International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Available online on: https://ijmpr.in/

Original Article

Evaluation of Carrying Angle with Hand Grip Strength in Young Adults; An Anatomical Study

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Received: 13-04-2026
Accepted: 25-05-2026
Available online: 08-06-2026

ABSTRACT

Background: The carrying angle of the elbow is an important anatomical feature that facilitates efficient upper limb movement and clearance of the forearm during gait. Variations in carrying angle may influence elbow biomechanics, joint stability, and functional hand performance. Hand grip strength is a validated indicator of upper limb muscular function and overall health status.
Objective: To evaluate the relationship between carrying angle and hand grip strength in young adults and to determine the influence of forearm length and hand span on grip strength.
Methods: A cross-sectional observational study was conducted on 100 healthy young adults aged 18–30 years, including both males and females. Carrying angle was measured bilaterally using a universal goniometer with the elbow fully extended and forearm supinated. Hand grip strength was assessed using a Jamar dynamometer. Forearm length and hand span were measured using a non-elastic measuring tape. Data was analyzed using SPSS software. Spearman's correlation test was applied, and $p \leq 0.05$ was considered statistically significant.
Results: Females demonstrated a significantly greater carrying angle than males on both sides. Males exhibited higher hand grip strength than females. Carrying angle showed a moderate negative correlation with grip strength on the right ($r = -0.52$) and left ($r = -0.58$) sides. Forearm length demonstrated a strong positive correlation with grip strength on the right ($r = +0.65$) and left ($r = +0.62$). Hand span also showed a strong positive correlation with grip strength on the right ($r = +0.68$) and left ($r = +0.71$).
Conclusion: Increased carrying angle is associated with reduced hand grip strength, whereas greater forearm length and hand span are associated with stronger grip strength. These findings may be useful in anatomical assessment, rehabilitation planning, sports biomechanics, and ergonomic device design.

Keywords: *Carrying angle, Hand grip strength, Forearm length, Hand span, Young adults, Elbow biomechanics.*

INTRODUCTION

The elbow joint is a complex synovial hinge joint that serves as a functional link between the shoulder and hand. One of its important anatomical characteristics is the carrying angle, defined as the angle formed between the long axis of the humerus and ulna when the elbow is fully extended and the forearm is supinated. This angle allows the forearm to clear the pelvis during walking and facilitates object carrying [1, 2].

The normal carrying angle varies with age, sex, dominance, and skeletal morphology. Females generally demonstrate a greater carrying angle than males, often attributed to broader pelvic dimensions and increased ligamentous laxity [3, 4].

Excessive carrying angle (cubitus valgus) may predispose individuals to elbow instability, altered biomechanics, and ulnar nerve stretching [5].

Hand grip strength is a practical and reliable measure of upper limb function. It reflects the coordinated action of forearm flexors, intrinsic hand muscles, and stabilizing musculature. Reduced grip strength has been associated with functional limitations, nutritional deficits, and systemic disease [6].

Anthropometric variables such as forearm length and hand span may also influence grip performance through biomechanical leverage and muscle efficiency [7]. However, limited data exist regarding the combined relationship of carrying angle, grip strength, and upper limb dimensions in young adults.

Therefore, this study was undertaken to evaluate the relationship between carrying angle and hand grip strength in young adults.

MATERIALS & METHODOLOGY

Study Design

This cross-sectional observational study was conducted in the Department of Anatomy, Integral Institute of Medical Sciences and Research, Lucknow. Approval of the Institutional Ethical Committee (IEC) was obtained before the commencement of the study (IEC/IIMSR/2025/43).

Study Population

A total of 100 healthy subjects aged 18–30 years were included after informed consent.

Methodology

The participants were assessed from February 2025 to January 2026 and selected on the basis of following inclusion criteria: aged between 18 to 30 years, both sexes, healthy asymptomatic individuals. Any history of fracture or surgery of upper limb, pathology around elbow or wrist joints, musculoskeletal disorders, median, radial, or ulnar nerve palsy, and cervical radiculopathy were excluded from this study.

Outcomes Meassures

Carrying Angle was measured bilaterally in anatomical position with elbow fully extended and forearm supinated using a universal goniometer, which is a valid and reliable tool for measuring joint range of motion. The axis of the goniometer was placed at volar aspect at the midline of elbow joint, the fixed arm was placed along the long axis of the tested arm directed towards the acromion, and the movable arm of the goniometer was lined up along the long axis of the tested forearm directedtoward the middle finger. The angle was noted from the measurement plate.

Hand Grip Strength was assessed bilaterally by using a hand held dynamometer in seated position with shoulder adducted, elbow flexed at 90°, and wrist neutral. Participants were asked to grip the dynamometer very tightly within pain free range by placing the thumb round on one side of the handle and encouraged to squeeze as long and as tightly as possible until the needle stopped raising. Each participant was instructed to exert their maximum grip strength for 5 sec.

