



Grip and Pinch Strength in Relation to Anthropometric Indices: Insights from a Cross-Sectional Investigation

(Grip and Pinch Strength in Relation to Anthropometric Indices)

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ABSTRACT:

Background: Handgrip strength (HGS) serves as a simple yet powerful biomarker of overall muscle strength, nutritional status, and functional capacity. Its association with hand anthropometry has important implications for ergonomics, rehabilitation, and clinical assessments.

Objective: To evaluate the correlation between handgrip strength and selected anthropometric indices among healthy male and female healthcare professionals.

Methods: A cross-sectional study was conducted on 335 participants (167 females and 168 males). Standardized measurements of hand dimensions- hand breadth across the thumb, maximum depth of the hand, elbow-wrist length, wrist breadth, hand length, hand breadth, hand span, and wrist circumference - were recorded. Handgrip strength was measured using a digital dynamometer. Pearson's correlation analysis was performed.

Results: In females, only hand span demonstrated a significant positive correlation with handgrip strength ($r = 0.290$, $p < 0.001$). In males, strong positive correlations were observed between HGS and elbow-wrist length ($r = 0.740$, $p < 0.001$), wrist circumference ($r = 0.717$, $p < 0.001$), hand breadth ($r = 0.713$, $p < 0.001$), hand length ($r = 0.644$, $p < 0.001$), and hand breadth across the thumb ($r = 0.588$, $p < 0.001$). Hand span also correlated positively with grip strength in males ($r = 0.347$, $p < 0.001$).

Conclusion: Male participants showed robust associations between grip strength and multiple anthropometric indices, whereas in females, hand span was the only significant predictor. These findings highlight sex-based differences in the determinants of handgrip strength, underscoring the importance of individualized ergonomic and clinical applications.

Introduction

Handgrip strength (HGS) is widely recognized as a reliable indicator of overall muscular strength, nutritional health, and functional performance.¹ It has

been strongly associated with morbidity, disability, and even mortality in both clinical and general populations. Beyond clinical implications, HGS is increasingly applied in ergonomics, sports science, and rehabilitation



research to assess manual dexterity and predict task performance.²

Anthropometric indices of the hand and upper limb are important determinants of grip function. Hand dimensions such as length, breadth, span, and wrist circumference influence the mechanical advantage and force transmission during gripping activities.³ Previous studies have demonstrated varying degrees of association between anthropometric variables and grip strength across different populations. However, results remain inconsistent, particularly with respect to sex differences.^{4,5}

Handgrip strength (HGS) is defined as the maximum amount of static forceful voluntary flexion of all fingers.⁶ Handgrip strength (HGS) is a measure of the strength of the carpal flexor muscles. Every additional hour of light physical activity was associated to a 6-kg increase in HGS among men, but not women.⁷ High sedentary time was identified as a cause of sarcopenia due to physical inactivity.⁷ Studies suggest that physical well-being and muscle strength, as indicated by HGS, can enhance the quality of life in older adults.^{8,9} Recently, it has also been used as a tool to evaluate and monitor physical characteristics in subjects with certain pathologies.¹⁰ HGS has been shown to be associated with various anthropometric measures, bio impedance parameters such as fat mass and skeletal mass, as well as physical activity levels, among other factors.¹¹ In grip sports, like rock climbing, basketball and handball, a notable positive correlation has been observed between handgrip strength and a majority of hand anthropometric dimensions.^{12,13} These findings hold significant potential for the identification of athletic talent in sports that heavily rely on grip strength.¹⁴ Furthermore, human grip strength plays a pivotal role in the operation of equipment within manufacturing and processing industries, underscoring the importance of assessing and quantifying grip strength to evaluate worker performance.¹⁵ Several studies have been conducted to investigate the relationship between anthropometric measurements and HGS.^{16,17,18,19} These studies have explored correlations between hand dimensions and maximum grip strength, as well as the influence of variables like grip span and hand dimensions on an individual's maximum grip strength.²⁰ Predictive models for grip strength have also been developed,

encompassing estimates for grip strength, maximum pinch strength, grip strength endurance, and various models for grip strength prediction.^{21,22,23,24,25} Notably, a deficiency in data pertaining to hand anthropometrics and grip strength within the Iranian population has led to the design of hand tools in Iran being primarily based on anthropometric data from exporting countries.²⁶

This study aimed to systematically investigate the relationship between grip strength and hand anthropometry among healthy adult males and females, thereby providing insights into ergonomic design, clinical assessment, and strength prediction models.

