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Original Article

Physiology Section

Handgrip Muscle Strength, Endurance and Anthropometric Parameters in Healthy Young Adults: A Cross-sectional Study

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ABSTRACT

Introduction: Handgrip muscle strength and endurance are non invasive simple diagnostic tool for diagnosis as well as to check prognosis in health and disease. But there are many factors like age, ethnicity etc., that influence the handgrip muscle strength and endurance. Failure to understand the determinants that influence the strength and endurance would decrease the reliability of these tests as diagnostic and prognostic tool.

Aim: To evaluate the influence of anthropometric parameters like height, weight, Body Mass Index (BMI) on handgrip muscle strength and endurance.

Materials and Methods: The present cross-sectional study was conducted in the Department of Physiology, Gauhati Medical College and Hospital, Guwahati, Assam, India, in the month of November and December 2019, after obtaining Institutional Ethical Committee (IEC) clearance. In this study 80 healthy young adults had given informed written consent to participate. After a brief history taking to ensure that participants met the inclusion criteria, height and weight were measured using measuring tape and weighing machine, respectively and BMI was calculated using the formula weight (kg)/height $(m)^2$. Handgrip muscle strength and endurance was measured using handgrip dynamometer. Statistical Package for the Social Sciences (SPSS) 16.0 version software was used to calculate mean of all variables, Pearson correlation coefficient to analyse the correlation of variables and Analysis of Variance (ANOVA) test was used for analysis of significance. The p-value ≤ 0.05 was considered statistically significant.

Results: In this study, 47 (58.75%) were males, showed higher values in almost all parameters like height, weight, muscle strength except BMI, than the females who constituted 33 (41.25%) of the study participants. There was also significant moderate positive correlation of height ($r=0.621$, $p<0.001$), weight ($r=0.519$, $p<0.001$) with handgrip muscle strength and only height ($r=0.438$, $p<0.001$) showed correlation with muscle endurance.

Conclusion: The present study showed positive correlation of height and weight with muscle strength and height with endurance. So, it can be concluded that height, weight are the anthropometric parameters that influence handgrip muscle strength. So, influences of these factors should be kept in mind while using handgrip muscle strength or endurance as diagnostic or prognostic tool.

Keywords: Body mass index, Handgrip strength, Height, Weight

INTRODUCTION

Handgrip Strength (HGS) is an integral part of performing precise and refined fine motor activities. In the physical assessment of various diseases affecting musculoskeletal neuromuscular and cardiorespiratory systems in children, elderly and obese populations, HGS measurement is also used as a most common part of the assessment [1-6]. HGS has predictive potential of nutritional status and short-term, long-term mortality and morbidity for many diseases. It is often used as a specific test in medicine for a diverse purpose, including diagnosis of diseases, evaluating and comparing treatments, assessing progression of treatment and providing feedback during the rehabilitation process [7]. Impaired HGS can cause significant functional limitations leading to decreased basic and instrumental activities of daily living, thereby diminishing quality of life of an individual. But the handgrip muscle strength is influenced by various factors, that mainly are fatigue, time of the day, age, gender, nutritional status, restricted motion, anthropometric parameters and pain [8]. Several studies have highlighted the influence of age, gender, body size, body height and body weight on HGS among children, particularly in the early stage of puberty [9-11]. Previous study also concluded that many other factors like body height, forearm girth, etc., also influence handgrip muscle strength in prepubertal children [12]. In another study, researchers have shown influence of age, height, weight on handgrip muscle strength but by using other methods like modified sphygmomanometer in healthy young adults [13].

Obesity has become a major health problem in today's world. Lack of exercise, sedentary lifestyle, food habits may be the main cause of obesity in young adults. On the other hand, obese people are at increased risk of developing a number of chronic disease conditions like type 2 diabetes, hypertension, high cholesterol, asthma and certain forms of cancer [14]. The relationship of the anthropometric parameters like height, weight, BMI with HGS and endurance among the healthy young adults has not been properly explored to determine the influence of the former on the later. Even though, the influence of anthropometric measures were examined in few studies in different parts of the country, but most of the studies done nationally or internationally were on old people or on players [15]. There are very few studies done on young adults [11,16] and there were no study done in this part. To fulfil the lacunae of literature, the present study was planned with the hypothesis that anthropometric parameters like height, weight, BMI have influence on handgrip muscle strength and endurance. So, the aim of this study was to evaluate the impact of anthropometric parameters like height, weight, BMI on handgrip muscle strength and endurance among healthy young adults and also to find the correlation of anthropometric parameters with handgrip muscle strength and endurance.

