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Ahana Chattopadhyay[1], Saswati Ray[2], Debarati Chanda[2], Debjani Chakraborti[2]

[1]Graduate Medical Student, Jagannath Gupta Institute of Medical Science and Hospital, Kolkata, India
[2]Department of Physiology, Jagannath Gupta Institute of Medical Science and Hospital, Kolkata, India

A study on hand grip strength and its association with body mass index, hand length and mid-upper arm circumference among Eastern Indian medical students using a hand-held dynamometer

Corresponding author:

Saswati Ray, Department of Physiology, Jagannath Gupta Institute of Medical Science and Hospital, Kolkata, India, e-mail: raysaswati2015@gmail.com

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ABSTRACT

Introduction: Hand Grip Strength, measured by hand-grip dynamometry, is a measure of muscular strength. This cross-sectional study was performed to determine the correlation between Hand Grip Strength (HGS) and different anthropometric measurements like Body Mass Index (BMI), Hand Length (HL) and Mid Upper Arm Circumference (MUAC) among undergraduate medical students of a Tertiary Health Care Institute in West Bengal.

Material and methods: This research, which was cross-sectional, analytical, and observational, had two groups of fifty male and fifty female participants in the 19–25 age range. An analogue, basic metal hand-grip dynamometer weighing 50 kg was used. The recorded HGS value was the average of three trials, with a 15-second inter-trial rest interval between each trial. For Statistical Analysis, Tests of Significance (Student's t-test and Pearson's Correlation Coefficient) have been used. P-values ≤ 0.05 have been considered significant.

Results: A hundred undergraduate medical students of the age group 19–25 years were divided into two groups, male (50) and female (50). A significant strong positive correlation of HL ($r = 0.6308$, $p < 0.00001$) with Dominant Hand Grip Strength (DHGS) was found in the general population. However, no significant correlation of BMI ($r = 0.0831$, $p = 0.411091$) with DHGS was observed. A significant weak positive correlation of age ($r = 0.2790$, $p = 0.004939$) with DHGS was observed and a significant moderate positive correlation of MUAC ($r = 0.4035$, $p = 0.000031$) with DHGS was seen. Significant weak positive correlations of HL ($r = 0.3227$, $p = 0.022275$) and MUAC ($r = 0.3788$, $p = 0.006674$) with DHGS were observed for females. Males recorded greater values of DHGS (17.6526 kg) and NDHGS (16.7430 kg) than females (DHGS = 7.3856 kg, NDHGS = 6.6404 kg) and the difference was statistically significant.

Conclusion: Thus, it may be concluded that the most significant predictor of hand grip strength (HGS) is hand length (HL).

Keywords: Hand grip strength, body mass index, hand length, mid-upper arm circumference, hand-held dynamometer

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Introduction

Muscular strength or the maximum force produced by one's forearm muscles is assessed using hand-grip dynamometry, which yields the Hand Grip Strength measurement [1]. It is a crucial assessment in both sports and medicine [2–3], and it is often used as a screening method to gauge an individual's upper body strength. For humans to conduct prehensile and precise hand activities, grip strength is essential. The assessment of Hand Grip Strength (HGS) is crucial in evaluating the effectiveness of various hand treatment

approaches and hand rehabilitation. Variations in HGS may indicate various local and systemic disorders, such as damage to the muscles and nerves [4]. HGS is one of the most accurate clinical techniques for assessing strength and a valuable overall health indicator [5, 6]. It has been shown that bone area and mineral content at the forearm locations are significantly influenced by hand grip strength. It may also be used as a functional indicator of nutritional status [7] and forecast the degree of difficulties that hospitalised patients may have after surgery [8]. Recently, sadness has even been predicted by grip strength [9]. More significantly, it has also been used to determine how long patients with moderate to severe COVID-19 will be in the hospital [10].

A measure of the strength of the hand and forearm muscles is handgrip strength (HGS) [11]. It is a straightforward, non-invasive, affordable, and dependable screening method that doesn't need for skilled workers [12]. Depending on calibrations made by applying one's maximal force to a handgrip strength dynamometer, HGS is often expressed in kilogrammes. The physiological variable of hand grip strength (HGS) has been shown to be influenced by a variety of parameters, including handedness [13], age [14], and gender [15]. Hand grip strength and anthropometric characteristics like hand length (HL) and mid-upper arm circumference (MUAC) have been reported to be correlated in the literature. Studies including infants [16], adults [17], and the senior population [18] have all shown these connections. On the other hand, conflicting findings on the connection between HGS and BMI have been found [18].

