

Full Length Research Paper

Carrying angle of an adult Nigerian population

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Apes and humans are distinguished from other primate species in possessing carrying angle at the elbow. No study exists in the literature regarding carrying angle of adult population of Southeastern Nigerians. 509 healthy volunteers from southeastern Nigeria with an average age range: 18-67 years participated in this study. The carrying angle measurements were performed first on the dominant extremity and then on the non-dominant extremity. The carrying angle was measured with a full-circle manual goniometer made of flexible clear plastic with 35 cm long arms. This device fulfilled the requirements of a universal goniometer. It was positioned on the volar surface of the arm and was aligned with the mid-axis of the humerus to the extended elbow and mid-axis of the fully supinated forearm. In the males, the right carrying angle was $16.9^{\circ} \pm 4.14^{\circ}$ and the left carrying angle was $14.2^{\circ} \pm 3.53^{\circ}$ ($P < 0.05$). In the females, right carrying angle was $20.5^{\circ} \pm 3.82^{\circ}$ and left carrying angle was $17.5^{\circ} \pm 3.87^{\circ}$ ($P < 0.05$). Right and left carrying angles of females were found to be higher than carrying angles of males. This study has established data on the carrying angle in Southeastern Nigerian adult population by anthropometric method. According to the study, the carrying angle of the females ranked higher than males and that of the dominant arm was found to be significantly higher than the non-dominant arm in both sexes. Greater carrying angle in female is considered as secondary sex characteristic. This study will assist the orthopedic surgeons and manufacturers preparing for elbow replacement implants.

Key words: Carrying angle, anthropometry, adults, Nigeria.

INTRODUCTION

Apes and humans are distinguished from other primate species in possessing carrying angle at the elbow. The evolution of a carrying angle in apes is related to the need to bring the center of mass of the body beneath the supporting hand during suspensory locomotion as seen

in lower limbs of humans in which the valgus knee brings the foot nearer the center of mass of the body during the single limb support phase of walking (Larson, 2000).

The intersection of the line along the mid-axis of the upper arm and the line along the mid-axis of the forearm defines the carrying angle of the elbow (Green, 1997).

The carrying angle of the elbow is a clinical measure of varus-valgus angulation of the arm with the elbow fully extended and the forearm fully supinated. Most accurate measurements of carrying angle usually are obtained

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Table 1. Shows values in range mean and standard deviation of carrying angle of males and females of southeastern Nigerian population.

Gender	Carrying angle	
	Right arm	Left arm
Male	16.9°±4.14°	14.2°±3.53°
Female	20.5°±3.82°	17.5°±3.87°

with a hinged goniometer and recorded in degrees (Harring, 2002).

The axis of the elbow joint is set obliquely at nearly 84° of both the humerus and ulna (Mall, 1905; Jones, 1953). This is caused by the obliquity of trochlea to the shaft of the humerus (Langer, 1905). Kapandji suggests that the angle is formed as a result of trochlear groove being vertical anteriorly but on the posterior aspect it runs obliquely distally and laterally (Kapandji, 1970). This result in formation of carrying angle in extension when posterior aspect of the oblique groove makes contact with the trochlear notch of ulna and the angle is marked during flexion when trochlear notch lies on the vertical groove in the anterior aspect. Last is of the opinion that in the ulna a curved ridge joins the prominence of the coronoid and olecranon process which fits the groove in the trochlea of the humerus (Last, 1978). The obliquity of the shaft of ulna to this ridge accounts for most of the carrying angle at elbow. Decker gave the same reason pointing out that the inner lip of trochlea of humerus is a ridge (groove) which is much deeper distally anteriorly so that ulna (with the forearm) is deflected in full extension by this ridge (Decker, 1986). William considered the medial edge of trochlea of humerus partly responsible as it projects nearly 6 mm below the lateral edge and the obliquity of the superior articular surface of the coronoid process which is not set at right angle to the shaft of ulna (William, 2005).

It is reported that carrying angles differ according to the sex and age (Smith, 1960; Beals, 1976; Amis, 1982; Tachdijan, 1990). Change in the carrying angle with age and gender has been reported (Smith, 1960; Beals, 1976; Amis, 1982; Harring, 2002). According to Khare, the carrying angle is greater in shorter persons compared to taller persons and the lesser the forearm bone lengths the greater the carrying angle will be (Khare, 1999).

However, no study exists in the literature regarding carrying angle of adult population of Southeastern Nigerians. This study was aimed at establishing the carrying angle of adult southeastern Nigerians.

MATERIALS AND METHODS

This study is comprised of 509 randomly selected healthy volunteers of southeastern Nigeria with an average age

range: 18-67 years. The carrying angle measurements were performed first on the dominant extremity and then on the non-dominant extremity. Individuals with a history of malunion or growth disturbance involving either upper extremity were excluded from the study.

The carrying angle was measured with a full-circle manual goniometer made of flexible clear plastic with 35 cm long arms. This device fulfilled the requirements of a universal goniometer. It was positioned on the volar surface of the arm and was aligned with the mid-axis of the humerus to the extended elbow and mid-axis of the fully supinated forearm.