MATERIALS AND METHODS

The present study was a cross-sectional study in which 80 young healthy adults (both males and females) aged 18-21 years were selected who were pursuing various Medical and Paramedical

courses in Gauhati Medical college and Hospital, Guwahati, Assam. Institutional Ethical Committee (IEC) clearance (No. MC/190/2007/Pt-11/7) was obtained, this study was done in the Department of Physiology, at the study institute, in the month of November and December 2019. Participants who gave informed written consent were recruited.

Sample size calculation: As per census 2011, adolescents constitute 20% of total population in India. In this study confidence level was considered at 95%, Z was 1.96, precision was taken as 8. After putting the values in the formula, sample size calculated was:

$N=Z^2 \times p \times q/d^2$, where, p=population=20, q=100-p=80, d=precision=8 in this study

$N=1.96 \times 1.96 \times 20 \times 80/8 \times 8=96$.

But only 80 volunteers participated in this study. As a previous study had shown variance in muscle strength in both hand in right hand dominant persons, although no difference in strength between the sides in left-handed person is documented [10].

Inclusion criteria: Subjects with right-hand dominance and without having any musculoskeletal or neurological deformity, were included in this study. Moreover, all the volunteers participated in this study were right-handed.

Exclusion criteria: Students with definite history of cardiovascular diseases, metabolic disorders, regular gym goers more than three weeks and players involving upper limbs like basketball, volleyball which may influence the results of handgrip measurements were excluded from the study.

Procedure

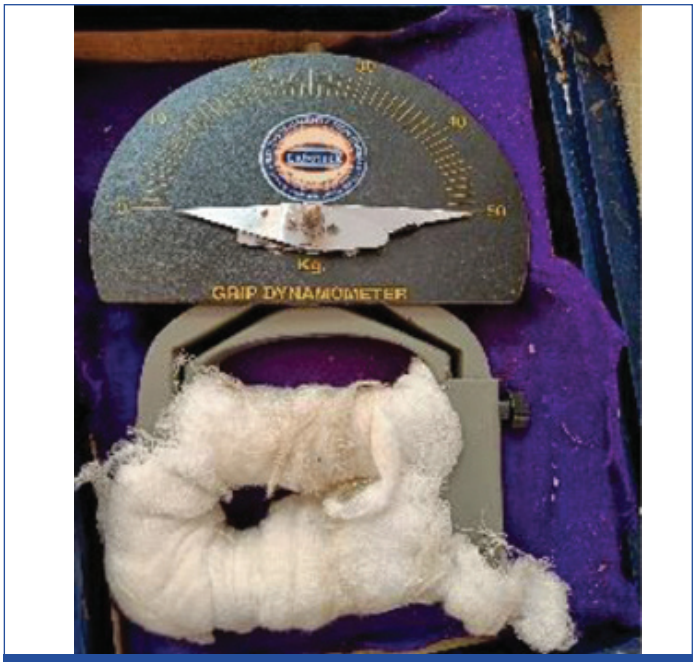
On the day of study, subjects were explained about the procedure. After taking brief history to exclude those who did not meet the inclusion criteria, height, weight and BMI, and right-handgrip strength and endurance of the participants were measured. Body weight was measured using digital weighing machine with light clothing on, without any footwear standing straight on the machine and looking straight ahead. Height was measured (in cm) using measuring tape with each subject in upright position against a wall looking ahead. Participants were asked to remove shoes and body should touch the wall at some point, preferably with heels, buttocks, upper back and head. The formula weight (kg)/height $(m)^2$ was used to calculate BMI. As per World Health Organisation (WHO) guideline, BMI is categorised as: underweight Below 18.5 kg/m^2, Normal weight 18.5-24.9 kg/m^2, overweight 25.0-29.9 kg/m^2 and obese above 30.0 kg/m^2 [17].

