

Comparison of Goniometric and Radiographic Measurement of Elbow's Carrying Angle in Adult Pakistani Population

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Abstract

Background: The carrying angle (CA) of elbow is an angulation of forearm with that of arm when the forearm is kept in supinated, and elbow in extended position. As there are different techniques of its measurement like goniometer and X-rays, it is not clearly known which one is better. This study is therefore designed to compare the two methods of its measurements.

Study type, settings & duration: This cross-sectional study was carried out at CMH Malir from March to October 2020.

Methodology: In the study, 80 adult males were included, with age group 18-22 years. Carrying angle of both elbows were measured by goniometric and on X-rays, the data was analyzed statistically, spearman's correlation was used to compare the mean values.

Results: The mean age of study participants was 19.06 ± 1.11 years, the mean height was 179.46 ± 3.10 cm and the mean of weight was 61.83 ± 1.88 kg. The mean of CA by goniometer was 17.91 ± 2.15 in right elbow while in the left elbow it was 16.53 ± 2.33 . The mean CA on X-ray was 18.06 ± 2.14 in right elbow and 16.56 ± 1.94 in the left. The mean values of CA by goniometer and on X-ray were when compared the 'p' value was 0.71 in right elbow which is non-significant; similarly, when the mean values of CA in left elbow by goniometer and on X-ray were compared the p value comes out 0.66 which is also non-significant.

Conclusion: The present study provides evidence that any of the method of measurement among goniometric and radiographic can be used for the estimation of CA elbow with similar results.

Key words: Carrying angle, goniometer, x-ray, elbow.

Introduction

The carrying angle (CA) is defined as "the angle between the median axis of arm and forearm in fully extended and supinated position".¹ It helps the arm to swing without hitting the hip while walking

and ranges between 5~15°. Normally it is 14° (female) and 11° (male) away from the body. The carrying angle results due to the "configuration of the articulating surfaces of humerus", which produces "normal valgus angulation of the forearm in relation to upper arm".²

The CA is said to be "greater in dominant limb than other one" in both sexes.³ It completely disappears when the elbow is fully flexed.⁴ This angle varies with varying age, gender, dominant or non-dominant upper limb, changes with hyperextension of elbow, and intertrochanteric distance.⁵ It is larger in female; the reason being, as women have smaller shoulder and wider hips than men, so it can be taken as secondary sex characteristic.⁶

If this angle increases more than normal range, it may cause elbow instability, reduce elbow flexion and pain on exercise or throwing games. In the forces, firing and load-carrying is an important

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Authors Contribution

MI, SS & ST conceptualized the project. MI, AM, KMBH & TY did the data collection. MI, AM, ST & KMBH also did the literature search. MI, ST & KMBH performed the statistical analysis. Drafting, revision & writing of manuscript were done by MI, SS, AM & ST.

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part of the training. With excessive carrying angle, aiming while firing and carrying a load can hinder the efficiency of a soldier and can become a matter of life and death during the action. Unilateral increase, if more than normal is always taken as abnormal.⁷ Its pathological variant is important in causing fracture of elbow and disease of both epicondyles.⁸⁻¹⁰

Presently two methods are employed to measure the CA i.e., goniometry and X-ray, the most controversy about the CA is the result of difference in methodologies. Goniometry is cheaper noninvasive and easily available technique and can be carried out even in clinics and should be done by a surgeon/consultant while X-ray is comparatively expensive, there is also exposure to ionizing radiations and may not be readily available in all clinical settings however a technician can perform it.

Goniometry is a widely used method for measuring the CA, however, the accuracy and reliability of goniometric measurements compared to radiographic techniques needs to be evaluated in the Pakistani population. This study is therefore designed to compare the two methods of measuring the carrying angle (CA) of elbow applying in same subjects and find the cheaper and more reliable method.

The objective of study was to determine the carrying angle in young adult Pakistani male population by goniometry and X-ray and to compare these two different measuring modalities i.e., goniometry and X-ray and to propose a simpler reliable method for measuring it.

Methodology

It was a cross sectional study. The study was carried out in CMH Malir from March to October 2020.

Sample size was determined by "keeping 5% margin of error, 95% confidence interval, power 80%" and means and standard deviations of carrying angle 11.21 ± 2.63 , 12.95 ± 1.93 as reported in Srivastava et al.¹¹

The desired sample size was calculated to be 56 but it was kept at 80 to make the study more applicable to general population.¹² Non-probability convenient sampling technique was used for this study.

The inclusion criteria was adult male who applied for induction in Pakistan Army with age range of 18-22 years, whereas the subjects having a past history of any bone disease, history of fracture in upper limb, any surgical procedure in upper limb, congenital anomalies of elbow were excluded.

After taking informed consent, the demographical data was obtained from each subject including age, height and weight. For measuring the weight, the electronic weighing scale was used. Subjects were weighed with minimal clothing and without shoes. The height was measured using standiometer.



Figure 1: Measurement of CA by goniometer.¹⁵



Figure 2: Measurement of carrying angle on x-ray film.

A manual goniometer was used to measure the CA of right and left elbows.¹³ The angle was measured in degrees.^{1,14}

The fixed arm of goniometer was settled on the median axis of upper arm, the moveable arm of goniometer was moved and settled correlating with the median line of forearm (Figure-1) and the angle shown on the goniometer⁶ was noted on every subject.

