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Association between Handgrip Strength and Forearm Circumference in Healthy Young Adults: A Cross-Sectional Study

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ABSTRACT

Background: Handgrip strength is frequently used to assess the functional performance of the hand and forearm muscles, nutritional status, and general physical health. It is a recognized prognostic marker in neuromuscular disease, nutritional depletion, and cardiovascular disorders, and it predicts rehabilitation outcomes and dependence in activities of daily living.

Objective: To determine the association between forearm circumference and handgrip strength in healthy young adults.

Methods: This cross-sectional, observational study was carried out in the Department of Allied Health Sciences, Sargodha Medical College, Sargodha, Pakistan, from September 2024 to January 2025. We recruited fifty healthy young adults aged 18-30 years using convenience sampling. Individuals with any physical disability, anatomical bony deformity of the upper limb, a neuromuscular condition, a history of surgery or fracture, psychological illness, or systemic illness like rheumatoid arthritis were excluded. Handgrip strength was measured in both hands with a digital hand dynamometer. Forearm circumference was recorded using a measuring tape at the midpoint between the elbow and wrist, with the forearm supinated and the measurement site free of clothing. Written consent was obtained from all participants before collecting measurements. Frequencies, percentages, means, and standard deviations were used to describe participants' characteristics. Pearson correlation coefficient was calculated to examine the relationship between forearm circumference and handgrip strength, overall and stratified by sex. Independent-samples t-tests compared handgrip strength and forearm circumference between sexes and between hands.

Results: Mean forearm circumference was 23.5±4 cm, and mean handgrip strength was 28.9±10.2 kg. A strong positive relationship was found between forearm circumference and handgrip strength ($r=0.87$, $p<0.001$). Males showed significantly greater forearm circumference and handgrip strength than females ($p<0.001$), and the correlation was stronger in males ($r=0.92$, $p<0.001$) than in females ($r=0.43$, $p=0.02$). The dominant hand showed significantly greater grip force than the non-dominant hand in both sexes.

Conclusion: This study demonstrated a strong positive association between forearm circumference and handgrip strength among healthy young adults, with the relationship being particularly strong in males. Participants with greater forearm circumference generally exhibited greater handgrip strength, supporting the potential role of forearm circumference as a simple and accessible anthropometric correlate of upper-limb muscular strength.

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INTRODUCTION

Handgrip strength (HGS) is the maximal force generated by the forearm and hand musculature during a sustained grasp and is commonly used to evaluate overall upper-extremity strength and general physical fitness.[1] Beyond describing hand function, HGS is a recognized prognostic marker in neuromuscular disease, nutritional depletion, and cardiovascular disorders, and it predicts rehabilitation outcomes and dependence in activities of daily living.[2-5] HGS declines with advancing age, while it tends to rise with greater stature and lean body mass, and, irrespective of age or sex, the dominant hand consistently produces greater force than the non-dominant hand.[6-8]

Males also exhibit consistently higher HGS than females.[9] Forearm circumference reflects the combined bulk of underlying musculature and subcutaneous fat and has therefore been used as a simple anthropometric marker of nutritional status[10] and as a candidate predictor of maximal grip strength, particularly in men. Values are conventionally obtained at the point of maximum girth, midway between the elbow and wrist, using a non-stretch tape.[11]

Grip strength itself is most commonly assessed with hydraulic dynamometry, regarded as the reference standard,[12] although digital dynamometers have gained acceptance owing to their accuracy, low cost, and ease of use.[13] Several factors such as age, sex, occupation, hand anthropometrics, and hand dominance have consistently emerged as correlates of HGS across the literature.[14]

Most normative and correlational data linking forearm circumference to HGS derive from older-adult cohorts,[15] even though skeletal muscle mass peaks between 18 and 25 years of age.[16] Comparatively little work has examined this relationship specifically in young adults, and the influence of forearm muscle circumference on grip strength in this age group remains inadequately characterized.

Establishing this association would show whether forearm circumference, an inexpensive and easily obtained measure, is a useful anthropometric correlate of upper-limb muscle strength where dynamometry is unavailable. This study aimed to determine the association between forearm circumference and handgrip strength in healthy young adults. The study also examined whether this relationship differed between males and females and compared handgrip strength between the dominant and non-dominant hands. We hypothesized that greater forearm circumference would be associated with greater handgrip strength and that this association would differ by sex. Although forearm circumference has been proposed as an anthropometric correlate of handgrip strength, evidence in young adults remains limited. Therefore, the purpose of the study was to determine whether forearm circumference is related to handgrip strength in healthy young adults.

