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Comparative Analysis of Hand Anthropometry and Grip Strength among Sport and Non-Sport Individuals

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ABSTRACT

Background: The hand consists of complex static and dynamic anatomical structures. It plays a crucial and essential role for humans, specifically designed for grasping and manipulating objects to serve as a sensory organ. The hand's normal functions rely on sufficient strength, ranging from delicate to gross motor activities. Grip strength serves as a crucial indicator for various essential factors such as energy, nutrition, weakness, and decreased physical activity. Therefore, measuring grip strength is essential for identifying individuals who could benefit from preventive measures or prompt intervention and continuous monitoring to prevent further deterioration.

Materials & Methods: A comparative analysis was performed with the participation of 100 subjects (50sport persons and 50 non-sport persons) for study of hand anthropometric parameters and hand grip strength the collected data thus obtained was statistically evaluated.

Results: Hand dimensions (width, length, and Third-digit length) were slightly greater in sports persons, but these differences were not statistically significant, indicating that basic hand size was similar in both groups. Hand index (ratio of hand breadth to hand length) also showed no significant variation between sport and non-sport individuals, suggesting that overall hand proportions were comparable. A statistically significant difference was detected/found/identified in the right palmar length-to-width ratio, which was greater in sports persons, indicating possible sport-related adaptation or stronger palmar structural development.

Conclusion: This study confirms that while the fundamental skeletal structure of the hand (anthropometric measurements) is not significantly altered by general sports participation in young adults, the functional capacity of the hand—as measured by Hand Grip Strength—is profoundly enhanced.

Keywords: *Hand grip strength, hand anthropometry, sport person, non-sport person.*

INTRODUCTION

The hand consists of complex static and dynamic anatomical structures. It plays a crucial and essential role for humans, specifically designed for grasping and manipulating objects to serve as a sensory organ. The hand's normal functions rely on sufficient strength, ranging from delicate to gross motor activities. [1, 2]

Grip strength serves as a crucial indicator for various essential factors such as energy, nutrition, weakness, and decreased physical activity. Therefore, measuring grip strength is essential for identifying individuals who could benefit from preventive measures or prompt intervention and continuous monitoring to prevent further deterioration. [3, 4, 5]
Hand grip and grasping power are essential for performing routine daily activities. Activities of daily living are the simple tasks that enable an individual to live an autonomous and independent life. Innervation, muscular power, and

movement capacity are required for ADLs to be performed. Examples of these tasks include opening a bottle of water, holding a coffee cup, turning a key in a lock, or even just getting dressed. [6]

Sports are physical activities that primarily involve skill, effort, and coordinated movement, often carried out for competition, recreation, or social participation. They are usually governed by established rules and organized through formal institutions or associations. In basketball, many movements depend heavily on continuous use of the wrist and finger flexor muscles for catching, gripping, shooting, and passing the ball, making hand strength highly important. Because players rely extensively on their upper extremities to control and handle the ball, injuries to the wrist and hand are relatively common among basketball players. [8]

In sports such as Baseball, Basketball, Volleyball, Tennis, Handball, and Wrestling, where a strong grasp is the most important component of ball handling ability, estimating hand grip strength plays a vital role. [9]

Handgrip strength is the maximum force an individual can voluntarily exert using the muscles of the hand and forearm. [10]

GS is widely regarded as only a predictor of intentional performance, [11] and it is influenced by a number of variables such as hand dominance, [12] anthropometric indices, and the forearm, elbow, and shoulder postures. [13, 14, 15]

The hand has a highly complex anatomical structure. There are 27 bones (divided into 8 carpals, 5 metacarpals, and 14 phalanges), 27 joints, and 34 intrinsic and extrinsic muscles. Several other structures such as ligaments and tendons, neurovascular structures add to the complexity of the hand. [2]

AIM

To examine and analyse hand anthropometric measurement and grip strength between sport and non-sport person.

OBJECTIVES

1. To compare the Hand grip Strength directly by using dynamometer.
2. To compare the; Hand Index, Digit Index, Palmer Length/ Width Ratio, Hand length/ height ratio

MATERIALS AND METHODS

Study Design

This comparative cross-sectional study was carried out in the Anatomy Department at Integral Institute of Medical Sciences and Research, Integral University, Lucknow, following approval by the Institutional Ethics Committee (IEC/IIMSR/2025/08) of IIMSR. The study was conducted between February 2025 to June 2026.

