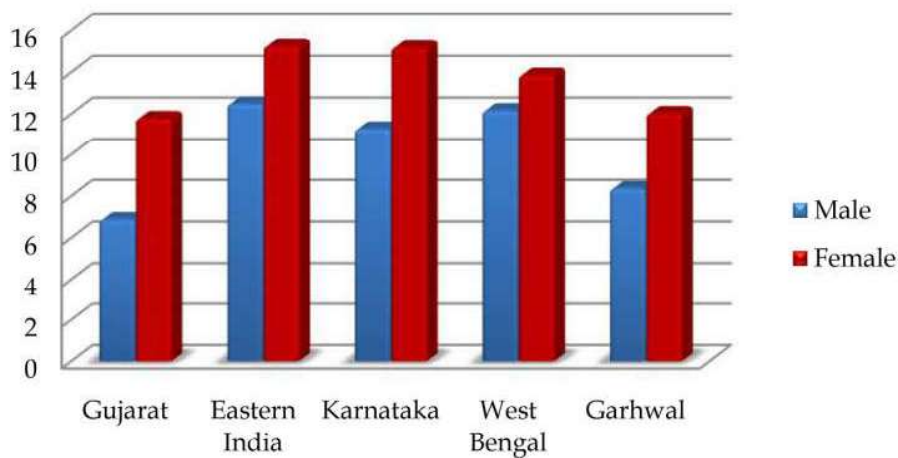
S. No.	Author	n	Male Mean ± SD [degree]	p-value	n	Female Mean ± SD [degree]	p-value
1.	Ruparelia S et al.[8] [Gujarat]	160	6.9±1.25	p<0.01	173	11.8±2.27	p>0.05
2.	Dey S et al.[20] [Eastern India]	180	12.5±0.57	p<0.01	180	15.26±0.45	p<0.01
3.	Mangalur V et al.[21] [Karnataka]	60	11.29±1.46	p<0.01	80	15.20±0.71	p<0.01
4.	Bari W et al.[22] [West Bengal]	200	12.18±2.62	p<0.01	200	13.88±3.46	p<0.01
5.	Present study [Garhwal]	201	R-8.71±2.54 L-8.06±2.77		199	R-12.31±2.53 L-11.76±2.73	

n: Number,SD: Standard deviation,R: Right, L: Left

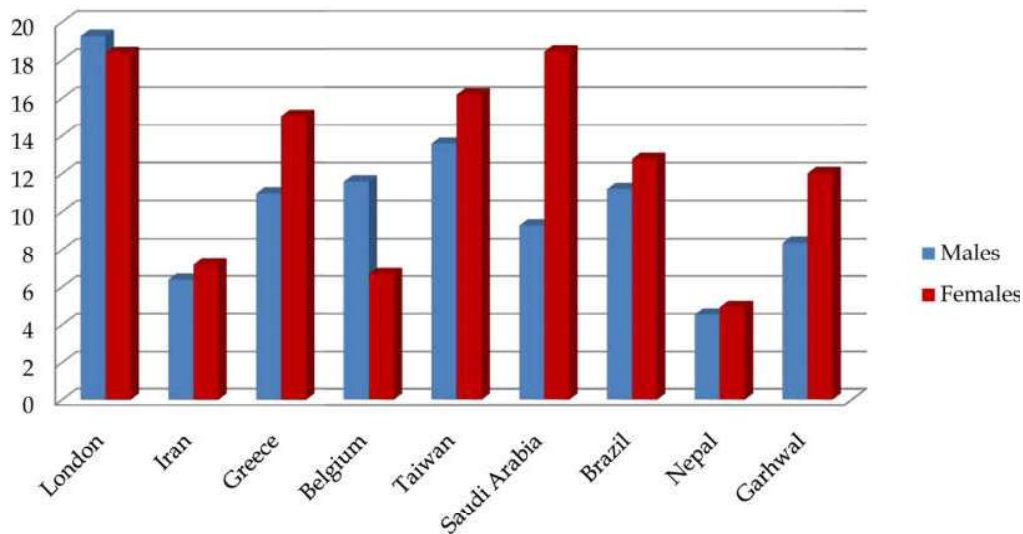
Table 3: Comparison of Carrying angle of both males and females found in this study with those reported by other authors in different ethnic groups of world