Not much data is available in the literature regarding the correlation between HGS and BMI in the Indian population, especially in Eastern India. Also, very few studies have been reported showing the association of HGS with BMI and other variables like age, gender, and handedness among the undergraduate (UG) medical student population in India. Hence, this present study was planned to determine the correlation between HGS and BMI, HL and MUAC among the UG medical student population. Also, the correlation of age, gender and handedness with HGS will be determined.

Material and methods

Study population

It was a Cross-sectional, analytical and observational kind of study and was performed in the Demonstration Room of the Physiology Department. The study was performed on undergraduate medical students (100) of a tertiary health care institute in West Bengal. They were divided into two groups, male (50) and female (50). Healthy subjects of the age group 19–25 years, who were willing to participate and had given written consent by signing the Informed Consent Form were included. The subjects who had undergone any recent hand injury or surgery, or had any hand deformity or any oedematous, inflammatory, or vascular condition of the hand, were excluded.

The proposed study was carried out in the Physiology Department of the Institute after obtaining permission from the Institutional Research and Ethics Committee of Jagannath Gupta Institute of Medical Science and Hospital (JIMSH-IEC-02-2022-10726) following all guidelines. Socio-demographic data on age, gender and handedness was collected verbally as answered by the participants and noted down accordingly in the Data Collection Sheet.

HGS recording

A basic metal analogue Utilised was a 50 kg handgrip dynamometer. The subject was forced to sit with their knees, pelvis, and back as near to 90 degrees as they could. The elbow was flexed to a 90-degree angle, the forearm was neutral, the wrist was kept between 0 and 15 degrees of ulnar deviation, and the shoulder was abducted and neutrally rotated. The dynamometer was positioned vertically and in line with the forearm, with neither the examiner nor any armrest providing support for the arm. The hand grip strength figure that was shown was then recorded when the subject was instructed to squeeze the dynamometer's handle with all of his or her might. The recorded HGS value was the average of three trials, with a 15-second inter-trial rest interval between each trial [19]. The same protocol was used to record the HGS value for the non-dominant and dominant hands.

BMI measurement

The body weight divided by the square of the body height, given in kilogrammes per square metre, is the definition of the body mass index, or BMI. The instruments used were a normal digital weighing machine (in kilogrammes) and a standard Stadiometer (height scale, in metres).

Hand length (HL)

Using a standard flexible measuring tape, the hand length (measured in centimetres) of each participant

was determined. The hand length is defined as the distance between the tip of the middle finger and the mid-point of the distal wrist crease [12].

Mid-upper arm circumference (MUAC)

The term "mid-upper arm circumference" refers to the measurement of the upper arm at the acromion and olecranon processes, which are the midpoints of the proximal points of the elbow and the shoulder, respectively [12].

Statistical analysis

The collected data was compiled and analysed with the help of appropriate software packages like Microsoft Excel from Microsoft Office Package 2021 and SPSS software. Descriptive statistical methods (mean ± standard deviation) have been applied and data have been presented in the form of tables. In some cases, Tests of Significance (Student's t-test and Pearson's Correlation Coefficient) have been used. P-values ≤ 0.05 have been considered significant.

Results

To be a part of the research, 105 healthy individuals in total were screened. Out of them, two declined to take part, and three were eliminated based on the inclusion and exclusion criteria. The mean ± SD age of the remaining 100 individuals was 21.63 ± 1.62 years, with a range of 19 to 25 years. The details of anthropometric parameters like BMI (24.89 ± 3.68 kg/m^2), HL (18.21 ± 1.15 cm), MUAC (27.57 ± 3.38 cm), DHGS (12.52 ± 6.42 kg), and NDHGS (11.71 ± 6.44 kg) of all participants were listed in Table 1.