Study Population

This study performed with the participation of 100 subjects (50 sport persons and 50 non-sport persons) at Integral University, Lucknow.

MATERIALS

This study performed by using the following apparatus:

- Digital Hand Dynamometer (for grip strength)
- Measuring tape (for height)
- Vernier callipers (for hand index, digit index, palmar length/width ratio and hand length)

METHODS

For Anthropometric Measurements

- Length of the hand was defined as the straight-line measurement extending from the proximal wrist flexion crease to the apex of the third digit, representing the most anteriorly projecting point.
- Breadth of the hand was defined as the perpendicular measurement spanning from the outermost lateral aspect over the second metacarpal head to the innermost medial aspect at the head of the fifth metacarpal bone.
- The index of the hand was calculated by dividing the hand breadth value by the hand length value and subsequently multiplying the obtained ratio by 100.
    - Index of the Hand: width of the hand x 100/length of the hand.
    - Index of the digit: Length of the third digit x 100/length of the hand.
    - Length of the palmer/width ratio: length of the palmer and width of the palmer.
    - Length of the hand /ratio of height: length of the hand/height of the body.

For Measuring the Grip Strength

Grip strength of all students was measured:

Each participant was asked to sit on a chair with flexed elbow at 90° with a semi-pronated forearm resting on an arm support for 5 seconds.

The individuals enrolled in the study were instructed to exert maximal force on the dynamometer for 5 seconds using their hand while maintaining the required posture, and the maximum grip strength values were then recorded.

Inclusion criteria

- Subjects belonging to North India.
- Subjects above 18 years of age group.
- Subjects ready to participate willingly.

Exclusion criteria

- Subjects with history of trauma to upper limb.
- Deformity of upper limb – acquired or congenital.
- The study cohort size was determined using the following method:
- The study cohort size was determined using a 95% confidence level and a relative precision of 5% of the mean value.

Statistical method

- All data obtained were recorded and organized using Microsoft Excel 2010.
- Descriptive statistics were calculated for all morphometric parameters and expressed as mean ± SD.
- Side-wise comparisons were carried out using the paired t-test statistical method.
- Differences among independent groups including sex underwent analyzed by means of the the unpaired t-test, whereas variation among several groups underwent examined and analyzed through the application of one-way analysis of variance (ANOVA).
- Morphological characteristics underwent assessed through the Chi-square test where relevant, and statistical significance was established at a p-value of less than 0.05.
- Correlation tests were performed to establish the association between different morphometric parameters.

RESULTS

This chapter outlines the results of the comparative study performed to assess the differences in hand anthropometric measurements and grip strength among sport participants and non-sport participants. The results are organized into demographic characteristics, hand anthropometry, grip strength assessments, and comparative statistical analyses.

Demographic Characteristics

A total of 100 individuals participated in the study, comprising **50 sports persons** along with **50 non-sport persons**. The sports group included individuals regularly participating in competitive or recreational sports activities for a minimum of one year, whereas the non-sport group consisted of individuals with no structured sports involvement.

Mean age (years): sports group: 21.84 ± 2.31, non-sport group: 21.12 ± 2.58

Sex distribution: sport group: 25 males, 25 females, non-sport group: 25 males, 25 females

Hand Anthropometric Measurements

Hand anthropometric parameters recorded included length of the hand, breadth of the hand, length of the palm, length of the middle finger, hand span, as well as grip strength for both hands. Descriptive parameters of sport and non-sport individuals between males and females are shown in Tables 1 and 2.

Table 1: Demographic parameters for non-sport persons among both genders (n=50).

