

Research Article

Goniometry of elbow carrying angle: a comparative clinical study on sexual dimorphism in young males and females

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ABSTRACT

Background: Carrying angle of the elbow joint is an angle formed between the axis of arm and axis of forearm in an extended elbow joint supinated at the radio-ulnar joints. It is an obtuse angle which facilitates free swinging of arm by deviating it from the pelvis during walking or carrying an object. Carrying angle increases with age and is reportedly greater in females. Morphometry of this angle may be helpful in identification of elbow disorders along with surgical reconstruction and evaluation of traumatic elbow. The aim of this study was to clinically observe sexual dimorphism of carrying angle among young males and females with normal anatomy and bony configuration of elbows between 21 to 25 years of age in the outdoor clinic of the Department of Orthopaedics.

Methods: Four hundred individuals of equal sex ratio underwent bilateral goniometry. The measurement of carrying angle was performed using goniometer.

Results: Carrying angle was observed to be greater in females. There was no correlation between carrying angle and height of individual or length of forearm.

Conclusions: Carrying angle is greater in females may be because exhibits high sexual dimorphism. It may also be considered as a secondary sexual characteristic. Utility of goniometry of carrying angle is observed during orthopaedic reconstruction of elbow disorders after treatment of distal fractures of humerus and evaluation of traumatic injuries at the elbow joint.

Keywords: Carrying angle, Elbow, Goniometry, Sexual dimorphism, Trauma

INTRODUCTION

The elbow joint is a uniaxial, synovial joint of hinge variety. The lower end of the humerus articulates with the upper ends of both radius and ulna. Flexion and extension are the two movements occurring at this joint. Proximal to the elbow joint lies another synovial joint of pivot variety at which movements of pronation and supination occur. It should be noted that the long axis of the extended forearm lies at an angle to the long axis of the arm. This angle which opens laterally is called the

carrying angle and is about 170° in the male and 167° in the female.¹ The angle disappears when the elbow joint is fully flexed. The carrying angle apparently develops in response to pronation of the forearm and keeps the swinging upper extremity away from the side of the pelvis during walking.^{2,3} Factors responsible for production of carrying angle are the medial flange of trochlear is 6mm deeper than the lateral flange and the superior articular process of the coronoid process of the ulna is placed oblique to the long axis of the bone.⁴ Clinically the carrying angle of the elbow joint is

assessed by radiographs to evaluate the reduction of distal humerus or radial head fractures and epicondylar pathologies.⁵ Studies have also revealed that due to greater depth of inner lip of trochlea of humerus the ulna is deflected in full extension. Carrying angle is the result of the inner condyle of the humerus being set obliquely so that the axis of the elbow joint is transverse between the radius and humerus but oblique between the ulna and the humerus.⁶ The carrying angle varies markedly between individuals and tends to be greater in females versus males and greater in adults versus children.⁷ Structurally, women on an average have smaller shoulders and wider hips than their male counterparts which may be one appropriate reason for having an acute carrying angle. The olecranon coronoid angle shows high sexual dimorphism and it may be one of the causes of sexual difference observed in carrying angle.⁸ Handling and monitoring of traumatic paediatric elbow injuries often require evaluation of the carrying angle. Forensic anthropologists may utilize knowledge of carrying angle to ascertain the sex of an individual from skeletal remains and biomechanical engineers may require knowledge of the same for designing a total elbow prosthesis.⁹

METHODS

After prior approval from the Institutional Ethics Committee (IEC), a total of eight hundred elbows of four hundred healthy, asymptomatic, young males and females in equal sex ratio with normal bony configuration in the age group of 21 to 25 years were examined in the Department of Orthopaedics. Handedness was not a factor in this study. Persons with shoulder or elbow or wrist pathologies, asymmetry, congenital malformations, history of elbow surgery and amputees of upper limbs were excluded from the study. Participants were seated on a fixed chair and bony landmarks were identified through palpation and marked with a skin pencil. The bony landmarks were olecranon process of the ulna, head of the radius, medial and lateral epicondyles of humerus and head of ulna. During measurement each forearm of the individual was extended, supinated and fixed. The fixed arm of the goniometer was placed on the median axis of the arm and the movable arm was placed on the median axis of the forearm. The angle was measured and read by two observers to avoid interobserver disparity. Data collected was recorded and analysed statistically.

RESULTS

In this study we observed that there were no significant differences between carrying angles of both sides of the same person. Significantly greater carrying angles were observed in females. No correlation could be established between length of the forearm and carrying angle in either sex. Carrying angles were observed to be $13.88 \pm 3.46^\circ$ in females and $12.18 \pm 2.62^\circ$ in males.

Table 1: Sex ratio of participants involved in this study.

n	Males	Female
400	200	200

Table 2: Distribution of participants according to age.

Age in Years	No. of males	No. of females
21	27	31
22	32	33
23	39	37
24	47	44
25	55	55

Table 3: Carrying angle observed according to sex after goniometry.

Carrying angle	Group
$12.18 \pm 2.62^\circ$	Males
$13.88 \pm 3.46^\circ$	Females

DISCUSSION

Evolution of the upper limb has resulted in two contrasting features that supersede it from the lower limb. They are rotation of the thumb for grasping and rotation of the forearm during supination-pronation complex. Evolution of a carrying angle in apes is related to the need to bring the centre of the 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 to the center of mass of the body during the single limb support phase of walking.¹⁰ The evaluation of carrying angle of elbow and knowledge of its variations is essential for the handling and monitoring of traumatic lesions.¹¹ In physiologic conditions this parameter varies according to age, gender, hyperextension of the elbow, dominant upper limb, anthropometric characteristics such as height and intertrochanteric distance.¹²⁻¹⁵ We observed mean values to be $12.18 \pm 2.62^\circ$ in males and $13.88 \pm 3.46^\circ$ in females. Some researchers are of the opinion that elbow carrying angle values are higher on the dominant side, yet we did not encounter such a correlation in our study.¹⁶ Carrying angle has been reported to increase with age and because of skeletal maturation and is always greater on the dominant side.^{17,18} As our age group was small, we could not document any data on change of carrying angle with age. We also observed that although length of the forearm bones is longer in males the carrying angle is however higher in females. Goniometry of the carrying angle has clinical significance as an increased carrying angle may be a risk factor for non-traumatic ulnar neuropathy. Reproduction of carrying angle measurement is easily applicable in routine orthopaedic practice however others challenge that its applicability is of little practical importance and maximum extension of the elbow should contribute to the increase of the elbow carrying angle.^{19,20}

CONCLUSION

Carrying angle is greater in females than in males and it may be considered to be a secondary sex characteristic in the female. This angle may be high in females due to laxity of articular ligaments, larger breasts and a wider pelvis which may result in a greater lateral deviation of the forearm on the arm. Carrying angle is an important anatomic feature when restoration of the elbow's function is required. Another application of goniometry of the carrying angle would be to evaluate the possible genesis of specific fractures of the elbow region. Clinical correlation of carrying angle helps orthopaedic and trauma surgeons during correction of deformity occurring after malunited supracondylar fracture of humerus. Carrying angle values and its pathologic variants are important in the management of elbow fractures and in the diagnosis of diseases of the lateral and medial epicondyles.

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