Original article

Study of carrying angle of medical students by using goniometer

1Dr. Manoranjitham. R., M.S, 2Dr. Suresh R. Gosai. M.D, 3Dr. Arunkumar . K.R., M.D, 4 Dr. Shalini. R. M.D, 5Dr. Parthasarathi. R., M.D

1Associate Professor, 2H.O.D & Prof, 3Asst Prof), 4 Asst Prof, 5 PS&M ]
Name of the Institute/college: Dept of Anatomy, Dhanalakshmi Srinivasan Medical College & Hospital.
Corresponding author: Dr. Manoranjitham. R., M.S, Associate Professor, Dept of Anatomy, D.S.M.C & Hospital, Siruvachur, Perambalur, Tamil Nadu.

Abstract

Introduction: Carrying angle is the angle between the median axis of arm and that of the fully extended and supinated forearm. The carrying angle is greater in females and in the dominant upper limb.

Aim and Objectives: To study the variations in the carrying angle of right and left upper limbs of same sex, to compare the difference in the carrying angle of right and left upper limbs between the sexes and to study the relation of the carrying angle with the height of the individual, hip circumference, arm and forearm length.

Materials and Methods: 560 healthy students of Dhanalakshmi Srinivasan Medical College and Hospital were selected. Height of the students was measured using a stature meter. Hip circumference, length of arm and forearm were measured using a measuring tape. The carrying angle was measured using a goniometer.

Results: The carrying angle was greater in females by 2.65º (p<0.001). The mean carrying angle in males was 11.5 º and in females was 14.5 º. The carrying angle in males on right side was 11.9 º and on left side was 11.1 º. The carrying angle in females on right side was 14.7 º and left side was 13.6 º. The carrying angle was inversely proportional to the height of individual, hip circumference, length of arm and forearm (p<0.001).

Conclusion: The carrying angle is significantly higher in females and also in the dominant upper limb. There is a negative correlation between the carrying angle and height of individual, hip circumference, length of arm and forearm.

Key words: carrying angle, goniometer, length of arm and forearm, height, hip circumference

Introduction:
The human skeleton is bilaterally symmetrical with the typical vertebrate pattern of an axis divided into segments for flexibility and two pairs of limbs pectoral and pelvic also divided into joined parts for grasping, locomotion etc. The knowledge of carrying angle is important anthropologically for differentiation of sex in fragmentary remains and also to understand sexual dimorphism which is more common in bones. The carrying angle is defined as the acute angle made by the median axis of the arm and that of fully extended and supinated forearm and thus it measures the lateral obliquity of the forearm. The carrying angle permits the forearm to clear the hips in swinging movements during walking and is important when carrying objects. Studies have shown that the range of motion of the elbow and carrying angle increase with age to skeletal maturity. The carrying angle is approximately 10º in men and 13 º in women. The carrying angle is greater in the dominant limb than in the non-dominant limb of both sexes, suggesting that natural forces modify the carrying angle. Developmental factors, racial influences also further add to the variability of this parameters. It is important to know the carrying angles of both elbows in the evaluation.
of deformities of distal humerus fractures (5). Increased carrying angle may lead to many clinical conditions like elbow instability, pain during exercise (6,7), decreased elbow flexion (8), and there is an increased risk of elbow dislocation (9). Increased carrying angle is also a risk factor for non-traumatic ulnar neuropathy at the elbow (10). The present study is designed to estimate the difference in the carrying angle of adolescent males and females of medical students studying in Dhanalakshmi Srinivasan Medical College, Perambalur. The study also aims to evaluate the relation of the carrying angle with heights of the individual, hip circumference and length of arm and forearm.

**Aims and objectives:**

1. To study the variations in the carrying angle of right and left upper limbs of same sex.
2. To compare the differences in the carrying angle of right and left upper limbs between the sexes.
3. To study the relation of the carrying angle with the height of the individual, hip circumference, arm and forearm lengths.
4. To see whether the variations in carrying angle are obtained are of any statistical significance.