Methods

Study Design and Participants

A cross-sectional study was conducted on 335 healthy adults (167 females, 168 males) aged 18-30 years. Participants with hand injuries, musculoskeletal disorders, or chronic illnesses affecting strength were excluded. Written informed consent was obtained from all participants, and the study adhered to institutional ethical guidelines.

Anthropometric Measurements

The following hand dimensions were recorded using standard anthropometric instruments:

1. **Hand breadth across the thumb**
2. **Maximum depth of the hand**
3. **Elbow-wrist length**
4. **Wrist breadth**
5. **Hand length**
6. **Hand breadth**
7. **Hand span (tip of thumb to tip of little finger with fingers maximally abducted)**
8. **Wrist circumference**
9. **Handgrip Strength Measurement**

HGS was measured with a calibrated digital hand dynamometer. Participants were seated with the shoulder adducted, elbow flexed at 90°, forearm in neutral, and wrist in slight extension. Three trials were performed with the dominant hand, and the best value was recorded.

Statistical Analysis



Data were analyzed using SPSS version 28. Pearson's correlation coefficients (r) were computed to assess relationships between grip strength and anthropometric

parameters. A p-value <0.05 was considered statistically significant.

Results

Table 1. Correlation of Handgrip Strength with Anthropometric Parameters (n = 167)

Parameters	N	r-value	p-value
Hand breadth across the thumb	167	0.112	0.162
Max depth of the hand	167	0.039	0.611
Elbow–wrist length	167	0.119	0.137
Wrist breadth	167	0.098	0.201
Hand length	167	0.145	0.062
Hand breadth	167	0.071	0.382
Hand span	167	0.305	0.000
Wrist circumference	167	0.061	0.455

Note: Significant correlation at $p < 0.01$.