Table 1. Descriptive statistics for general sample (n = 100)

Parameters	Mean ± SD	Min-max (range of values)
Age [years]	21.63 ± 1.62	19–25
BMI [kg/m^2]	24.89 ± 3.68	14.69–33.45
HL [cm]	18.21 ± 1.15	15.5–21
MUAC [cm]	27.57 ± 3.38	17–37
DHGS [kg]	12.52 ± 6.42	3–28
NDHGS [kg]	11.71 ± 6.44	2–31

BMI — Body Mass Index; DHGS — Dominant Hand Grip Strength; HL — Hand Length; MUAC — Mid Upper Arm Circumference; NDHGS — Non-Dominant Hand Grip Strength

Table 2 presents an analysis and list of the parameters that were compared between the two groups, namely the men (n = 50) and the females (n = 50), with statistical significance. Table 2 shows that except for BMI, all other parameters are greater in males than in females and it is statistically highly significant.

Table 3 and Table 4 show a significant strong positive correlation of HL (r = 0.6308, p < 0.00001) with DHGS was found. However, no significant correlation of BMI (r = 0.0831, p = 0.411091) with DHGS was observed. A significant weak positive correlation of age (r = 0.2790, p = 0.004939) with DHGS was observed and a significant moderate positive correlation of MUAC (r = 0.4035, p = 0.000031) with DHGS was seen.

For further clarity, the general population sample (n=100) was divided based on gender into males (n=50) and females (n=50) and then the Pearson's Correlation Coefficient test was individually repeated for each of the two subsets of the sample.

Table 5 and Table 6 show that in males there is no significant correlation of DHGS with any of the 4 variables studied viz. age, BMI, HL and MUAC.

Table 2. Comparison of the parameters between males (n = 50) and females (n = 50) with statistical significance

Parameters	Male (n = 50)		Female (n = 50)		P-value
	Mean ± SD	Min-max. (range of values)	Mean ± SD	Min-max. (range of values)	
Age [years]	21.94 ± 1.92	19–25	21.32 ± 1.20	19–25	0.027363*
BMI [kg/m^2]	24.87 ± 3.82	16.73–33.45	24.91 ± 3.57	14.69–32.04	0.96658
Hand Length [cm]	18.96 ± 0.84	17–21	17.46 ± 0.90	15.5–19.5	(2.102 × 10–13)*
MUAC [cm]	28.66 ± 3.39	22–37	26.48 ± 3.04	17–34	0.000701*
DHGS [kg]	17.65 ± 4.89	6.5–28	7.38 ± 2.37	3–12	(5.5 × 10–21)*
NDHGS [kg]	16.74 ± 5.19	6.5–31	6.64 ± 2.24	2–11	(3.08 × 10–19)*

BMI — Body Mass Index; DHGS — Dominant Hand Grip Strength; HL — Hand Length; MUAC — Mid Upper Arm Circumference; NDHGS — Non-Dominant Hand Grip Strength. *p ≤ 0.05 has been considered significant

Table 3. Correlation between the variables for the general sample (n = 100)

	Age	BMI	Hand length	MUAC	DHGS
Age	1				
BMI	–0.0235	1			
Hand length	0.1097	–0.0497	1		
MUAC	0.1140	0.7737	0.2664	1	
DHGS	0.2790	0.0831	0.6308	0.4035	1

BMI — Body Mass Index; DHGS — Dominant Hand Grip Strength; HL — Hand Length; MUAC — Mid Upper Arm Circumference. Pearson's correlation coefficient test was done to determine the correlation among two variables. The values given here are the correlation coefficients or "r" values

Table 4. Correlation of DHGS with anthropometric parameters and corresponding P-values (n = 100)

Variables correlated	Correlation coefficient (r)	P-value (2-tailed)
DHGS vs. age	0.2790	0.004939*
DHGS vs. BMI	0.0831	0.411091
DHGS vs. HL	0.6308	< 0.00001*
DHGS vs. MUAC	0.4035	0.000031*

BMI — Body Mass Index; DHGS — Dominant Hand Grip Strength; HL — Hand Length; MUAC — Mid Upper Arm Circumference; *$p \leq 0.05$ has been considered significant. For labelling the strength of association, for absolute values of r, 0–0.19 has been regarded as very weak, 0.2–0.39 as weak, 0.40–0.59 as moderate, 0.6–0.79 as strong and 0.8–1 as very strong correlation in this study

Table 5. Correlation between the variables, males (n = 50)