S. No.	Author	n	Male Mean ± SD [degree]	p-value	n	Female Mean ± SD [degree]	p-value
1.	Steel FLD et al.[23] [London]	50	19.28±4.67	p<0.01	50	18.38±8.41	p<0.01
2.	Emami MJ et al.[24] [Iran]	1726	6.4±1.73	p<0.01	2540	7.2±1.99	p<0.01
3.	Paraskevas G et al.[25] [Greece]	320	10.97±4.27	p<0.01	280	15.07±4.95	p<0.01
4.	Roy PV et al.[26] [Belgium]	10	11.6±3.2	p<0.01	10	16.7±2.6	p<0.01
5.	Chang CW et al.[27] [Taiwan]	13	13.6±3.0	p<0.01	23	16.2±3.2	p<0.01
6.	Alsubael MO et al.[28] [Saudi Arabia]	45	9.29±2.98	p<0.01	45	18.47±4.12	p<0.01
7.	Park S et al.[29] [Seoul]	15	14.9±2.60	p<0.01	10	18.3±4.38	p<0.01
			[X-ray]			[X-ray]	
8.	Terra BB et al.[18] [Brazil]	255	11.20±4.45	p<0.01	255	12.79±5.35	p>0.05
9.	Eliakaim- -Ikechukwu C et al.[30] [Nigeria]	170	R-17.63±0.25	p<0.01	129	R-18.67±0.35	p<0.01
		Ibo	L-15.05±0.24	p<0.01	Ibo	L-16.64±0.33	p<0.01
		105	R-15.35±0.35	p<0.01	100	R-17.57±0.39	p<0.01
		Yoruba	L-13.25±0.35	p<0.01	Yoruba	L-15.55±0.37	p<0.01
10.	Sharma K et al.[31] [Nepal]	335	R-4.55±3.37	p<0.01	197	R-4.95±3.78	p<0.01
11.	Present study [Garhwal]	201	R-8.71±2.54 L-8.06±2.77		199	R-12.31±2.53 L-11.76±2.73	

n: Number,SD: Standard deviation,R: Right, L: Left



Graph 1: Comparison of Carrying angle of both males and females found in this study with those reported by other authors in different ethnic groups of India



Graph 2: Comparison of Carrying angle of both males and females found in this study with those reported by other authors in different ethnic groups of world

Significant differences [$p < 0.01$] are found between the values of Carrying angle found in the present study and those reported by other authors in their studies done in different ethnic groups. These regional and racial variations might be due to the influence of environmental and genetic factors during growth and development of an individual.

These variations could also be due to different methods employed by different authors to measure the Carrying angle, ranging from simple Goniometer to complex radiological procedures [10] and differences in the choice of bony landmarks for defining the Carrying angle [26].

This is in agreement with what was documented by Dey S et al. [20] and Patil GV et al. [10] that the Carrying angle shows wide regional variations. Udoaka AI et al. [32] and Eliakaim-Ikechukwu C et al. [30] also found racial influence on Carrying angle in their studies.

Allouh MZ et al. [33] in 2016 also studied variations in Carrying angle with respect to race. The study included 457 Jordanian and 345 Malaysian individuals of age group 18-21 years. All participants were right limb dominant. Carrying angle was significantly greater in Malaysian males as compared to Jordanian males, and significantly smaller in Malaysian females as compared to Jordanian females.

However, Lim V et al. [17] in their study did not find any significant racial variation in Carrying angle.

Conclusion

The present study was conducted to determine the range of normal values of Carrying angle of individuals belonging to Garhwal region of Uttarakhand, and to compare these values with those reported by other authors in their studies done in different ethnic groups.

The study included healthy individuals of both sexes of age group 18-40 years. A total of 400 individuals [201 males and 199 females] were measured. The mean right Carrying angle was found to be $8.71^\circ \pm 2.54^\circ$ in males and $12.31^\circ \pm 2.53^\circ$ in females. The mean left Carrying angle was found to be $8.06^\circ \pm 2.77^\circ$ in males and $11.76^\circ \pm 2.73^\circ$ in females.

Comparison between the results of the present study with other studies done in different ethnic groups showed wide regional and racial variations in the values of Carrying angle.

This study has established data on the Carrying angle of Garhwal population of Uttarakhand, which could be useful for Orthopaedicians in their clinical practice during management of various elbow disorders, like- fractures, dislocations and in elbow reconstructions and for Biomechanical engineers for preparing elbow replacement implants. The results of this study will also help Forensic experts and Anthropologists during prediction of sex and race of an individual especially in fragmentary skeletal remains. The simple method to measure the

Carrying angle used in this study can also be used in routine clinical practice and in future researches.

Conflict of Interest

None.