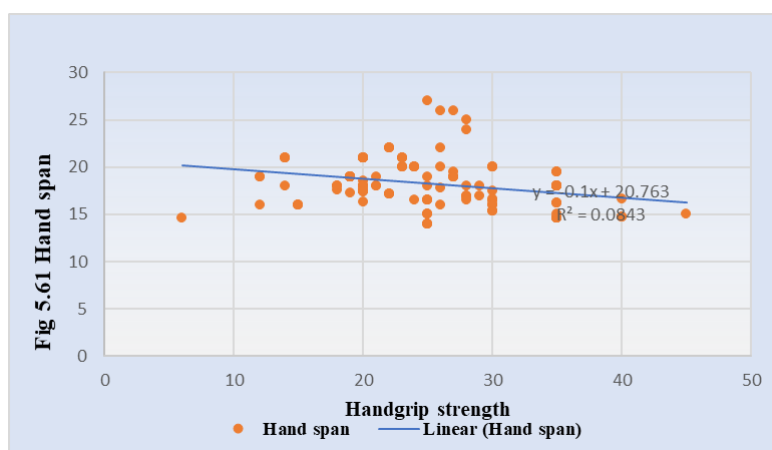
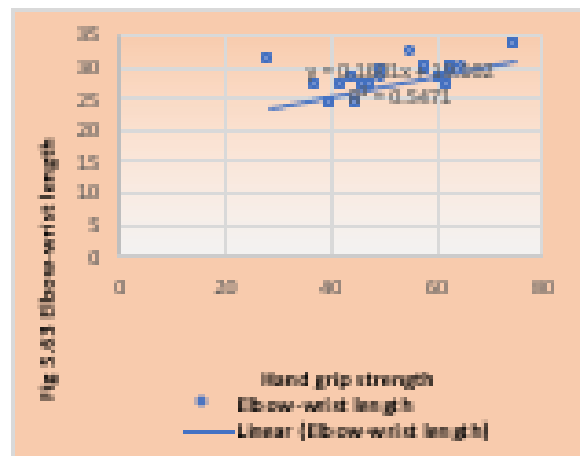
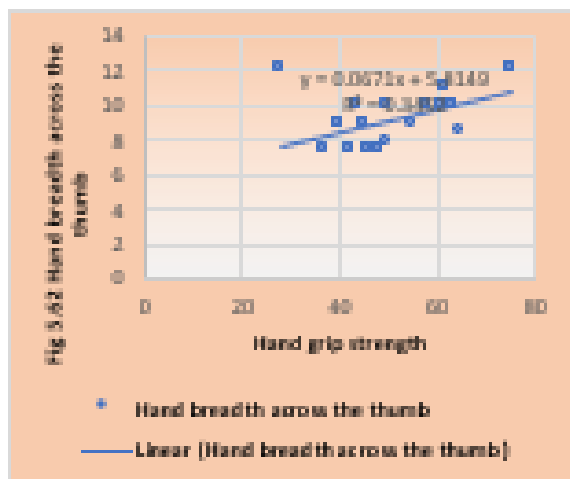
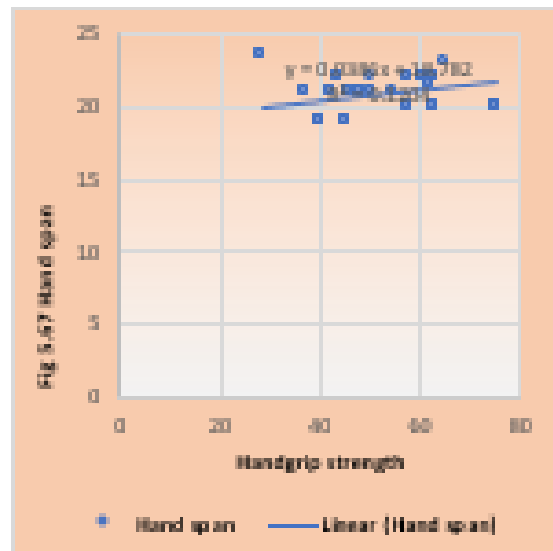
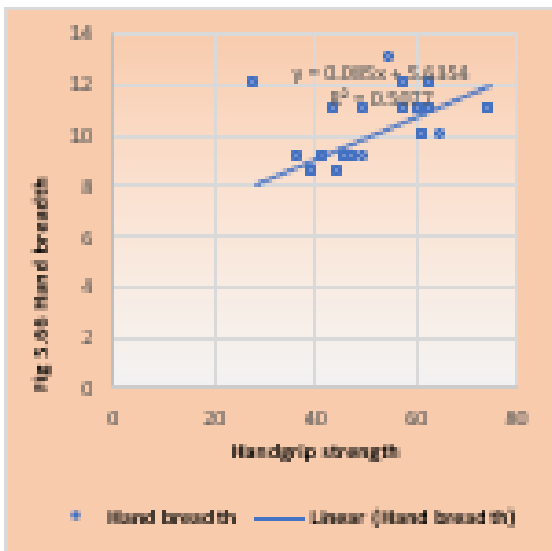
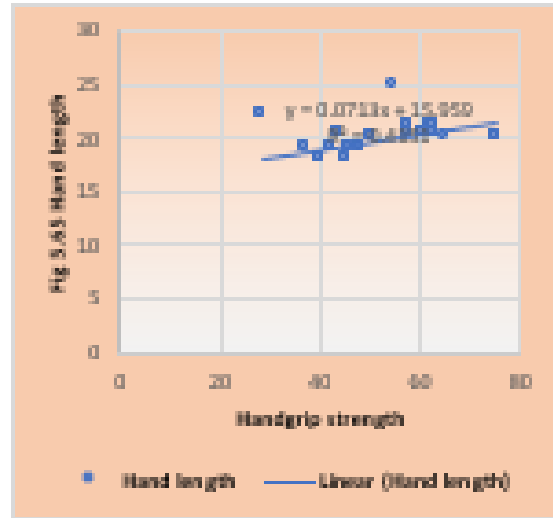
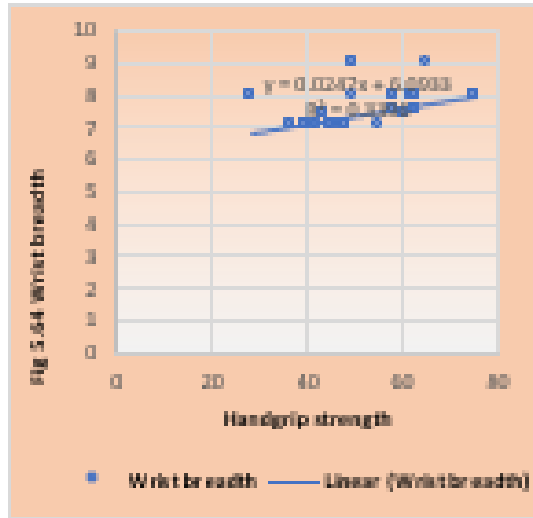
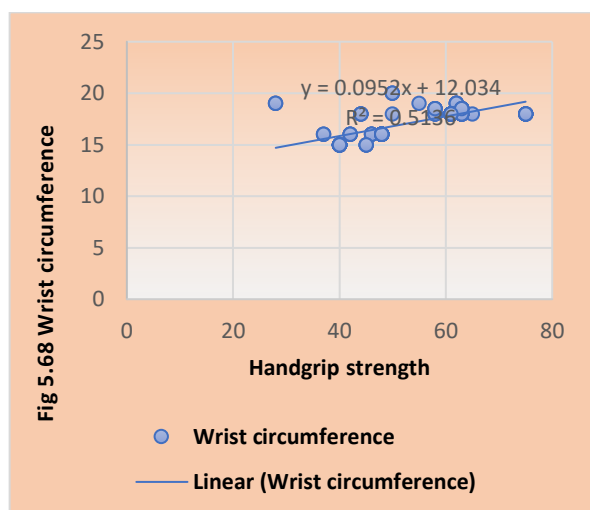