Parameters	Side	Mean	SD
Hand width	Right	81.5	6.437
	Left	80.38	6.968
Hand length	Right	180.84	12.151
	Left	181.46	12.007
3rd digit length	Right	79.88	5.944
	Left	79.8	5.217
Hand index	Right	44.68	2.831
	Left	43.86	2.665
Palmar length/width	Right	0.126	1.052
	Left	1.283	1.020
Hand length/height	Right	0.109	0.145

	Left	0.109	0.142
Hand grip strength	Right	29.588	12.265
	Left	27.34	11.582

Table 2: Descriptive parameters of sport persons among both genders (n=50)

Parameters	Side	Mean	SD
Hand width	Right	82.04	7.89
	Left	81.48	7.82
Hand length	Right	183.58	10.33
	Left	183.04	10.74
3rd digit length	Right	80.88	7.98
	Left	80.42	8.17
Hand index	Right	44.12	199.6
	Left	43.94	197.3
Palmar length/width	Right	1.29	0.49
	Right	1.27	0.54
Hand length/height	Left	0.11	0.12
	Right	0.11	0.12
Hand grip strength	Left	38.66	12.67
	Right	37.13	12.92

Comparison of parameters between sports and non-sports persons among both genders shown in the Table 3. The hand anthropometric measurements showed that most parameters did not show a notable difference between the two groups. Bilateral hand width was slightly higher in the sports group (82.04 ± 7.88 mm and 81.48 ± 7.82 mm, respectively) In comparison with the non-sports group. (81.50 ± 6.43 mm and 80.38 ± 6.97 mm), even so the recorded variations failed to demonstrate statistical relevance (p = 0.7084 as well as p = 0.4595). Similarly, right and left hands length also showed no significant difference, with sports persons measuring 183.58 ± 10.33 mm and 183.04 ± 10.74 mm, compared to 180.84 ± 12.15 mm and 181.46 ± 12.00 mm in non-sports persons (p = 0.2274 and p = 0.4897).

Table 3: Comparison of parameters between sports and non-sports persons among both genders (n=50)

Parameters	Side	Categories	Mean±SD	p-value
Hand width	Right	sports	82.04±7.89	0.708
		non-sports	81.50±6.44	
	Left	sports	81.48±7.82	0.459
		non-sports	80.38±6.97	
Hand length	Right	sports	183.58±10.33	0.227
		non-sports	180.84±12.15	
	Left	sports	183.04±10.74	0.489
		non-sports	181.46±12.01	
3rd digit length	Right	sports	80.88±7.98	0.479
		non-sports	79.88±5.94	
	Left	sports	80.42±8.17	0.652
		non-sports	79.80±5.22	
Hand index	Right	sports	44.12±9.60	0.984
		non-sports	44.68±2.83	
	Left	sports	43.94±7.30	0.998
		non-sports	43.86±2.67	
Palmar length/width	Right	sports	1.27±0.49	<0.0001
		non-sports	0.13±1.05	
	Left	sports	1.27±0.54	0.922
		non-sports	1.28±1.02	
Hand length/height	Right	sports	0.11±0.12	0.969
		non-sports	0.11±0.15	
	Left	sports	0.11±0.12	0.969
		non-sports	0.11±0.14	
Hand grip strength	Right	sports	38.66±12.67	1.000
		non-sports	38.66±12.67	
	Left	sports	37.13 ±12.92	0.0001*
		non-sports	27.34 ±11.58	

Third-digit length on both right and left sides was marginally greater in sports persons, but again, the differences were statistically non-significant (right: 80.88 ± 7.98 mm v/s 79.88 ± 5.94 mm, p = 0.4791; left: 80.42 ± 8.17 mm v/s 79.80 ± 5.22 mm, p = 0.6523).

Right and left hands indices also showed no meaningful variation among the groups (p = 0.9843 and p = 0.9977).
In contrast, a highly notable distinction was found in the right palmar length/width ratio, which was markedly higher among sports persons (1.268 ± 0.490) compared to non-sports persons (0.126 ± 1.052), with p = 0.00001. However, the left palmar ratio did not demonstrate a statistically significant difference (p = 0.9220).Hand length/height ratios on both sides were nearly identical between the groups (p = 0.9698).

Grip strength comparison showed mixed results. Right hand grip strength was identical between sports and non-sports persons (38.664 ± 12.673 kg for both groups; p = 1.0). However, left hand grip strength was significantly higher in sports persons (37.132 ± 12.924 kg) than in non-sports persons (27.34 ± 11.582 kg), with p = 0.0001.

A comparison of hand anthropometric parameters between males and females among sports and non-sports persons showed several statistically significant differences.