	Age	BMI	Hand length	MUAC	DHGS
Age	1				
BMI	–0.1421	1			
Hand length	–0.1726	–0.1042	1		
MUAC	–0.0502	0.8142	0.0813	1	
DHGS	0.2423	0.1166	0.2074	0.2153	1

BMI — Body Mass Index; DHGS — Dominant Hand Grip Strength; HL — Hand Length; MUAC — Mid Upper Arm Circumference, Pearson's correlation coefficient test was done to determine the correlation between the two variables. The values given here are the correlation coefficients or "r" values

Table 6. Correlation of DHGS with anthropometric parameters and corresponding P-values for males (n = 50)

Variables correlated	Correlation coefficient (r)	P-value (2-tailed)
DHGS vs. Age	0.2423	0.090009
DHGS vs. BMI	0.1166	0.420019
DHGS vs. HL	0.2074	0.148398
DHGS vs. MUAC	0.2153	0.133209

BMI — Body Mass Index; DHGS — Dominant Hand Grip Strength; HL — Hand Length; MUAC — Mid Upper Arm Circumference; *$p \leq 0.05$ has been considered significant

From Table 7 and Table 8 can be found significant weak positive correlations of HL ($r = 0.3227$, $p = 0.022275$) and MUAC ($r = 0.3788$, $p = 0.006674$) with DHGS in females.

To find out the association between HGS and Gender, and HGS and Handedness, the Student's t-test was performed. From Table 9, it is evident that DHGS was slightly greater than NDHGS in the general sample (n=100) but the difference is not statistically significant.

Discussion

In this cross-sectional study, 100 undergraduate medical students were included and the relationships between their HGS and several anthropometric parameters were studied. The study's findings indicate that male students outperform female students in all measured parameters, including HL, MUAC, and HGS (both DHGS and NDHGS), except for BMI. These

Table 7. Correlation between the variables, females (n = 50)

	Age	BMI	Hand length	MUAC	DHGS
Age	1				
BMI	0.1803	1			
Hand length	0.2000	–0.0179	1		
MUAC	0.2475	0.8268	0.0704	1	
DHGS	0.1255	0.2380	0.3227	0.3788	1

BMI — Body Mass Index; DHGS — Dominant Hand Grip Strength, HL — Hand Length; MUAC — Mid Upper Arm Circumference; Pearson's correlation coefficient test was done to determine the correlation among two variables. The values given here are the correlation coefficients or "r" values

Table 8. Correlation of Dominant Hand Grip Strenght with anthropometric parameters and corresponding P-values for females (n = 50)

Variables correlated	Correlation coefficient (r)	P-value (2-tailed)
DHGS vs. Age	0.1255	0.385168
DHGS vs. BMI	0.2380	0.096041
DHGS vs. HL	0.3227	0.022275*
DHGS vs. MUAC	0.3788	0.006674*

BMI — Body Mass Index; DHGS — Dominant Hand Grip Strength; HL — Hand Length; MUAC — Mid Upper Arm Circumference; *$p \leq 0.05$ has been considered significant.

Table 9. Relationship between Hand Grip Strength and Handedness (n = 100)

HGS [kg]	Handedness		P-value (2-tailed)
	DH	NDH	
Mean HGS	12.52	11.71	0.3759

HGS — Hand Grip Strength

results are somewhat in line with those of a study by Zaccagni L et al. [18], which found that male students outperformed female students in all tested parameters, including BMI. In the present study, BMI values were more or less equal in males and females, rather slightly greater in females — this is consistent with another study conducted by Ibegbu AO et al. [20]. The reason behind this could be due to higher body fat deposition in females as compared to males.

The males showed greater values of HGS (both DHGS and NDHGS) than females and it agrees with the study conducted by Innes EV [21] and İsa Sağiroğlu et al. [22] where it was confirmed that males have greater grip strength than females regardless of the testing instrument used. Testosterone is one of the numerous variables that contribute to the growth of muscle mass, which explains why men have higher HGS than women. Also, the existence of greater muscularity among male students compared to their female counterparts may be because of the prevalence of greater physical activity among males which prevented accumulation of body fat in them.