**Methodology:**

For the present study, a total of 560 healthy medical students (227 males and 333 females) of Dhanalakshmi Srinivasan Medical College, were selected after obtaining clearance from Institutional Ethics Committee. These students voluntarily participated with eagerness to know the readings. They belong to various states of South India and their ages ranged from 17 to 22yrs. The carrying angles were measured by using a Goniometer. Informed and written consent was obtained from the students before taking the measurements. The age and sex of the students were noted. The height, hip circumference, length of arm and forearm were recorded.

Measurement of height of students was done using a stature meter. Height was measured from vertex to heel of the individual with bare foot in anatomical position in centimetres. A measuring tape was used to measure the hip circumference, length of arm and forearm in centimetres. Hip circumference was measured using a measuring tape passing around the highest point of iliac crest on both sides. The length of arm was measured by taking the following points: - Proximally midpoint between the tip of the coracoid process of scapula and lesser tubercle of humerus and distally midpoint between the medial and lateral epicondyle of the humerus. The length of forearm was measured as the distance between the following points: - Above the midpoint between the medial and lateral epicondyles of the humerus and below the midpoint between radial and ulnar styloid processes (10). The readings were taken in both right and left upper limbs. Students with fractured limbs, physically handicapped, non traumatic neuropathy were excluded from the study.

**Measurement of Carrying Angle:**

The students were made to stand in anatomical position with the elbow fully extended and supinated. The arms of the goniometer were kept on a straight line and the goniometer measurement plate was placed at the fulcrum of right elbow. The fixed arm of the goniometer was placed along the long axis of the right arm. The movable arm of the goniometer was lined up along the long axis of the right forearm. The angle was measured from the measurement plate. The same procedure was repeated on the left arm.
All the measurements were recorded, tabulated and statistically analysed. Mean and standard deviation for each of the parameters was calculated using Epi info version 4.3. The Chi square test was used as the test of statistical significance to calculate the ‘p’ value. A ‘p’ value less than 0.001 was taken to be statistically significant.

**Results:**
The mean Carrying Angle in Males on the Right upper limb was 11.9° and in females was 14.7° and the mean carrying angle in Males on the Left upper limb was 11.1° and in females was 13.6°. We noticed the greater Carrying angle in dominant limb than the non dominant limbs. Carrying angle of Females is more (14.15°) when compared to Males (11.5°). The difference of carrying angle is 2.65°. There was significant negative correlation between height, hip circumference, length of arm, length of forearm and Carrying Angle.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Carrying angle on right upper limb in degree</th>
<th>Carrying angle on left upper limb in degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>11.9°</td>
<td>11.1°</td>
</tr>
<tr>
<td>Female</td>
<td>14.7°</td>
<td>13.6°</td>
</tr>
</tbody>
</table>

Table 1. Carrying angle in right and left upper limb of same sex:

<table>
<thead>
<tr>
<th>Method of Measurement</th>
<th>Carrying angle in males (mean in degrees)</th>
<th>Carrying angle in females (mean in degrees)</th>
<th>Differences in Carrying Angle in Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foot-Rule</td>
<td>11.5°</td>
<td>14.15°</td>
<td>2.65°</td>
</tr>
</tbody>
</table>

Table 2. Study of Carrying Angle in Sex Ratio (Male: Female) (227 Males : 333 Females)

<table>
<thead>
<tr>
<th>Sex</th>
<th>Mean of Height in cm</th>
<th>Hip circumference in cm</th>
<th>Right arm length in cm</th>
<th>Left arm length in cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>173.4±6.80</td>
<td>88.4±9.42</td>
<td>32.3502 ±2.43</td>
<td>32.3±2.35</td>
</tr>
<tr>
<td>Female</td>
<td>157.8±9.32</td>
<td>86±10.82</td>
<td>30.1±.15</td>
<td>30±2.11</td>
</tr>
</tbody>
</table>

Table 3. Comparison of Height, Hip circumference, Upper Limb measurements to Carrying Angle:
Figure 1. Graph showing relation between height and carrying angle in males. X axis- height of males in centimetres and Y axis – carrying angle in degrees. C.angle- carrying angle.
Figure 2. Graph showing relation between forearm length and carrying angle in males. X axis- forearm length in centimetres and Y axis- carrying angle in degrees. c. angle- carrying angle