Among sports persons, males demonstrated significantly higher values than females for almost all measurements, including the width and length of both hands, as well as the length of the third finger on each hand ($p < 0.0001$). Similarly, both right and left hands indices Demonstrated a notable disparity between individuals of both sexes ($p < 0.001$). However, length of the palmar-to-ratios of the width along with length of the hand-to-ratios of the height failed to reveal any notable disparity between genders among the sports cohort ($p > 0.05$).

Among non-sports persons, a similar trend was observed. Males showed significantly higher values for hand width, hand length and the third digit length of the compared towards females ($p < 0.001$). Hand index values, however, did not show a notable disparity between individuals of both sexes. ($p > 0.05$). Palmar ratios also revealed no meaningful distinctions among participants of both sexes ($p > 0.05$). A notable distinction emerged in the length of the right hand-to-height ratio ($p < 0.0001$), while the left aspect was non-significant.

Table 4: Comparison of parameters of the both sides between genders between sports and non-sports persons (n=25).

Parameters	Side	Categories	Sex	Mean	SD	P-value
Hand width	Right	sports	M	88.96	3.194	<0.0001
			F	75.12	4.126	
		non-sports	M	85.68	5.885	4.29×10^{-7}
			F	77.32	3.682	
Hand width	Left	sports	M	88.36	3.327	<0.0001
			F	74.6	3.894	
		non-sports	M	85.04	5.689	8.62×10^{-8}
			F	75.72	4.641	
Hand length	Right	sports	M	192.72	5.271	<0.0001
			F	174.44	4.011	
		non-sports	M	188.12	10.274	3.30×10^{-6}
			F	173.56	9.242	
Hand length	Left	sports	M	192.48	5.561	<0.0001
			F	173.6	4.358	
		non-sports	M	189.2	9.966	3.35×10^{-7}
			F	173.72	8.379	
3rd digit length	Right	sports	M	88.16	2.867	<0.0001
			F	73.6	3.378	
		non-sports	M	83	5.454	7.69×10^{-5}
			F	76.76	4.701	
3rd digit length	Left	sports	M	87.76	3.357	<0.0001
			F	73.08	3.581	
		non-sports	M	83	4.281	1.63×10^{-6}
			F	76.6	3.989	

Table 4 (cont..): Comparison of parameters of the both sides between genders between sports and non-sports persons (n=25).

Parameters	Side	Categories	Sex	Mean	SD	P-value
Hand index	Right	sports	M	45.64	0.952	2.22×10^{-16}

			F	42.6	.554	
		non-sports	M	45.08	3.121	0.323
			F	44.28	2.508	
Hand index	Left	sports	M	45.44	0.916	3.81×10^{-10}
			F	42.44	1.556	
		non-sports	M	44.48	2.583	0.100
			F	43.24	2.65	
Palmar length/width	Right	sports	M	1.201	0.905	0.502
			F	1.348	0.601	
		non-sports	M	1.256	0.849	0.971
			F	1.267	1.224	
Palmar length/ width	Left	sports	M	1.199	1.048	0.398
			F	1.420	0.759	
		non-sports	M	1.246	0.998	0.859
			F	1.305	1.321	
Hand length/height	Right	sports	M	1.093	0.171	0.836
			F	1.085	0.087	
		non-sports	M	8.081	0.003	< 0.0001
			F	0.109	0.178	
Hand length/height	Left	sports	M	0.109	0.181	0.981
			F	0.108	0.095	
		non-sports	M	0.081	0.003	0.372
			F	0.109	0.154	
Hand grip strength	Right	sports	M	49.968	6.058	< 0.0001
			F	27.36	5.002	
		non-sports	M	39.08	8.48	3.12×10^{-12}
			F	19.268	3.657	
Hand grip strength	Left	sports	M	48.66	6.6255	< 0.0001
			F	25.606	5.006	
		non-sports	M	36.884	7.042	9.90×10^{-14}
			F	17.796	5.877	

Grip strength measurements showed the strongest gender differences in both groups. In sports persons, males demonstrated considerably greater grip strength in both hands compared to females ($p < 0.0001$). Similarly, in non-sports persons, males exhibited markedly greater grip strength on both sides ($p < 0.0001$).

