

A comparative study of carrying angle among males and females in Garhwal region of Uttarakhand

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Abstract

Background: When the upper extremity is in anatomical position, the long axis of humerus and the long axis of ulna form an acute angle medially at the elbow which is called the Carrying angle. It is generally greater in females than in males and ranges from 2°-21° in males and 2°-26° in females. Racial and regional influences add further to its variability. Thus, knowledge of Carrying angle is useful for Forensic experts and Anthropologists during prediction of sex and race of an individual, for Orthopaedicians during management of various elbow disorders and for Biomechanical engineers for preparing elbow replacement implants. So this study was conducted to compare the values of Carrying angle in males with those of females. **Materials and Methods:** A cross sectional study was conducted among 400 healthy individuals of both sexes of age group 18–40 years belonging to 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. Mean right Carrying angle and mean left Carrying angle were found to be greater in females than in males and differences were statistically highly significant (p<0.01). **Conclusion:** The Carrying angle is significantly greater in females as compared to males and the difference has been considered to be a secondary sexual characteristic.

Key Words: Carrying angle, Cubitus valgus, Elbow, Goniometer.

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INTRODUCTION

The Carrying angle is defined as the acute angle between the median axis of arm and that of the fully extended and supinated forearm. Thus it measures the lateral obliquity of the forearm¹. The external angle formed between the long axis of arm and that of the extended forearm is an obtuse angle². It is normally 175° in males and 165° in females³. Whereas the internal angle formed between the arm and the forearm is an acute angle. This angle is

greater in females than in males. It ranges from 2°-21° in males and 2°-26° in females⁴. The angle is 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 ulna³. The greater Carrying angle in females has been considered to be their secondary sexual characteristic⁵. The angle is very similar in boys and in men, but varies in females with age, suggesting that the hormones may influence the Carrying angle in females⁶. It may also be due to increased joint laxity in females permitting a greater degree of extension of elbow and hence greater Carrying angle. Besides this, in females the medial lip of trochlea projects more distally than the lateral lip and the valgus tilt of the distal humeral articulation with respect to the longitudinal axis of humerus is more as compared to males⁷. The Carrying angle also shows a direct relationship with the width of pelvis. Thus broader pelvis in females is also attributed to be a cause for wider Carrying angle in females⁸.

However, in 3-5 years of age group, the Carrying angle is greater in males as compared to females⁹. The broad shoulders and narrow hips of males allow the arms to hang straight downwards with the long axis of upper and lower segments approximately in the same straight line. Whereas in females, narrow shoulders and broader hips require a splaying out of the forearm axis so that the hanging arms clear off the hips¹⁰. The Carrying angle also shows variation with various other anthropometric parameters, like- height, length of forearm etc¹¹. Ageing and racial influences add further to the variability of the Carrying angle¹². 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 angle¹². Increased Carrying angle may lead to elbow instability and pain during exercise¹³. It may predispose to dislocations¹⁴ and increase chances of fracture around elbow when falling on an outstretched hand¹⁵. The type of fracture a child sustains after fall on an outstretched hand is determined by the value of Carrying angle¹⁵. Sometimes after healing of certain fractures of elbow, the Carrying angle may increase or decrease abnormally, i.e. Cubitus valgus or Cubitus varus respectively¹⁶. A case of Cubitus valgus may lead to gradual stretch of ulnar nerve behind the medial epicondyle and may cause ulnar nerve palsy¹⁷. Thus, the knowledge of Carrying angle is useful for Forensic experts and Anthropologists during prediction of sex and race of an individual especially in fragmentary skeletal remains¹⁸, for Orthopaedicians in their clinical practice for management of various elbow disorders, like- fractures, dislocations and in elbow reconstructions¹⁹ and for Biomechanical engineers for preparing elbow replacement implants¹³. So, this study was conducted to compare the normal values of Carrying angle in males with those of females.

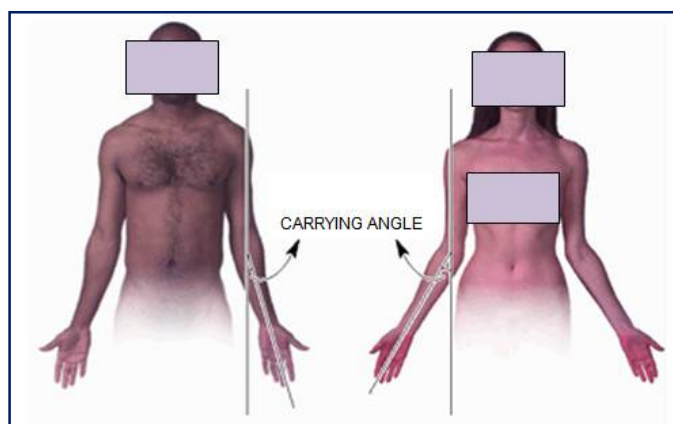


Figure 1: Carrying angle (A)-males, (B)-females²⁰.