Table 2. Correlation of Handgrip Strength with Anthropometric Parameters (n = 168)

Parameters	N	r-value	p-value
Hand breadth across the thumb	168	0.572	0.000
Max depth of the hand	168	0.058	0.498
Elbow–wrist length	168	0.728	0.000
Wrist breadth	168	0.569	0.000
Hand length	168	0.631	0.000
Hand breadth	168	0.701	0.000
Hand span	168	0.331	0.000
Wrist circumference	168	0.702	0.000

Note: Significant correlation at $p < 0.01$.





Correlation of HGS with Anthropometry in Females (n = 167)

In females, a significant positive correlation was observed only between handgrip strength and **hand span** ($r = 0.305$, $p < 0.001$). All other anthropometric parameters, including hand length, wrist breadth, and wrist circumference, showed weak and statistically non-significant associations with handgrip strength.

Correlation of HGS with Anthropometry in Males (n = 168)

In males, handgrip strength demonstrated strong positive correlations with **elbow–wrist length** ($r = 0.728$, $p < 0.001$), **hand breadth** ($r = 0.701$, $p < 0.001$), and **wrist circumference** ($r = 0.702$, $p < 0.001$). Moderate correlations were also found with **hand length** ($r = 0.631$, $p < 0.001$), **hand breadth across the thumb** ($r = 0.572$, $p < 0.001$), **wrist breadth** ($r = 0.569$, $p < 0.001$), and **hand span** ($r = 0.331$, $p < 0.001$). In contrast, **maximum hand depth** showed no significant correlation with grip strength ($r = 0.058$, $p = 0.498$).