METHODS

This cross-sectional, observational study was carried out in the Department of Allied Health Sciences, Sargodha Medical College, Sargodha, Pakistan, from September 2024 to January 2025. We recruited fifty healthy young adults (22 males, 28 females) aged 18-30 years using convenience sampling. Individuals with any physical disability, anatomical bony deformity of the upper limb, a neuromuscular condition, a history of surgery or fracture, psychological illness, or systemic illness (e.g., rheumatoid arthritis) were excluded. Written consent was obtained from all participants before collecting measurements.

Handgrip strength was measured in both hands with a digital hand dynamometer (Model EH101). Each participant sat upright with the shoulder adducted and neutrally rotated, the elbow bent to 90°, the forearm in a neutral position, and the wrist neutral, following the American Society of Hand Therapists recommendations.[12,17] The handle was set to position 2 to suit the participant's hand size. Participants were asked to squeeze the handle as hard as they could for 3-5 seconds, with the same standard verbal encouragement given each time. Each hand was tested three times, starting with the dominant hand. The mean of the trials for each hand was used for analysis.[18] Forearm circumference was recorded using a measuring tape at the midpoint between the elbow and wrist, with the forearm supinated and the measurement site free of clothing.[20] The handle was set to position 2 to suit the participant's hand size. Participants were asked to squeeze the handle as hard as they could for 3-5 seconds, with the same standard verbal encouragement given each time.[20]

Data were analyzed using the Statistical Package for Social Sciences (SPSS), version 26 (IBM Corp., Armonk, NY). Frequencies, percentages, means, and standard deviations were used to describe participants' characteristics. Normality of continuous variables was assessed using the Shapiro–Wilk test. Pearson's correlation coefficients (95% CIs) were calculated overall and by sex; the sex difference in correlations was tested with Fisher's z-test; and multiple regression was used to adjust for sex. Independent-samples t-tests (Welch's where variances were unequal) compared

Table 1: Descriptive statistics of forearm muscle circumference and handgrip strength

Variables	Side	Mean±SD
Forearm circumference (cm)	Right	23.8±4.14
	Left	23.25±3.91
	Mean	23.51±3.99
Hand-grip strength (kg)	Right	30.98±10.1
	Left	26.91±10.63
	Mean	28.91±

males and females were compared, and paired t-tests compared dominant and non-dominant grip, with mean differences, 95% CIs, and Cohen's d. Significance was set at $p<0.05$. The required sample size was estimated a priori using G*Power, assuming an expected correlation coefficient of 0.50, $\alpha = 0.05$, and 80% statistical power.

RESULTS

Fifty participants (22 males, 28 females) with a mean age of 22±3 years (range 18-30) were included. Most participants belonged to the middle socioeconomic class, 39(78%), and resided in urban areas, 34(68%). The mean forearm muscle circumference was 23.5±4 cm, and the mean HGS was 28.9±10.2 kg (Table 1). Males demonstrated significantly greater mean forearm circumference (26.8±3.5 cm vs. 21.0±2 cm) and HGS (39.2±4.8 kg vs. 20.8±3.8 kg) than females, $p<0.001$ for both (Table 2).

The dominant hand showed significantly greater grip strength than the non-dominant hand in both sexes (Table 2). This table shows that males had significantly greater forearm circumference and handgrip strength than females. All differences in forearm circumference and dominant and non-dominant handgrip strength were statistically significant ($p<0.001$). A strong positive correlation was found between forearm circumference and HGS overall ($r=0.87$, $p<0.001$) (Figure 1). When stratified by sex, the correlation was strong in males ($r=0.92$, $p<0.001$) and moderate in females ($r=0.43$, $p=0.02$).

DISCUSSION

This cross-sectional study examined the association between forearm muscle circumference and handgrip strength in fifty healthy young adults. A strong, statistically significant positive correlation was observed between forearm circumference and HGS ($r=0.87$), consistent with the premise that greater forearm muscle bulk underlies greater grip force generation in this age group.