References

- Kothapalli J, Murudkar PH, Seerla LD. The Carrying Angle of Elbow- A Correlative and Comparative Study. *Int J Cur Res Rev.* 2013;5(4):71-6.
- Snell RS. *Clinical Anatomy.* 7 ed. London: Lippincott Williams and Wilkins; 2004.
- Standring S, Borley NR, Collins P, Crossman AR, Gatzoulis MA, Healy JC, et al., editors. *Gray's Anatomy: The Anatomical Basis of Clinical Practice* 40 ed. London: Churchill Livingstone Elsevier; 2008.
- Khare GN, Goel SC, Saraf SK, Singh G, Mohanty C. New observations on carrying angle. *Indian J Med Sci.* 1999;53(2):61-7.
- Atkinson WD, Elftman H. The carrying angle of the human arm as a secondary sex character. *Anat Record.* 1945;91:49-53.
- Baughman FA, Higgins JV, Wadsworth Thomas G, Demaray MJ. The Carrying Angle in Sex Chromosome Anomalies. *JAMA.* 1974;230(5):718-20.
- Yilmaz E, 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(11):1360-3.
- Ruparelia S, Patel S, Zalawadia A, Shah S, Patel SV. Study Of Carrying Angle And Its Correlation With Various Parameters. *NJIRM.* 2010;1(3):28-32.
- Baskar S, Kumar S. Variations in Carrying Angle between Two Sexes on Complete Extension. *J Pharm Sci & Res.* 2013;5(12):269.
- Patil VG, Apoorva D, Shishirkumar. Carrying Angle: A Morphometric Study in South Indian Population. *J of Evidence Based Med & Hlthcare.* 2014;1(13):1686-9.
- Hutchinson MR, Wynn S. Biomechanics and development of the elbow in the young throwing athlete. *Clin Sports Med.* 2004;23:531-44.
- Habernek H, Ortner F. The influence of anatomic factors in elbow joint dislocation. *Clin OrthopRelat Res.* 1992;274:226-30.
- Norman SW, Christopher JKB, O'Connell PR, editors. *Bailey & Love's Short Practice of Surgery.* 25 ed. London: Edward Arnold [Publishers] Ltd; 2008.
- McMinn RMH, editor. *Last's Anatomy Regional and Applied.* 9 ed. London: Churchill Livingstone; 1994.
- Balasubramanian P, Madhuri V, Muliylil J. Carrying angle in children: a normative study. *J Pediatr Orthop B.* 2006;15(1):37-40.
- Punia RS, Sharma R, Usmani JA. The carrying angle in an Indian population. *J Anat Soc India.* 1994;43(2): 107-10.
- Lim V, Jacob NA, Ghani MFS, Wang DC, K AD. An Anthropometric Study on the Carrying Angle of Elbow among Young Adults of Various Ethnicities in Malaysia *NJIRM.* 2014;5(6):20-3.
- Terra BB, Silva BCM, Bella H, Carvalho FD, Dobashi ET, Pinto JA, et al. Evolution of the Carrying Angle of the Elbow: A Clinical and Radiographic Study. *Acta Ortop Bras.* 2011;19(2):79-82.
- Zampagni ML, Casino D, Martelli S, Visani A, Marcacci M. A protocol for clinical evaluation of the carrying angle of the elbow by anatomic landmarks. *J Shoulder Elbow Surg.* 2008;17(1):106-12.
- Dey 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 Journal of Basic & Applied Medical Research.* 2013;8(2):823-30.
- Mangalur V, Karadkhelkar VP, Kshirsagar SV. Sexual dimorphism of carrying angle. *International Journal of Recent trends in Science and Technology.* 2015; 15(3):476-8.
- Bari W, Alam M, Omar S. Goniometry of elbow carrying angle: a comparative clinical study on sexual dimorphism in young males and females. *Int J Res Med Sci.* 2015;3:3482-4.
- Steel FLD, Tomalinson JDW. The 'carrying angle' in man. *J Anat.* 1958;92(2):315-7.
- Emami MJ, Abdinejad F, Khodabkshshi S, Amini M, Naseri B. The Normal Carrying Angle of the Elbow in Shiraz. *Medical Journal of the Islamic Republic of India.* 1998;12(1):37-9.
- Paraskevas G, Papadopoulos A, Papaziogas B, Spanidou S, Argiriadou H, Gigis J. Study of the carrying angle of the human elbow joint in full extension: a morphometric analysis. *Surg Radiol Anat.* 2004;26(1): 19-23.
- Roy PV, Baeyens JP, Fauvart D, Lanssiens R, Clarijs JP. Arthrokinematics of the elbow: study of the carrying angle. *Ergonomics.* 2005;48:1645-56.
- Wei Chang C, Chian Wang Y, Hung Chu C. Increased Carrying Angle is a Risk Factor for Nontraumatic Ulnar Neuropathy at the Elbow. *Clin Orthop Relat Res.* 2008;466(9):2190-5.
- Alsubael MO, Hegazy AAM. Radiographic Evaluation of the Normal Elbow Carrying Angle in Adults. *Journal of Medical Sciences.* 2010;10:40-4.
- Park S, Kim E. Estimation of Carrying Angle Based on CT Images in Preoperative Surgical Planning for Cubitus Deformities. *Acta Med Okayama.* 2009;63(6): 359-65.
- Eliakim-Ikechukwu C, Atu L, Etika M, Udo-affah G. The Carrying Angle of the Ibo and Yoruba Ethnic Groups of Nigeria and its Relationship with the

- Height of Individuals. *Journal of Biology, Agriculture and Healthcare*. 2012;2(11):157-62.
31. 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.
32. Udoaka AI, Oghenemavwe L. A Radiographic Study of the Carrying Angle in the People of Niger Delta Region in Southern Nigeria. *Afr J Med Phy, Biomed Eng & Sc*. 2009;1:18-20.
33. Allouh MZ, Ghaida JHA, Jarrar AA, Khasawneh RR, Mustafa AG, Bashaireh KM. The carrying angle: racial differences and relevance to inter-epicondylar distance of the humerus. *Folia Morphol*. 2016;75(3):388-92.
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