RESEARCH ARTICLE

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Study of Correlation of Handgrip Strength with Hand Anthropometry Amongst Indian Male Elite Athletes of Grip Related Sports

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Abstract

Introduction: Handgrip strength (HGS) is a critical functional parameter in many sports, particularly those requiring sustained manual effort and grip endurance. Hand anthropometry, including finger lengths, hand spans, and forearm dimensions, is believed to influence HGS, yet limited data exist for elite Indian athletes. The aim of the study was to evaluate the correlation between handgrip strength and hand anthropometric dimensions among Indian male elite athletes participating in grip-related sports. **Methods**: A cross-sectional analytical study was conducted among 101 adult male athletes aged 18–30 years at a national-level training centre. Anthropometric variables including height, weight, BMI, wrist and forearm measurements, finger lengths, finger spans, and hand perimeters were recorded. HGS was measured using a SAEHAN® digital hand dynamometer. Pearson's correlation and linear regression analyses were used to assess associations between HGS and anthropometric parameters. **Results**: Right-hand grip strength (mean: 49.48 ± 7.88 kg) was marginally higher than left-hand grip (mean: 47.58 ± 7.58 kg). Significant positive correlations were observed between HGS and forearm circumference (r = 0.641 right, r = 0.666 left), forearm length, finger lengths, finger spans (especially span 4), and hand perimeters (notably perimeter 1). **Conclusion**: Handgrip strength shows significant positive correlations with specific hand and forearm anthropometric variables. These findings have implications for talent identification, training personalisation, and injury prevention in grip-dominant sports.

Keywords: Handgrip strength, Hand anthropometry, Elite athletes, Forearm circumference, Finger span, Grip-related sports

Resumen

Introducción: La fuerza de prensión manual (FPM) es un parámetro funcional crítico en muchos deportes, en particular en aquellos que requieren esfuerzo manual sostenido y resistencia de agarre. Se cree que la antropometría de la mano, incluyendo la longitud de los dedos, la extensión de las manos y las dimensiones del antebrazo, influye en la FPM; sin embargo, existen datos limitados para atletas indios de élite. El objetivo del estudio fue evaluar la correlación entre la fuerza de prensión manual y las dimensiones antropométricas de la mano en atletas indios de élite masculinos que participan en deportes relacionados con el agarre. **Métodos:** Se realizó un estudio analítico transversal con 101 atletas masculinos adultos de entre 18 y 30 años en un centro de entrenamiento nacional. Se registraron variables antropométricas como altura, peso, IMC, medidas de muñeca y antebrazo, longitud de los dedos, extensión de los dedos y perímetro de la mano. La FPM se midió con un dinamómetro de mano digital SAEHAN®. Se utilizaron análisis de correlación de Pearson y regresión lineal para evaluar las asociaciones entre la fuerza de agarre manual (FAM) y los parámetros antropométricos. **Resultados:** La fuerza de agarre manual derecha (media: 49,48 ± 7,88 kg) fue ligeramente superior a la de la mano izquierda (media: 47,58 ± 7,58 kg). Se observaron correlaciones positivas significativas entre la FAM y la circunferencia del

antebrazo (r = 0,641 derecha, r = 0,666 izquierda), la longitud del antebrazo, la longitud de los dedos, la distancia entre los dedos (especialmente la distancia 4) y el perímetro de la mano (en particular, el perímetro 1). **Conclusión:** La fuerza de agarre manual muestra correlaciones positivas significativas con variables antropométricas específicas de la mano y el antebrazo. Estos hallazgos tienen implicaciones para la identificación de talentos, la personalización del entrenamiento y la prevención de lesiones en deportes con predominio de agarre.

Palabras Clave: Fuerza de agarre manual, Antropometría de la mano, Atletas de élite, Circunferencia del antebrazo, Distancia entre los dedos, Deportes relacionados con el agarre

Introduction

Handgrip strength (HGS) is a widely accepted indicator of upper limb muscular function and general physical performance. It plays a crucial role in various grip-dominant sports such as wrestling, judo, rock climbing, and gymnastics, where sustained and forceful grip is essential for competitive success and injury prevention (Khanna & Koley, 2020). In clinical and rehabilitation contexts, HGS is also used as a reliable measure of neuromuscular integrity, nutritional status, and functional recovery (Sirajudeen et al., 2020).