Overall, the results indicate that males consistently exhibit larger hand dimensions and greater grip strength than females in both sports and non-sports populations, while hand proportional indices (palmar ratios and length/height ratios) generally do not differ significantly between genders.

DISCUSSION

The present study assessed an analytical comparison of hand anthropometric measurement and grip strength among sports-active participants and non-sports-active participants".

The main purpose of the current research was to evaluate hand morphology measurements and hand grip force between two distinct groups: sports persons and non-sports persons. The results of this study offer meaningful understanding of the morphological and performance-related adaptations related to the hand influenced by habitual physical activity and training.

Comparison of Hand Grip Strength (HGS)

The chief finding from the present analysis was the considerable difference observed in functional strength between the two groups. Hand grip strength was observed to be statistically and considerably greater in sports persons in comparison with non-sports persons for both the primary hand ($p = 0.0003$) as well as the secondary hand ($p = 0.0001$).

This result strongly supports the hypothesis that regular participation in sports and athletics leads to superior development of the hand and forearm musculature, which directly contributes to increased grip strength. This finding aligns with the existing literature, such as the study by Fallahi AA et al. (2011), which reported a highly significant difference in absolute handgrip strength ($p<0.001$) between athletes and non-athletes.

In sports such as volleyball, basketball, and handball, a strong grasp is essential for grasping, gripping, passing, and shooting the play ball, thereby requiring consistent and forceful engagement of the finger and wrist flexor muscle. The

greater mean HGS observed in the sports group (Right hand: 37.766 ± 11.08; Left hand: 37.132 ± 12.924) compared to the non-sports group (Right hand: 29.588 ± 12.265; Left hand: 27.34 ± 11.582) is a clear indicator of this chronic adaptive response to training.

Comparison of Hand Anthropometric Measurements

In contrast to the highly significant difference in HGS, the study found no statistically significant difference between sports persons and non-sports persons for the majority of the analysed hand anthropometric parameters, including the width and length of both hands, along with the length of the 3rd digit finger on each hand. For instance, the p-value for right hand width was 0.7084, and for right hand length was 0.2274, indicating a lack of meaningful structural difference between the groups.

The computed hand indices (Hand Index, Digit Index, Hand length/height ratio) likewise revealed no meaningful distinction between the two groups. This finding indicates that the inherent skeletal structure and proportional development of the hand—which is largely genetically determined does not undergo substantial structural alteration as a result of general sports participation in young adults.

This finding partially contradicts other studies, such as **Khanna A. et al. (2020)**, who reported significant anthropometric differences (hand length, hand breadth, digit length) between volleyball players and a reference group. The disparity may be due to the varied types of sports included in the "sports person" group in the present study, as specific 'grip-focused' sports may induce more pronounced hand-size adaptations than general athletic participation. The implication is that the superior strength in the sports group is a result of functional muscular hypertrophy rather than large-scale structural morphometric variation.

Influence of Gender on Hand Parameters

The findings of this research align with established anatomical and physiological norms regarding sexual dimorphism in hand measurements and strength.

Grip Strength: Males in both the sports group (Right HGS $p < 0.0001$) and the non-sports group (Right HGS $p < 0.0001$) demonstrated markedly and highly significant greater grip strength than their female counterparts. This difference is typically attributed to the higher levels of testosterone, resulting in greater lean body mass and muscle cross-sectional area in males.

Anthropometric Dimensions: Similarly, males exhibited significantly larger values for virtually all anthropometric parameters, including width of the hand, hand length as well as third digit length, in both groups ($p < 0.0001$).

CONCLUSION

The current research establishes that no notable variation was found among most hand anthropometric measurements between sports and non-sports persons, indicating that hand dimensions are mainly influenced by genetic and developmental factors rather than physical activity. However, when functional aspects are considered, grip strength shows noticeable variation, where right-hand grip strength shows no significant difference, but left-hand grip strength is significantly higher in sports persons, reflecting the effect of regular training. Additionally, the right palmar ratio shows a significant difference, suggesting some level of structural adaptation in athletes. Overall, the findings emphasize that sports activity improves functional strength more than hand structure, and therefore, grip strength is a better indicator of physical fitness than anthropometric measurements.

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