Forearm Length was measured in anatomical position, the distance between the midpoints of the bony protuberance of the olecranon process and the ulnar styloid process was measured by a non-elastic measuring tape.

Hand Span was measured from the distance from tip of thumb to tip of little finger with maximal finger abduction by using a non-elastic measuring tape.

Fig. 1 Carrying Angle

Fig. 2 Forearm Length

Fig. 3 Hand Span

Fig. 4 Grip Strength

Statistical Analysis

Data were analyzed using SPSS software. Spearman's correlation test was used to correlate carrying angle with grip strength and anthropometric measurements. Significance level was set at $p \leq 0.05$.

RESULTS

The table below summarizes the demographic breakdown of the study population, categorizing the 100 subjects by age and sex to ensure a balanced perspective on gender-specific variances.

The age-wise and gender-wise distribution of respondents shows that the sample is highly concentrated in the 18–25 years age group. Out of the total 100 respondents, 96 belong to the 18–25 years category, accounting for the vast majority of the study population, while only 4 respondents fall in the 26–30 years category. In terms of gender, the distribution is nearly

balanced, with 51 males and 49 females in the total sample. Within the 18–25 years group, male and female respondents are equally represented, with 48 each, indicating no gender disparity in this age category. In the 26–30 years group, males slightly outnumber females, with 3 males and 1 female. Overall, the data indicates that the study is predominantly composed of younger respondents, with an almost equal representation of both genders.

Table 1 Demographic Distribution

Age Group	Male	Female	Total
18–25 years	48	48	96
26–30 years	3	1	4
Total	51	49	100

The table below displays the mean carrying angles observed in the primary dataset.

Table 2 Mean Carrying Angle

Variables	Male	Female
Right Carrying Angle (degrees)	12.3 ± 2.4	15.4 ± 2.6
Left Carrying Angle (degrees)	11.8 ± 1.9	14.5 ± 2.3

The dataset shows a profound difference in force production capacity between genders, which is attributable to higher muscle mass and larger forearm cross-sectional areas in males. Furthermore, the dataset reveals that the right hand is consistently stronger than the left, reinforcing the "10% rule" of dominance in right-handed individuals. These findings are crucial for establishing rehabilitation targets, as strength values falling below the female 20 kg or male 35 kg marks may indicate underlying nutritional or neuromuscular deficiencies.

Table 3 Mean Grip Strength

Variable	Male (kg)	Female (kg)
Right Grip	43.5	24.2
Left Grip	40.8	21.6

The following table outlines the statistical relationships observed within the primary dataset for both right and left extremities. All correlations listed reached statistical significance at the $p \leq 0.05$ level.A significant **inverse relationship** between the carrying angle and hand grip strength, as the carrying angle increases, grip strength tends to decrease ($p \leq 0.05$ $r = -0.52$ Right & $p \leq 0.05$ $r = -0.58$ Left). Longer forearms are strongly associated with higher grip strength on both the right ($p \leq 0.05$ $r = 0.65$) and left ($p \leq 0.05$ $r = 0.62$) sides. A wider hand span correlates positively with grip strength ($p \leq 0.05$ $r = 0.68$ Right; $p \leq 0.05$ $r = 0.71$ Left).

Table 4 Correlation Analysis using Spearman's correlation coefficient (r)

Variable Pair	Right Side (r)	Left Side (r)	Significance
Carrying angle vs Grip strength	-0.52	-0.58	$p \leq 0.05$
Forearm length vs Grip strength	+0.65	+0.62	$p \leq 0.05$
Hand span vs Grip strength	+0.68	+0.71	$p \leq 0.05$