The handgrip muscle strength of right hand was measured using a standard handgrip dynamometer [Table/Fig-1] (manufactured by Labotech and supplied by B.D Instrumentation India, An ISO 9001.2008, WHO-GMP Certified Co.) in sitting position with feet on the floor. The dominant arm was placed on the table in such a position that elbow flexed at 90°, forearm in mid prone position and the wrist in neutral position [Table/Fig-2]. The participants were encouraged to squeeze the handles as hard as possible and to sustain for atleast three seconds. Two values were measured within 30 seconds duration in between and best value was recorded [18].

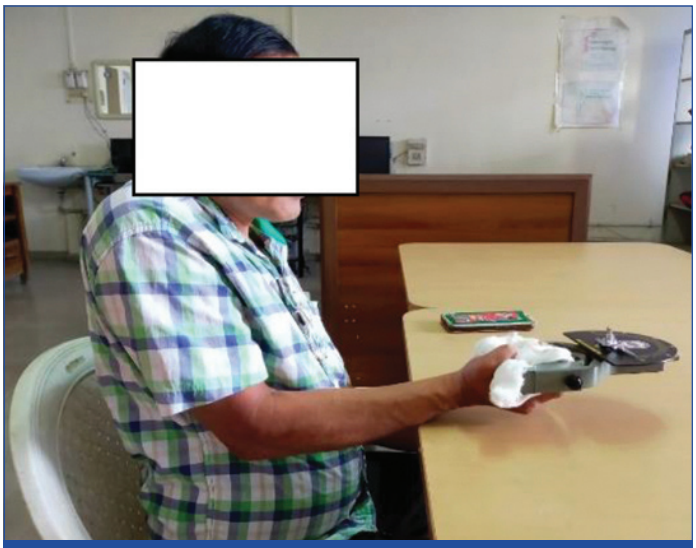
Subjects were asked to maintain 1/3 of maximal voluntary contraction for as long as he/she could to determine Handgrip Endurance (HGE) and the time was recorded in seconds [16].

STATISTICAL ANALYSIS

Statistical Package for the Social Sciences (SPSS) 16.0 version software was used for statistical analysis. Descriptive statistics (mean±standard deviation) were determined for all directly measured and derived variables. The correlations between dependant variables handgrip strength, endurance and independent variable anthropometric traits viz., height, weight, BMI were analysed through Pearson correlation coefficient. ANOVA test was also used for comparison. The p-value ≤0.05 was considered statistically significant.



[Table/Fig-1]: Handgrip dynamometer.



[Table/Fig-2]: Procedure of measuring muscle strength by handgrip dynamometer.

RESULTS

In this study, 80 subjects both males and females with the age group between 18-21 years had participated. Out of these 80 subjects, 47 (58.75%) were males and 33 (41.25%) were females. The average height of males and females were 166.40±6.27 cm 155.21±6.08 cm respectively. Average weight of males and females were 60.18±11.09 kg and 52.48±8.83 kg, respectively. The average BMI of male and female subjects were 21.71±4.03 kg/m^2 and 21.77±3.39 kg/m^2 respectively. The average handgrip muscle strength among males were 27.15±6.984 kg and 12.12±10.295 kg in females. HGE was 34.67±18.03 seconds and 16.32±8.37 seconds among males and females, respectively. All these descriptive data are shown in [Table/Fig-3].

The differences in handgrip muscle strength and endurance in different categories of BMI was investigated. Although it was seen that handgrip muscle strength was maximum in obese person but it was statistically non significant. The distribution of HGS and HGE according to BMI among male and female subjects is shown in [Table/Fig-4].

Pearson correlation coefficient was calculated to analyse the association of various anthropometric parameters like height, weight,

Variables	Male (n=47, 58.75%) Mean±SD	Female (n=33, 41.25%) Mean±SD	Total (N=80, 100%) Mean±SD
Height (cm)	166.40±6.27	155.21±6.08	161.79±8.28
Weight (kg)	60.18±11.09	52.48±8.83	57.01±10.85
BMI (kg/m^2)	21.71±4.03	21.77±3.39	21.74±3.76
HGS (in kg)	27.15±6.984	12.12±10.295	20.95±11.26
HGE (in sec)	34.67±18.03	16.32±8.37	31.63±27.25