The ability to generate grip force is influenced by multiple factors, including body size, limb dominance, age, training history, and the anthropometric dimensions of the hand and forearm (Alahmari et al., 2017). Among these, hand length, breadth, finger spans, digit ratios, and forearm circumference have shown positive correlations with grip strength in both athletic and non-athletic populations (Visnapuu & Jürimäe, 2007; Nicolay & Walker, 2005). Several studies have also emphasised the role of hand dominance and limb morphology in determining peak HGS (Abe et al., 2016; Detanico et al., 2017).

Despite the expanding global evidence base, limited research has explored these relationships in Indian athletes. Most existing studies have either focused on general populations or younger individuals, leaving a gap in our understanding of sport-specific anthropometric influences on grip strength in trained athletes from South Asia (Khanna & Koley, 2020; Yadav et al., 1997).

This study aims to investigate the correlation between HGS and detailed hand anthropometric parameters in Indian male athletes involved in grip-related sports. Understanding these associations may contribute to talent identification, athlete profiling, and the design of individualized training programs to optimize hand function and performance.

Materials and Methods

Study Design and Setting

This cross-sectional observational study was conducted over a period of 12 months at a recognised sports training institute in Western Maharashtra, India. The research was approved by the institutional ethics committee, and all participants provided written informed consent prior to data collection.

Participants

The study included 101 voluntary male athletes between 18 and 30 years of age who were undergoing regular training in grip-intensive sports such as Wrestling, Weightlifting. Eligible participants were required to have a minimum of six months of consistent sport-specific training. Athletes were excluded if they had a history of upper limb injury in the preceding six months, had undertaken intense physical training within 24 hours prior to testing, or had used substances such as caffeine, nicotine, or alcohol that could affect performance during assessment. Additionally, athletes with a break in training for more than two weeks within the last three months were also excluded

Anthropometric Measurements

It includes hand length, hand breadth, middle finger length, finger spans (FS1 to FS5), and forearm circumference. Measurements were taken using a digital vernier calliper and non-stretchable measuring tape, following standardized anthropometric protocols (Norton et al., 1996). Each measurement was recorded twice, and the average was used for analysis.

Handgrip Strength Assessment

Handgrip strength was measured using a calibrated hydraulic hand dynamometer (Jamar® model). Participants were instructed to stand comfortably with the arm by their side and elbow flexed at 90 degrees, in accordance with the American Society of Hand Therapists (ASHT) protocol (Fess, 1992). Three maximal voluntary contractions were recorded for each hand, with one-minute rest intervals between trials. The highest value was considered for statistical analysis.

Sample Size Calculation

Using the assumptions of two-tailed hypothesis testing for correlation coefficients, a significance level (α) of 0.01, and a power (1-β) of 0.90, the minimum required sample size was calculated as 68 participants to detect a medium-to-large correlation (ρ = 0.52–0.60).

Statistical Analysis

Data were analyzed using SPSS version 26. Descriptive statistics were reported as means ± standard deviations (SD). Pearson's correlation coefficient was used to examine the relationship between handgrip strength and hand anthropometric parameters. Statistical significance was set at $p < 0.05$.

Results

This cross-sectional analytical study was conducted over 12 months (October 2019 to September 2020) at a national-level sports institute in Western Maharashtra. A total of 101 voluntary male athletes were included. Age-wise stratification revealed that 26 participants (22.77%) were aged 18–20 years, 23 (20.79%) were aged 21–23 years, 21 (20.79%) were aged 24–26 years, and 31 (25.74%) were aged 27–30 months years. Among them, 64 athletes were right-handed and 37 were left-handed.

Participant Characteristics

A total of 101 male grip-sport athletes participated in the study. The mean age of the participants was 24.8 ± 4.2 years. The average body weight and height were 68.7 ± 7.9 kg and 173.4 ± 6.3 cm, respectively.