A pilot study was carried out initially to test the goniometer and to ascertain if the measurements were associated with acceptably low intra-examiner and inter-examiner errors. Before the measurements were made, the goniometer was determined to be accurate within 1° of the measurement of the known angles. Students' *t* tests were used to compare the values of the carrying angles. A *P* value <0.05 was considered significant.

RESULTS

This study included 509 volunteers, 251 males (49.3%) and 258 (50.7%) females. Right arm dominance was in 478 (93.9%) volunteers and left arm dominance was in 31 (6.1%) volunteers.

In the males, the right carrying angle was 16.9°±4.14° and the left carrying angle was 14.2°±3.53° (*P*<0.05) (Table 1). In the females, right carrying angle was 20.5°±3.82° and left carrying angle was 17.5°±3.87° (*P*<0.05) (Table 1). Right and left carrying angles of females were found to be higher than carrying angles of males. Though not documented, when comparing females and males, Right arm carrying angles of the right arm dominant volunteers were higher as well as left arm carrying angles of the left arm dominant volunteers.

DISCUSSION

The carrying angle, which is found even in utero and is completely developed in a new born is an outward angulations' of the supinated forearm with the elbow

extended (Jain et al., 2000) It exhibits considerable individual variation. Comparisons for the carrying angle should be made with the contralateral side rather than with any "normal standard" (Harring, 2002).

The broad shoulders and narrow hips of the males, allow the arms to hang straight downwards with the long axis of the upper and lower segment approximately in the same straight line. Whereas in the females, the narrower shoulders and broader hips require a splaying out of the forearm axis in order that the hanging arms clear the hips. This observation made by Hooton became the basis for the theory of "carrying angle" (Hooton, 1946). A change in the carrying angle following a supracondylar fracture can result from malunion after inadequate/loss of reduction or as a result of growth disturbance at the lower end of humerus (Jain, 2000).

In the present study, the mean carrying angle in males was ; right carrying angle $16.9^{\circ} \pm 4.14^{\circ}$ and the left carrying angle was $14.2^{\circ} \pm 3.53^{\circ}$ ($P < 0.05$). In the females, right carrying angle was $20.5^{\circ} \pm 3.82^{\circ}$ and left carrying angle was $17.5^{\circ} \pm 3.87^{\circ}$ ($P < 0.05$) The difference between males and females carrying angle was statistically significant ($P < 0.05$).

Paraskevas studied carrying angle in 600 living individuals from Greece and observed that carrying angle was significantly greater in females (Paraskevas, 2004). Our findings agree with this observation.

Carrying angle does not help in keeping the forearm away from the side of pelvis during walking as during walk the forearm is pronated and carrying angle disappears in pronation of forearm (Khare, 1999). They found that carrying angle is inversely related to the height of a person, since the average height of females is lesser than the average height of males so average carrying angle is greater in females than males.

Steel and Tomlinson (1958) investigated the left upper limb of 100 European adults using radiographs to measure carrying angle and obtained no statistically significant difference (Steel and Tomlinson, 1958). Beals conducted study on various age groups including adult population in New Zealand, using radiographs. According to him, the mean carrying angle in adults was 17.80 and difference between males and females carrying angle was statistically not significant (Beals, 1976). This study did not employ the use of radiographs.

Paraskevas reported that carrying angle in right-handed subjects' angle was significantly greater in right upper limb in both sexes and in left-handed subjects; it was significantly greater in left upper limbs in both sexes (Paraskevas, 2004).

From this study, we also observed that the carrying angle in right-handed subjects was significantly greater in right upper limb in both sexes and in left-handed subjects; it was significantly greater in left upper limbs in both sexes. Thus, our observation on difference in

carrying angle on dominant and non dominant arms is in agreement with this.

Different authors have found different values of carrying angle; this could be due to different methods used by different authors and due to racial difference of the population studied. Punia mentioned that according to Moore, knowledge of carrying angle is useful anthropologically for differentiation of sex in fragmentary skeletal remains but according to us racial differences in carrying angle should also be taken into consideration (Punia, 1994; Moore, 1985).

Carrying angle has a cosmetic significance (Mcgregor, 1986). The carrying angle of the elbow remains constant as the elbow flexes and its variability is reflected in differences in design of resurfacing and semiconstrained elbow replacement implants. This has made clinical results with elbow prostheses disappointing (An, 1984). Therefore, detailed knowledge of elbow joint geometry and mechanics is necessary to improve prosthetic design.

Most other studies focused on the question of carrying angle difference in sex (Potter, 1895; Atkinson and Elftman, 1995; Purkait and Chandra, 2004) has considered greater carrying angle in females to be a secondary sex characteristics because according to their findings there is no difference in the carrying angle in male and female up to the puberty. But in the female, it is increased after puberty.

Conclusions

This study has established data on the carrying angle in Southeastern Nigerian adult population by anthropometric method. According to the study, the carrying angle of the females ranked higher than males and that of the dominant arm was found to be significantly higher than the non-dominant arm in both sexes. Greater carrying angle in female is considered as secondary sex characteristic. This study will assist the orthopedic surgeons and manufacturers preparing for elbow replacement implants.

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