Mean forearm circumference in this sample (26.8±3.5 cm in males, 21.0±2 cm in females) was slightly higher than values reported in an Iranian cohort of school-aged participants (23.2±1.4 cm in males, 21±1.6 cm in females),[8] a difference plausibly attributable to variation in age range, body composition, or occupational activity across populations. Mean HGS values in the present sample (39.2±4.8 kg in males, 20.8±3.8 kg in females) were lower than those reported among competitive martial-arts athletes,[18] but broadly comparable to community-based estimates reported elsewhere reflecting expected differences between trained and untrained populations.[11]

Consistent with prior reports, the dominant hand produced significantly greater grip strength than the non-dominant hand in both sexes, and comparable between-group differences in laterality have been documented in independent samples.[19,20] Sex-based differences in both forearm circumference and HGS were significant, with males outperforming females on both measures, a pattern that aligns with previously published normative comparisons.

The correlation between forearm circumference and HGS reported here mirrors findings from a United States-based cohort in which forearm size and grip strength were positively and significantly related, as well as work in South Asian young adults linking forearm circumference and hand length to grip strength.[21] Comparable positive associations between hand-forearm anthropometrics and maximal grip strength have also been reported in Saudi[21] and mixed-sex Western samples, together reinforcing forearm circumference as a simple, accessible anthropometric

Figure 1: Relationship between forearm circumference and handgrip strength in young adults

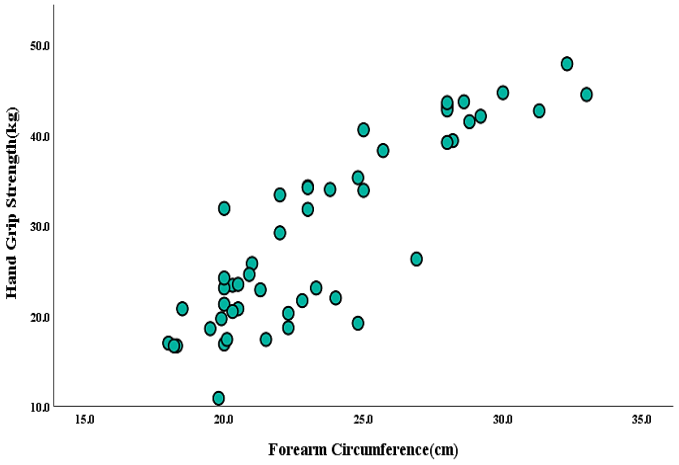


Table 2: Comparison of variables between males and females using an independent-samples t-test

Variables		Male Mean ± SD	Female Mean ± SD	t (df=48)	p-value
Forearm circumference (cm)	Mean	26.76 ± 3.47	20.96 ± 2.05	7.36	<0.001
Hand grip strength (kg)	Mean	39.23 ± 4.84	20.81 ± 3.76	15.15	<0.001
	Dominant	41.90 ± 6.17	23.29 ± 3.89	13.03	<0.001
	Non-dominant	36.63 ± 3.78	18.39 ± 3.99	16.41	<0.001
r-value		0.92	0.43		

marker of upper-limb muscular strength in this age group and warrant confirmation in larger, multi-center studies across more diverse populations.

CONCLUSION

This study demonstrated a strong positive association between forearm circumference and handgrip strength among healthy young adults, with the relationship being particularly strong in males. Participants with greater forearm circumference generally exhibited greater handgrip strength, supporting the potential role of forearm circumference as a simple and accessible anthropometric correlate of upper-limb muscular strength. The study also confirmed significantly greater handgrip strength in males and in the dominant hand.

Given that forearm circumference can be measured easily and at low cost, it may have practical value in settings where dynamometry is not readily available. However, because this was a cross-sectional study involving only 50 participants recruited through convenience sampling, the findings should be interpreted cautiously and cannot establish causality or be generalized broadly. Larger, multicenter studies involving more diverse populations are warranted to further validate these findings.

DECLARATIONS

Consent to participate: Written informed consent was obtained from all participants before enrollment.
Ethical Approval: Ethical approval for this study was obtained from the Institutional Ethics Review Committee, Sargodha Medical College, and University of Sargodha.
Availability of Data and Materials: Data will be made available upon request. The corresponding author will submit all dataset files.
Competing interests: None
Funding: No funding source involved.
Authors' contributions: All authors have read and approved the final manuscript.
AA: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, and Writing – original draft.
MF: Investigation, data curation, and writing.
SA: Investigation, review & editing.
NA: Data collection and Writing.
FA: Proofreading & editing.
AT: Statistical analysis and Validation.

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