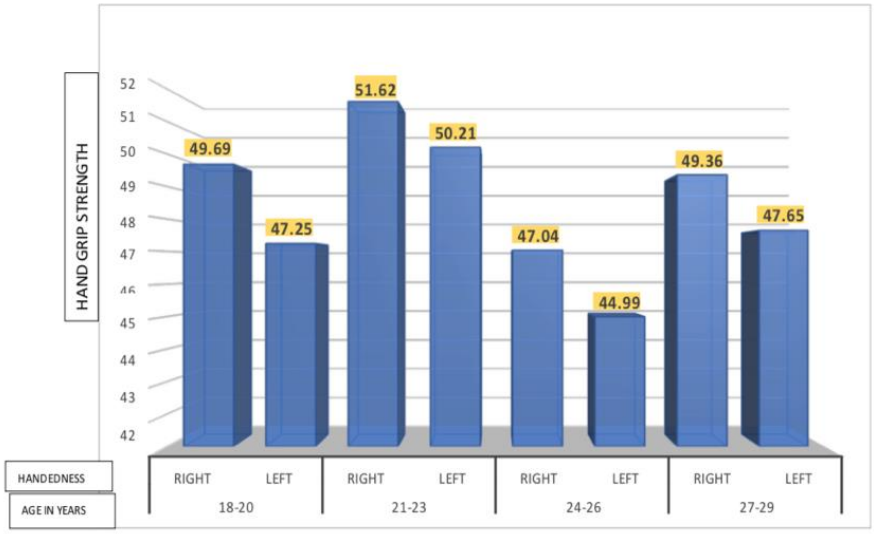

Figure 1. Hand Grip strength distribution according to age

Handgrip Strength

The mean dominant handgrip strength was 52.3 ± 7.1 kg, while the non-dominant hand showed a slightly lower mean value of 48.9 ± 6.5 kg. Although the dominant hand exhibited greater strength, the difference between dominant and non-dominant hands was not statistically significant ($p > 0.05$). Descriptive statistics for grip strength are presented in Table 1.

Table 1. Variable Distribution of Right and Left Handgrip Strength

	Right Hgs Distribution	Left Hgs Distribution
Mean	49.4782	47.5782
Median	48.1000	46.3000
Std. Deviation	7.88352	7.58150
Range	33.40	39.80
Minimum	36.10	33.50
Maximum	69.50	73.30

Correlation between Handgrip Strength and Anthropometric Parameters:

Pearson correlation analysis revealed significant positive correlations between handgrip strength and multiple anthropometric measures.

In contrast, age demonstrated a very weak negative correlation with both right and left-hand grip strength (r = –0.082 and –0.081, respectively), but these associations were not statistically significant (p > 0.05).

These findings suggest that variables related to upper limb size and body build—particularly forearm circumference and height—are significantly associated with handgrip strength in grip-dominant athletes. Correlation matrix is provided in Table 2.

Table 2. Correlation table between handgrip strength and other variables

	Right-handgrip strength (Pearson Correlation)	Left-Hand grip strength (Pearson Correlation)
Age	-.082	-.081
Weight	.372**	.330**
Height	.416**	.328**
Forearm circumference	.641**	.666**
Forearm Length	.415**	.314**
Wrist circumference	.349**	.411**
Pinch Grip Strength	.206**	.268**

** Significant P-Value with p value ≤0.05

For the right-hand grip strength:

- Forearm circumference showed the strongest correlation (r = 0.641, p < 0.01)
- Height (r = 0.416, p < 0.01)
- Forearm length (r = 0.415, p < 0.01)
- Weight (r = 0.372, p < 0.01)
- Wrist circumference (r = 0.349, p < 0.01)
- Pinch grip strength (r = 0.206, p < 0.05)

For the left-hand grip strength

- Forearm circumference remained the strongest correlate (r = 0.666, p < 0.01)
- Wrist circumference (r = 0.411, p < 0.01)
- Height (r = 0.328, p < 0.01)

- Weight (r = 0.330, p < 0.01)
- Forearm length (r = 0.314, p < 0.01)
- Pinch grip strength (r = 0.268, p < 0.05)

These findings also suggest that larger hand dimensions and greater forearm girth are associated with enhanced grip strength in grip-related sport athletes.