In this study, a weak correlation of age with HGS was found in the general population (n = 100). This agrees with the study of Hanten WP et al. [23] where a weak correlation of age with grip strength was established. A study conducted by Burke WE et al. [24] stated that there is an increase in grip strength in the 12–25 years age group followed by a gradual decline in HGS after the 25th year till 79 years of age. The reason behind the increase in HGS with the increase in age in the young adult age group could be because the age-dependent increase in HGS is strongly associated with increasing muscle mass. However, in this study no significant correlation was found between age and HGS among the males and females separately, and this can be attributed to the small sample size involved.

A significant positive strong correlation of hand length with HGS was established in this study among the general population (n = 100). This agrees with the findings of the study conducted by Alahmari KA et al. [25] which said that hand length was found to be the most significant variable in predicting hand grip strength.

A significant positive moderate correlation between MUAC and HGS was noticed in this study for the general population (n = 100) and it agrees with the findings of a number of studies that found similar results [18]. MUAC is a marker of an individual's nutritional status and the major determinant of MUAC is arm muscle mass. Since HGS is a measure of muscular strength, hence increased arm muscle mass may have an impact on increasing HGS.

In this study, no significant correlation was found between BMI and HGS among the general population (n = 100). Similar results were seen even in the case of males (n = 50) and females (n = 50).

This is supported by the findings of a similar study with an almost equal sample size conducted by Bhattacharjya J et al. [26]. The correlation between HGS and BMI was found to be insignificant in other studies too [27–28]. In males too, no significant correlation between BMI and HGS was found and this agrees with the study carried out by Mitsionis G et al. [28] where no association between BMI and dominant HGS was seen in male participants. In females also no significant correlation between BMI and HGS was seen and this matched with the findings of a study carried out by Shah UN et al. [29] where no significant correlation between BMI and HGS was found among fifty healthy female participants. BMI measures both body fat and lean muscle mass so it may very well happen that an underweight person with less body fat and muscle mass and, an overweight person with more body fat and comparatively less muscle mass both end up having the same HGS while a person belonging to the healthy range of BMI ends up having greater HGS as he/she has more lean muscle mass. Hence, probably one cannot expect a simple positive or negative correlation between HGS with BMI, it can be something quite complex. Also, BMI does not accurately indicate fat distribution in the body.

Among males, no significant correlation with HGS was found for any of the 4 parameters studied. This differs from the findings of other studies like those conducted by Koley S et al. [30] and Ibegbu et al. [20] where they found a significant positive correlation of HGS with all the parameters studied among males. Among females, though no significant correlations of HGS were found with age and BMI, significant positive weak correlations of HGS were found with hand length and mid-upper arm circumference. These findings are consistent with the findings of the studies conducted by Shah UN et al. [29] where a significant positive correlation of HGS was found with hand length and, dominant HGS was found to be significantly correlated with dominant hand MUAC among females, respectively.

Coming to the relationship between HGS and handedness, this study did not find any significant difference between HGS values of the dominant hand and the non-dominant hand. This agrees with the study conducted by Härkönen et al. [31] where no significant difference was found between DHGS and NDHGS. A possible explanation behind this fact may be because many ambidextrous individuals exist who have equal strength in both the dominant and non-dominant hand; also it has been seen that left-handed individuals often have equal strength in the non-dominant hand as well as dominant hand [32], if not more. Each of these study's practical implications for clinical practice is noteworthy. Before establishing normalised values of muscular strength for a specific group of persons, appropriate standardisation should be carried out since factors such as age, hand length, and mid-upper arm circumference affect muscle strength.

Limitations and future scope

As a small sample size cannot reflect the general population, this study needs to be done on a larger sample size. Also, the use of electronic dynamometers would be preferable.

Conclusion

The study's findings demonstrated that, in the whole sample, there is a moderate positive association between mid-upper arm circumference and HGS and a high positive correlation between hand length and HGS. Therefore, regardless of gender, hand length may be considered the most important factor in determining hand grip strength. BMI did not show any significant correlation with HGS in the general sample, as well as among males and females. Age was shown to have a weak positive correlation with HGS in the general sample while no such significant correlation was found separately among males and females. Gender was found to affect the values of HGS (both DHGS and NDHGS) with males having higher grip strength than females. Handedness did not have a significant impact on HGS in this present study population with DHGS values being nearly similar to NDHGS values. The findings of the present study would be of value in medical anthropology research, to diagnose various musculoskeletal deformities, especially related to upper extremities, and for their rehabilitation.

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