MATERIALS AND METHODS

A cross-sectional study¹¹ 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 (201 males and 199 females) were selected using Stratified random sampling method. The age range was selected to minimise the confounding factor where Carrying angle has been documented to alter with age⁷. 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 Carrying angle of individuals⁷. 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 brachii tendon at its insertion and palmaris longus tendon at the wrist were used to demarcate the median axis of arm and forearm¹¹. An angle was formed between the two axis on the medial aspect of elbow¹⁵, which was read out as the Carrying angle. Measurements were read out 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 among various groups. A p-value < 0.05 was considered significant and p-value < 0.01 highly significant.

OBSERVATIONS AND RESULTS

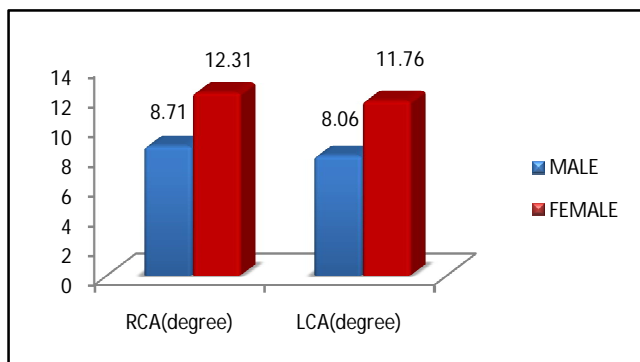
Mean right Carrying angle (RCA) and Mean left Carrying angle (LCA) of males and females are shown in table 1, graph 1.

Table 1: Mean Carrying angle

Parameters	Male (n=201) Mean \pm S D	Female (n=199) Mean \pm S D	p-value
RCA	8.71 \pm 2.54	12.31 \pm 2.53	p < 0.01
LCA	8.06 \pm 2.77	11.76 \pm 2.73	p < 0.01

n: number, SD: standard deviation

Mean right Carrying angle and mean left Carrying angle were found to be greater in females than in males and differences were statistically highly significant ($p < 0.01$).



Graph 1: Mean right Carrying angle and mean left Carrying angles of males and females

DISCUSSION

In this study, 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. Mean right Carrying angle and mean left Carrying angle were found to be greater in females than in males and differences were statistically highly significant ($p < 0.01$). Greater Carrying angle in females can be considered as their secondary sexual characteristic¹¹, because there is no difference in Carrying angle in males and females until puberty, after which it increases in females⁵. It might also be due to their increased joint laxity, allowing a greater degree of extension of elbow and hence greater Carrying angle²¹. Steel FLD *et al.* in 1958 studied Carrying angle in left upper limb of 100 adults (50 males and 50 females) in London using radiographs. They measured the internal Carrying angle and found a mean value of 19.28° in males and 18.38° in females. The difference in the angle between the two genders was statistically not significant²². Beals RK in 1976 also studied Carrying angle radiographically in 422 individuals (divided into four age groups i.e. 0 to 4 years, 5 to 11 years, 12 to 15 years and adults) in New Zealand. He measured the internal Carrying angle and did not find any significant difference between Carrying angle of males and females in any age group²³. Khare GN *et al.* in 1999 conducted a cross-sectional study on Carrying angle in Varanasi in 200 adult males and 200 adult females. The mean Carrying angle was found to be 13.56° in males and 16.92° in females¹⁵. Purkait R *et al.* in 2004 undertook a study on dry bones in central India to identify the sexually dimorphic features in the bones of the elbow joint which makes the Carrying angle a sex indicator. The study included 40 humeri (20 males and 20 females) and

160 ulnae (100 males and 60 females). Two measurements of humerus (Trochlear angle and Inclination angle of Olecranon fossa) and three measurements of ulna (Olecranon-Coronoid angle, length and width of inferior medial trochlear notch) were studied. The measurements on humerus did not show any sex difference. However the dimensions of ulna exhibited statistically significant differences in male and female bones. They concluded that Olecranon-Coronoid angle exhibiting high sexual dimorphism may be one of the causes of different values of Carrying angle observed in the two sexes. The smaller Olecranon-Coronoid angle of female ulna suggests that the projection of Olecranon process may be relatively larger in females as compared to males¹⁰. This was also later supported by Ruparelia S *et al.*¹¹. Zampagni ML *et al.* in 2008 studied Carrying angle in 37 adults (17 males and 20 females) aged 41 to 81 years using an Electro-Goniometer and found a mean value of 12.39° in males and 12.9° in females. The difference was statistically not significant²⁴. A radiographic evaluation of Carrying angle was also done in 90 healthy adults (45 males and 45 females) aged 18 to 76 years in Saudi Arabia by Alsubael MO *et al.* in 2010. Plain radiographs antero-posterior views of elbow joint were taken. The internal angle between a line passing through the mid-axis of lower third of humerus and a line along the mid-axis of the upper third of the forearm between radius and ulna was measured with a Goniometer and found a mean value of $9.29^{\circ} \pm 2.98^{\circ}$ in males and $18.47^{\circ} \pm 4.12^{\circ}$ in females²⁵. Ruparelia S *et al.* in 2010 conducted a cross-sectional study in Gujarat. They measured Carrying angle in 333 individuals (160 males and 173 females) aged 17 to 22 years and found a mean value of 6.9° in males and 11.8° in females. It was significantly greater in females than in males¹¹ which is similar to that found in the present study. Kumar B *et al.* in 2010 studied Carrying angle in 54 adult individuals (31 males and 23 females) in south India using radiographs. They found a mean value of 17.02° in males and 17.77° in females and the difference was statistically not significant²⁶. Rana G *et al.* in 2013 conducted a study on Carrying angle in 30 males and 30 females of age group 18-25 years in Nepal. They measured the angle by two methods- Surface anatomical landmark method and radiological landmark method and found it to be greater in females than in males by both methods²⁷. Kothapalli J *et al.* in 2013 studied Carrying angle in 220 subjects (110 males and 110 females) aged 18-22 years belonging to Karnataka and Andhra Pradesh and found a mean value of 12.09° in males and 13.54° in females. It was greater in females than in males⁶. Patil GV *et al.* in 2014 studied Carrying angle in 400 healthy volunteers (160 males and 240 females) of south Indian origin, aged 18-38 years and