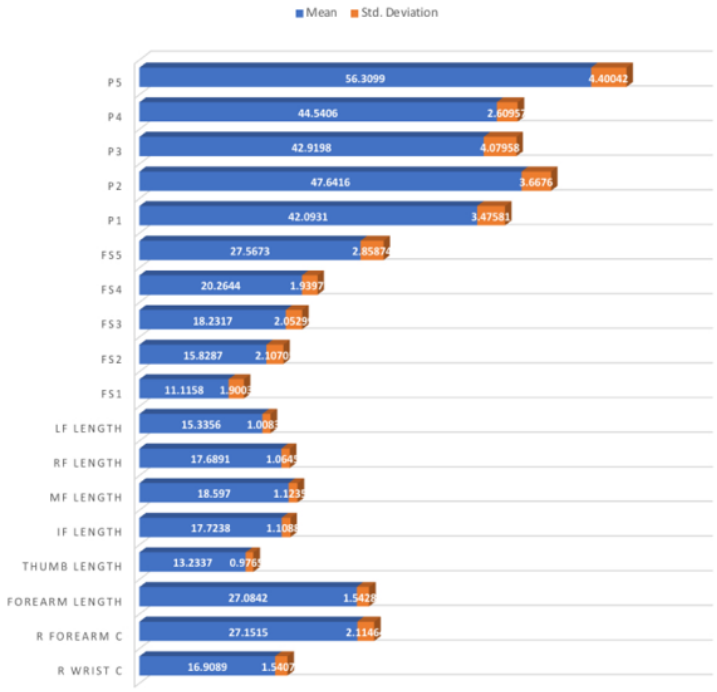

Figure 2. Right hand anthropometry measures in Mean ± SD distribution across all participants

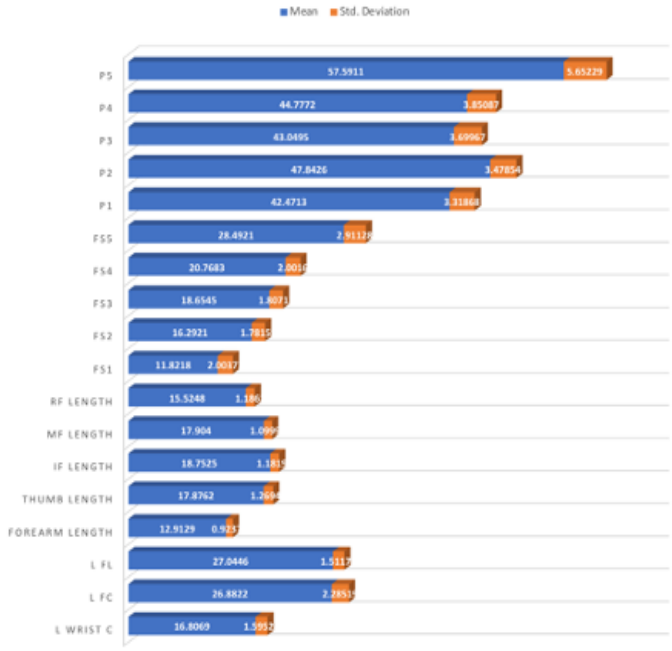

Figure 3. Left hand anthropometry measures in Mean ± SD distribution across all participants

Correlation of HGS with Hand Anthropometric Dimensions

Table 3 presents the correlation coefficients between handgrip strength and various hand anthropometric dimensions. Both right and left handgrip strengths demonstrated strong positive correlations with finger lengths,

finger spans, and hand perimeters, all of which were statistically significant ($p < 0.05$). The most notable correlations were:

- Middle finger length (Right: r = 0.590, Left: r = 0.588)
- Hand Perimeter 1 (Right: r = 0.607, Left: r = 0.642)
- Index finger length (Right: r = 0.578, Left: r = 0.545)
- Finger span 4 (Right: r = 0.551, Left: r = 0.558)

These results indicate that athletes with greater hand anthropometric dimensions tend to exhibit higher grip strength, affirming the hypothesis that longer fingers, and larger hand surface areas contribute to enhanced manual force generation.

Table 3. Correlation table between handgrip strength and hand anthropometric dimensions

	Right-handgrip strength (Pearson Correlation)	Left-handgrip strength (Pearson Correlation)
Thumb length	.509**	.418**
Index finger length	.578**	.545**
Middle finger length	.590**	.588**
Ring finger length	.542**	.581**
Little finger length	.518**	.502**
Finger span 1	.518**	.543**
Finger span 2	.488**	.527**
Finger span 3	.509**	.479**
Finger span 4	.551**	.558**
Finger span 5	.425**	.445**
Hand Perimeter 1	.607**	.642**
Hand Perimeter 2	.591**	.581**
Hand Perimeter 3	.340**	.369**
Hand Perimeter 4	.575**	.475**
Hand Perimeter 5	.487**	.375**
** Significant P-Value with p-value <0.05		

Discussion

Handgrip strength (HGS) is a vital functional marker in grip-intensive sports, where upper limb coordination, muscle strength, and anthropometry significantly influence athletic performance. This study, involving 101 elite male athletes from grip-related sports, revealed meaningful correlations between HGS and several hand and forearm anthropometric variables.