Figure 3. Graph showing relation between height and carrying angle in females. X axis- height of females in centimetres and Y axis- carrying angle in degrees. c. angle- carrying angle.
Discussion:
In the present study, the carrying angle is greater in females. The difference in carrying angle is 2.65° which is statistically significant (p<0.001). In the study by Kumar B. et al, the difference in carrying angle measured from radiograph was not statistically significant (11). The results of the present study are similar to Baughman et al, with the carrying angle in male as 11.0° and females 15° (12). The carrying angle was higher on the right upper limb in both sexes. The difference between the carrying angles of right and left upper limb in the same sex was statistically significant. The difference between the carrying angles of right and left sides may suggest ligamentous laxity at the medial elbow or asymmetrical bone growth (13).

The difference in carrying angles of right side in males and females is 2.8° is statistically significant. The difference in carrying angles of left side in males and females is 2.5° which is statistically significant (p<0.001). Hence in the present study the carrying angle is more in the right upper limb in females when compared to males. These results are similar to the studies of Ruparelia et al, in which the carrying angle is more in females in right upper limb compared to males (14).

The average height of males was 173.4 ± 6.80 centimetres and the mean carrying angle was 11.9° on right side and 11.1° on left side. The average height of females was 157.8±9.32 centimetres and the mean carrying angle on right side was 14.7° and left side was 13.6°. Hence the carrying angle and height are inversely related in the present study. If the height of a person is lesser and therefore length of ulna is lesser, then because of shorter lever arm the proximal end has to angulate more in order to bring the hand in pronated position for routine work. So in shorter person, the medial part of trochlear notch of ulna goes more away from the medial flange or asymmetrical bone growth (14).

The hip circumference and carrying angle are negatively correlated in the present study. The hip circumference was significantly
higher in males 88.4 centimetres when compared to similar aged females who had a hip circumference of 86 centimetres. The carrying angle was less in males and more in females. In the study by Rajest et al, the hip circumference and carrying angle were not statistically significant \(^{(15)}\). But Paraskevas G et al, in his study has noted that carrying angle is inversely related to inter trochanteric diameter \(^{(3)}\). Previously it was believed that greater carrying angle develops in response to broader pelvis in females and it keeps the forearm away from the side of the pelvis when the upper limbs swing during walking is now proved to be wrong. The carrying angle is formed only when the forearm is fully supinated and extended at the elbow. But during walking, the forearms are pronated and elbow is slightly flexed. So the carrying angle is not present during walking \(^{(3)}\).

The length of arm was significantly more in males 32.4 centimetres on right side and 32.3 centimetres on left side when compared to females 30.1 centimetres on right arm and 30 centimetres on left arm. In this present study, there is a statistically significant negative correlation \((p<0.001)\) between the length of arm and carrying angle in both males and females.

The length of forearm was also significantly more in males 28.3 centimetres on right side and 28.1 centimetres on the left side when compared to females 25.2 centimetres on right side and 25 centimetres on the left side. In the present study, there is a statistically significant negative correlation \((p<0.001)\) between the length of forearm and carrying angle in both males and females. Rajesh et al, has also found that the carrying angle is higher in girls, having lesser forearm length \(^{(15)}\). Khare et al, has also found similar observations \(^{(16)}\). Paraskevas et a,l has also noted the carrying angle is inversely related to the length of forearm \(^{(3)}\). Greater the length of forearm bones, lesser is the angulation of proximal articular surface and therefore lesser is the carrying angle.

The evaluation of carrying angle will help the orthopaedician in the management of elbow disorders like elbow displacement, fractures, epicondylar diseases and elbow reconstruction.

**Conclusion:**
From the present study, it is concluded that the carrying angle is significantly more in females when compared to males. The carrying angle is significantly higher in the dominant right upper limb when compared to the non dominant limb. The carrying angle has significant negative correlation with the height of the individual, hip circumference and length of arm and forearm. The results of this study will help orthopaedicians in the management of elbow disorders.

**Acknowledgements:**
Our heartul thanks to the students of Dhanalakshmi srinivasan medical college and hospital, Perambalur, Tamilnadu. Who actively participated in this study.

**References:**