Discussion

This study highlights marked sex differences in the anthropometric predictors of handgrip strength.

In **males**, grip strength exhibited strong correlations with multiple hand dimensions, particularly elbow–wrist length, wrist circumference, and hand breadth. These findings are consistent with biomechanical principles, as larger lever arms and greater wrist girth provide mechanical and muscular advantages for force generation.

In **females**, however, hand span emerged as the only significant predictor. This suggests that structural hand dimensions may play a less dominant role compared to neuromuscular or hormonal influences in determining female grip strength. Similar patterns have been reported in previous studies, where female grip strength correlated weakly with anthropometry.

The results have practical implications. Ergonomic tools, occupational designs, and rehabilitation programs may need to incorporate sex-specific anthropometric predictors. For example, hand span could be emphasized in grip-related assessments for women, whereas multiple hand dimensions may be predictive in men.

According to our study, Table 1: Correlated handgrip strength with hand breadth across the thumb, max depth of the hand, elbow–wrist length, wrist breadth, hand length, hand breadth, hand span, wrist circumference in females. The hand span strongly correlated with handgrip strength, except for other anthropometric parameters. Table 2: Showed the correlation between handgrip strength and hand breadth across the thumb, max depth of the hand, elbow–wrist length, wrist breadth, hand length, hand breadth, hand span, wrist circumference in males. This table shows that most of the parameters showed a strong significant correlation, except for the maximum depth of the hand, which is insignificant.

Rostamzadeh S et al.,²⁷ Pearson's correlation test was applied to check the association between anthropometric parameters and hand grip strength in this study. All the parameters showed strong correlations with hand grip strength.

Ruiz-Ruiz et al.,²⁸ In this research, which investigated the differences in anthropometric measures across genders and ethnic groups, they found that hand length positively correlates with pinch and grip strength.²⁹

A study conducted by **Li et al.**,²⁹ found a positive relationship between hand grip strength and wrist circumference.^{30,31,32,33} The relationship between various anthropometric parameters and maximum grip strength is examined using different dynamometers. The Pearson correlation coefficient test was applied to check the relationship between hand grip strength and wrist circumference. A significant correlation between handspan and handgrip strength was found. This research



indicated that handspan and handgrip strength were positively correlated.

Wen J et al.,³⁴ focused on young adult males in their research, most of whom were South Asian. They discovered no correlation between hand grip strength and the entire hand length.

Noonari SB et. Al.,³⁵ The study revealed a favourable correlation between dominant and non-dominant handgrip strength and height, weight, hand span, and wrist circumference. Furthermore, hand length correlates with handgrip strength, although body mass index and handspan have no significant correlation with handgrip strength in healthy Indian girls.^{36,37}

Strengths and Limitations

- Strengths: robust sample size, standardized methodology, and clear sex stratification.
- Limitations: single age group (young adults), cross-sectional design, and exclusion of factors such as body composition, physical activity, and hormonal profiles.

Conclusion

The present study demonstrates that handgrip strength shows strong correlations with multiple anthropometric indices in males, whereas in females, hand span emerges as the sole significant determinant. These findings highlight clear sex-based variations in the determinants of grip strength, underscoring the importance of considering gender-specific factors in both clinical assessment and ergonomic design. Recognizing these variations can aid in developing tailored strategies for occupational health, rehabilitation, and sports science applications. Moreover, the results point to the necessity of incorporating individualized approaches when evaluating musculoskeletal performance and designing interventions. Future research should expand these findings by including diverse age groups, larger population samples, and longitudinal study designs to better understand causal relationships and age-related changes in grip strength determinants. Such efforts will strengthen the evidence base and provide broader applicability across clinical, occupational, and athletic contexts.

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