For radiographic procedure X-rays was taken with arm fully extended and forearm in supination. Normal anteroposterior radiographs were taken¹² and longitudinal axis of humerus and ulna were drawn and angle thus formed between the two was measured as CA (Figure-2). The readings were noted for both right and left elbows.

The data was analyzed using "SPSS version 20". The statistical tests applied were "Wilcoxon Signed Ranks Test" and "Spearman's correlation coefficient".

The ethical approval was obtained from the Ethical Review Committee of Combined Military Hospital, Malir vide reference No. 24/2020/Trg/.

Results

In the present study, we estimated the age, height and weight, carrying angle of adult Pakistani males who were the candidate for the recruitment in army. The mean age of study participants was 19.06 ± 1.11 years, the mean height was 179.46 ± 3.10 cm and the mean of weight was 61.83 ± 1.88 kg.

The mean of CA ongoniometer was 17.91 ± 2.15 degrees in right elbow and 16.53 ± 2.33 degrees in the left elbow (Table-1).

Table-1: Descriptive statistics CA of right and left elbow with goniometry and with x-rays. (N=250)

	Descriptive Statistics of Carrying Angle			
	Min	Max	Mean	Std. Dev.
Right elbow CA by goniometry	12	26	17.91	2.154
Left elbow CA by goniometry	5	24	16.53	2.334
Right elbow CA by X-ray	13	28	18.06	2.143
Left elbow CA by X-ray	11	20	16.56	1.949

The measurements CA of same subjects on X-rays were taken, the mean carrying angle calculation for right elbow was 18.06 ± 2.14 and for left it was 16.56 ± 1.94 degrees (Table-1).

The mean values of CA elbow through goniometer and X-ray when compared by using Wilcoxin Signed Ranks Test, the *p* value came out

to be 0.71 in right elbow which was non-significant. Similarly when the mean values of CA in left elbow were compared, the *p* value comes out to be 0.66 which is also non-significant (Table-2).

To assess normality of right elbow CA by goniometry and X-ray and left elbow CA by Goniometry and X-ray, Shapiro-Wilk test was applied and found the *p* value ≤ 0.05 which indicates that the data is skewed.

Discussion

The carrying angle, a deflection of forearm with the arm has importance due to its functional and clinical importance.¹³ Knowledge of the carrying angle as well as its variants are also important as it has a role while carrying the load and handling and monitoring the traumatic lesion.⁸ Increased carrying angle was found to be associated with increased incidence of lateral epicondylitis.¹⁶ Its physiological variant depends on age, gender, and dominant limb.^{4,17} A higher carrying angle has been reported on the dominant side.¹⁸ It is not uncommon to see vulgus in persons participating in throwing games; i.e., an adoptive change.

Carrying angle has also been studied with relation to hip circumference in female but "no significant relationship was found between the two".¹⁹ In same study "no significant relationship was found between weight and carrying angle".

The CA is generally estimated by goniometer or on a radiograph but there is controversy regarding the accurate methods of measurement. In this study, an effort has been made to find any difference in CA by using different techniques of measurements. There may be variations in inter-observer assessment specially by goniometric measurement. We focused on these two techniques and hypothesized that there is significant difference in CA between techniques of estimation. This angle was estimated in adult Pakistani male population in both arms and by both methods.

Table-2: Comparison of goniometry & x-ray in measurement of carrying angle of both elbows.

	CA Right Elbow		CA Left Elbow	
	Goniometry	X-ray	Goniometry	X-ray
Mean $\pm$ SD	17.91 ± 2.15	18.06 ± 2.14	16.53 ± 2.23	17.56 ± 1.94
Median (IQR)	18(3)	18 (3)	16(3)	17(3)
<i>p</i> -Value	0.07		0.66	

Our study is in agreement with that of Allouh et al¹³ who showed the same values in both right and left elbow as that in our study.

In our study, the carrying angle (CA) was higher in right elbow in right-handed subjects by both techniques which is consistent with that of Goldfrab²⁰ and Ahmed.²¹ Our study is in contrast to Baskin and Kumar who have reported the mean values for CA as 19.4° in the right arm and 12.8° in the left in a male population, these values are smaller than in our population.²²

We also compared the mean values of carrying angle in right and left elbow, and a highly significant difference was noted; it confirms the results of previous studies which also showed similar differences in CA of right and left elbows.^{5,6} However, these results are in contrast with Bari W and Açıkgöz AK who found the same values of CA in right and left elbows.^{4,23}

In one of the previous study carried by Srivastava AK, using both techniques of measurements were used but this study included both male and female, secondly the radiographs were taken from different participants.¹¹ In this regard, present study differs because we have measured the angle using different techniques on the same subjects.

To our knowledge, no study in past have worked on comparison between the results of two techniques of measurements. We are first to compare these techniques. It is pertinent here to say that Hasegawa, was the first to find out the association between humerus, wrist and elbow angles and the carrying angle.²⁴

As both the methods of CA measurement, employing goniometry or X-ray modality, give similar results. The study thus concludes that goniometer can be used as a reliable technique in any clinic for the estimation of CA, thereby protecting patients from the hazards of X-rays on one hand while saving both time and money on the other hand.

Conflict of interest: None declared.

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