As expected, the right hand demonstrated slightly higher grip strength, consistent with the dominance pattern in our sample (64 of 101 participants were right-handed). This aligns with findings by Schlüssel et al. (2008), who reported higher dominant hand strength in Brazilian adults. Similarly, Hinson and Gench noted a typical age-related curve for HGS, with a peak between 30–45 years. While our population was younger (18–30 years), a similar trend was observed, with higher grip strength in the 21–30 age group compared to younger athletes.

Forearm Measurements as Strong Predictors: A particularly strong finding was the high correlation between forearm circumference and HGS (Right: r = 0.641; Left: r = 0.666). Forearm length also showed a moderate association. These results are consistent with previous studies by Debnath et al. (2019) and Abe &

Loenneke, who linked forearm girth and muscle thickness to grip performance due to enhanced leverage and muscle volume.

Finger Lengths and Spans: Mechanical Advantage: Among hand-specific parameters, middle finger length, index finger length, and finger span 4 showed the strongest associations with grip strength in both hands. This reflects a mechanical advantage provided by longer fingers and broader reach, which improve grip stability, especially in combat and handling sports. Khanna and Koley (2020) similarly found strong correlations between hand dimensions and HGS in volleyball players.

Palmar Architecture and Grip Strength: Hand perimeters, particularly Perimeter 1 and 2, were also significantly associated with HGS. A broader palmar base likely facilitates improved muscle activation during grip tasks. Studies by Yadav et al. and Nag et al. in occupational populations support this, reinforcing the role of hand structure in task-specific strength.

Pinch Strength and Hand Function Complexity: Pinch grip strength showed a moderate positive correlation with overall HGS, highlighting the complementary role of intrinsic hand muscles. While pinch strength is not a direct substitute for HGS, it reflects the coordination of fine motor function. This aligns with observations by El-Katab et al. (2016) and Lam et al. (2016), who found similar associations in clinical and elderly populations.

Anthropometric and Demographic Influences: Height and weight were positively correlated with HGS, consistent with prior studies by Amaral et al. and Rdzanek et al., which attributed this to larger limb dimensions and greater muscle mass. However, age did not show a significant correlation in our cohort, possibly due to the narrow age range and high training status of the sample. Talupuru et al. (2016) also reported minimal HGS differences between 20–25 and 26–38 age groups among cricketers, supporting this observation.

Regression Analysis Insights: Regression analysis identified forearm circumference, forearm length, pinch grip strength, hand perimeter 5 (P5), and finger span 4 (FS4) as key predictors of grip strength. These findings mirror those by Fallahi and Jadidian (2011), who reported similar predictive utility of hand shape and size in male grip athletes.

Additionally, 2D:4D digit ratio showed a weak yet statistically significant correlation with right-hand HGS, echoing the results of Nanda and Samanta (2017), who suggested its relevance in male athletic populations. However, contrasting results by Li et al. (2010) in Chinese females point to possible gender- or population-specific differences.

Conclusion

This study established a significant positive correlation between handgrip strength and several hand and forearm anthropometric parameters in elite Indian male athletes engaged in grip-related sports. Among all variables, forearm circumference, forearm length, middle and index finger lengths, finger span 4, and hand perimeters emerged as consistent predictors of grip strength. These findings underscore the functional role of hand morphology in generating manual force and offer valuable insights into the biomechanical determinants of performance in grip-intensive sports. The observed relationships suggest that athletes with larger hand dimensions and stronger forearm musculature possess a distinct advantage in tasks requiring sustained grip. From a practical standpoint, these results may be used for talent identification and athlete selection in sports like wrestling, judo, climbing, and weightlifting and personalised training programs emphasizing grip and forearm conditioning rehabilitation planning and baseline strength assessments for return-to-play protocols. Further research involving sport-specific subgroups, inclusion of female athletes, and exploration of dynamic grip patterns will enhance the applicability and depth of these findings.

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Conflicts of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Informed Consent Statement

All the athletes included in the study provided written informed consent.

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