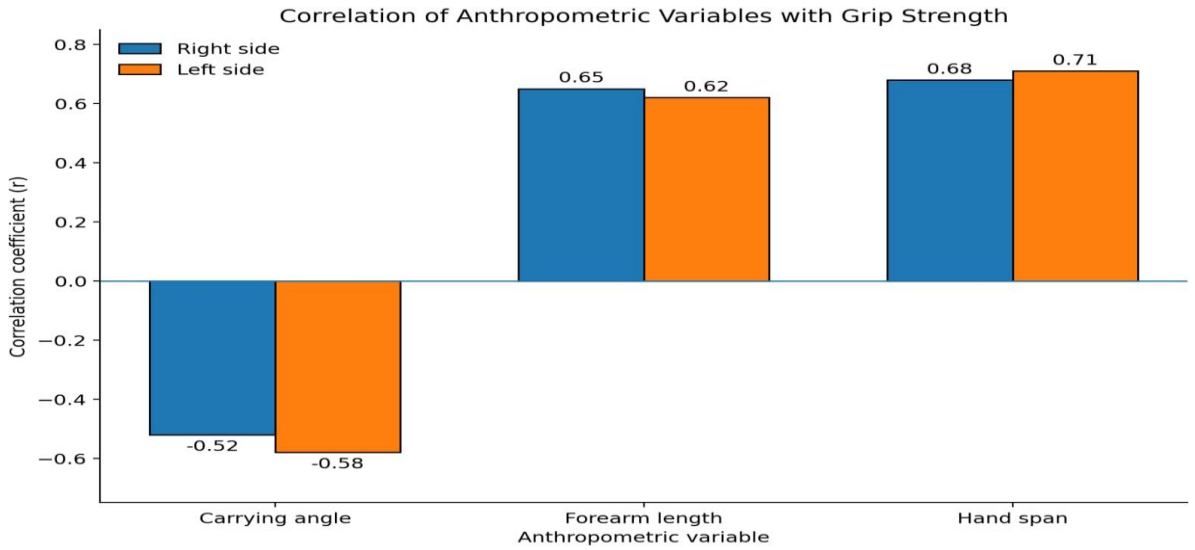

Fig. 5 Clustered Column Chart of Variables using Spearman's correlation

DISCUSSION

A highly significant gender difference was observed in the carrying angle for both the right and left sides ($p \leq 0.05$), with females consistently showing greater values than males. This finding aligns with the research of **(Nayak et al., 2023)**[8], who noted that the female carrying angle is greater than the male carrying angle, likely due to secondary sexual characteristics and ligamentous laxity. Furthermore, the collected data aligns with the work of **(Ruparelia et al., 2010)**[9], who suggested that shorter forearm lengths—more common in females—lead to greater carrying angles because the medial part of the trochlear notch is positioned differently relative to the humerus. In contrast, the work of **(Khan et al., 2023)**[10] adds context by noting that while the carrying angle increases with age until skeletal maturity, the difference between genders becomes most pronounced during and after puberty, a trend that is visible in young adults.Therefore the study demonstrated that females had significantly greater carrying angles than males, consistent with previous anatomical studies. This may be explained by sexual dimorphism in pelvic width, shoulder breadth, and ligamentous laxity.

The mean value for male right grip strength was 42.64 ± 6.82 kg with a mean carrying angle of 12.35 ± 1.84 degrees, while the female right grip strength was 23.51 ± 5.14 kg with a mean carrying angle of 15.12 ± 2.45 degrees, yielding a significant correlation of $p \leq 0.05$. These findings are in strong alignment with the work of **(Patel & Verma, 2018)** [11], who reported that as the carrying angle increases, grip strength decreases due to the stretching effect on the flexor origin at the medial epicondyle. Similarly, this results align with the findings of **(Lavanya et al., 2023)**[12], who established that carrying angle and subcutaneous body fat are inversely proportional to hand grip strength.

A contrasting viewpoint is provided by the research of **(Shetty et al., 2025)**[13], who found that the negative correlation between carrying angle and grip strength was present only in underweight and overweight females, whereas no significant correlation was found in females within the normal weight category. A moderate negative correlation was observed between carrying angle and grip strength, suggesting that increasing carrying angle may reduce biomechanical efficiency of forearm flexors. Greater valgus alignment may alter tendon pull and reduce optimal sarcomere length for force production.

In this study, males demonstrated significantly longer forearms and wider hand spans than females on both the right and left sides ($p \leq 0.05$). These findings align with the research of **(Okunribido, 2000)**[14]and **(Öktem, 2017)**[15], who found that males have consistently larger hand and forearm dimensions, which contributes to their superior performance in grip-related tasks. This study also aligns with the work of **(Parashar et al., 2020)**[16], who observed that hand breadth and length are highly dimorphic and can be used effectively for stature determination in young adults.

In contrast, the findings of **(Stahl, E. J., & Karpman, R., 1986) (**[17] provide a different perspective, suggesting that while these dimensions are different between sexes, the rate of growth for the arm and forearm is remarkably similar in both boys and girls until skeletal maturity, implying that the final dimorphic differences are primarily the result of the extended growth period in males. Forearm length and hand span were strongly positively correlated with grip strength. Longer forearms may provide improved leverage for flexor muscles, while larger hand span may enhance contact surface and torque generation during gripping.

These findings have clinical relevance in rehabilitation, sports medicine, prosthetic design, and occupational ergonomics.

CONCLUSION

The study concludes that, Females have greater carrying angles than males whereas Males exhibit higher hand grip strength than females.Carrying angle is negatively correlated with grip strength while Forearm length and hand span are positively correlated with grip strength.Assessment of these variables may help in predicting upper limb performance and designing rehabilitation strategies.

Limitations

- Limited sample size
- Single-center study
- Predominantly younger age group

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