found a mean value of $13.8^{\circ} \pm 3.02^{\circ}$ on the right side and $12.2^{\circ} \pm 1.84^{\circ}$ on left side in males, $18.4^{\circ} \pm 2.62^{\circ}$ on the right side and $17.5^{\circ} \pm 2.84^{\circ}$ on left side in females. The Carrying angle was significantly greater in females as compared to males²⁸. Similar findings were found in the present study. Lim V *et al.* in 2014 studied Carrying angle in 201 individuals (90 males and 111 females) of age group 18-25 years in Malaysia and found a mean value of 6.02° in males and 10.37° in females. They concluded that the Carrying angle was significantly greater in females than in males⁷. Chinweif KC *et al.* in 2014 conducted a study on Carrying angle in 900 adolescents (411 females and 489 males) aged 10-19 years in Nigeria and found a mean value of $13.82^{\circ} \pm 1.65^{\circ}$ on right side and $12.55^{\circ} \pm 1.76^{\circ}$ on left side in females, $12.30^{\circ} \pm 1.88^{\circ}$ on right side and $10.99^{\circ} \pm 1.87^{\circ}$ on left side in males. It was significantly greater in females as compared to males²⁹. Allouh MZ *et al.* in 2014 studied Carrying angle in 1223 individuals (456 males and 767 females) aged 7 to 35 years in Jordan and found a mean value of 13.0° on right side and 10.8° on left side in males, whereas 16.6° on right side and 14.5° on left side in females. It was significantly greater in females as compared to males³⁰. Bari W *et al.* in 2015 conducted a study on Carrying angle in 400 individuals (200 males and 200 females) of age group 21-25 years in West Bengal and found a mean value of $12.18^{\circ} \pm 2.62^{\circ}$ in males and $13.88^{\circ} \pm 3.46^{\circ}$ in females. Mean Carrying angle was found to be greater in females as compared to males and the difference was found to be statistically significant³¹. Anibor E *et al.* in 2016 conducted a study on Carrying angle in 384 adolescents (194 males and 190 females) of age group 10-19 years in Nigeria. The Carrying angle did not show any significant gender difference³². Kumari KL *et al.* in 2016 conducted a study on Carrying angle in 60 children (30 boys and 30 girls) of age group 8-15 years and 184 adults (94 males and 90 females) of age group 17-38 years in Andhra Pradesh. Among children, the mean Carrying angle was found to be $9.08^{\circ} \pm 0.51^{\circ}$ on right side, $8.00^{\circ} \pm 0.95^{\circ}$ on left side in males and $12.77^{\circ} \pm 1.13^{\circ}$ on right side, $10.27^{\circ} \pm 0.35^{\circ}$ on left side in females. In adults, they found a mean value of $14.2^{\circ} \pm 3.01^{\circ}$ on right side, $12.4^{\circ} \pm 1.12^{\circ}$ on left side in males and $19.4^{\circ} \pm 2.91^{\circ}$ on right side, $17.5^{\circ} \pm 2.48^{\circ}$ on left side in females. In both age groups, mean Carrying angles were found to be significantly greater in females as compared to males³³.

CONCLUSION

The present study was conducted to compare the value of Carrying angle in males with those of females. The study was conducted in Garhwal region of Uttarakhand and it included 400 healthy individuals (201 males and 199

females) of age group 18-40 years. 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. Mean right Carrying angle and mean left Carrying angle were found to be greater in females than in males and differences were statistically highly significant ($p < 0.01$). Thus, it was inferred that females have significantly greater Carrying angle as compared to males and it can be considered as their secondary sexual characteristic. The results of this study will help Forensic experts and Anthropologists during prediction of sex of an individual especially in fragmentary skeletal remains. It will also be useful for Orthopaedicians in their clinical practice for management of various elbow disorders, like fractures, dislocations and in elbow reconstructions and for Biomechanical engineers for preparing elbow replacement implants. The simple method used in this study to measure the Carrying angle can be used in clinical practice and in future researches.

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