[Table/Fig-3]: Descriptive statistics for general samples.
SD: Standard deviation; N: Total number; cm: Centimetre; kg: Kilogram; m: Meter; sec: Second; HGS: Handgrip muscle strength; HGE: Handgrip muscle endurance

Parameters		Underweight (M=12, F=4, T=16)	Normal (M=27, F=24, T=51)	Overweight (M=6, F=4, T=10)	Obese (M=2, F=1, T=3)	p-value
HGS (Mean±SD)	Male	24.42±5.78	27.37±6.845	29.67±9.42	33±4.24	0.261
	Female	10.2±2.16	11.21±10.84	19.75±11.587	---	0.484
	All	20.81±8.18	19.76±12.03	25.70±10.97	26±12.49	0.405
HGE (Mean±SD)	Male	43.42±25.74	47.67±34.03	23.50±10.06	24±5.66	0.270
	Female	18.75±7.27	15.71±10.79	14.50±7.14	---	0.833
	All	37.25±24.850	32.63±30.25	19.90±9.74	23.67±4.04	0.415

[Table/Fig-4]: Distribution of HGS and HGE according to BMI among male and female subjects.
M: Male, F: Female, T: Total, p≤0.05 was considered significance, ANOVA test was done to compare different groups

BMI with handgrip muscle strength and endurance. A moderate positive significant correlation of weight (r=0.519, p<0.001) and height (r=0.621, p<0.001) with handgrip muscle strength was observed. That means, with increase in height as well as weight there is increase in handgrip muscle strength. A low positive significant correlation of height and muscle endurance (r=0.438, p<0.001) was found which showed that with increase in height muscle endurance also increases. But no significant correlation of BMI with handgrip muscle strength or endurance was found. The correlation values and significance were depicted in the [Table/Fig-5].

Variables correlated	Correlation coeff. (r)	p-value
Weight vs. Handgrip strength	0.519	<0.001*
Height vs. Handgrip strength	0.621	<0.001*
BMI vs. Handgrip strength	0.198	0.78
Weight vs. Muscle endurance	0.200	0.075
Height vs. Muscle endurance	0.438	<0.001*
BMI vs. Muscle endurance	-0.049	0.663

[Table/Fig-5]: Correlation of anthropometric traits with handgrip strength and muscle endurance (N=80).
*p≤0.05 was considered significant. Pearson correlation coefficient test was done to determine the correlation among two variables. Coeff: Coefficient

DISCUSSION

In this cross-sectional study, association of anthropometric parameters with handgrip muscle strength and endurance, were assessed. Investigations showed that height has positive influence on both muscle strength and endurance whereas weight influences muscle strength. Clinicians should rule out influence of these parameters on muscle strength and endurance before using handgrip muscle strength as specific test for various purpose. Results of this study showed that male participants have higher values than females in all tested parameters like height, weight, HGS, and muscle endurance except in BMI and these findings are consistent with a study, where the investigation was done among Nigerian Secondary School Students of age group 14 to 18 years [19]. This may be due to the fact that out of many factors involving in the development of muscle mass, testosterone is also a factor. Testosterone also helps in increasing bone density [20]. A study by Kowal M et al., showed significant relationship between male stature and testosterone level [21].

In this study, positive correlation of height and weight with handgrip muscle strength was established. Chatterjee S and Chowdhuri BJ also agreed that handgrip strength when measured by Jammer hand dynamometer was positively correlated with weight, height and body surface area. In case of height, a positive correlation with the handgrip strength could be the result of the factor that greater heights lead to longer arms, with greater lever arm for force generation, resulting in generation of efficient amount of force. The association of body weight with the HGS can be explained as body weight not only measures body fat but also lean body mass [22]. More lean body mass can generate more strength [23]. Chandrasekaran B et al., also found an excellent correlation of age, height and weight with handgrip strength when measured using a standard modifiable sphygmanometer [24].

Although in the study on cricketers, researchers found significantly positive correlations of right-handgrip strength with height (r=0.383), weight (r=0.498), BMI (r=0.401) [15]. But in present study, no significant correlation of handgrip muscle strength with BMI was found. This may be due to small sample size of present study. Moreover, BMI measures both body fat and lean muscle mass and does not indicate distribution of fat. For fat distribution reliable marker is measurement of waist circumference. Another study showed that high waist circumference is associated with low muscle strength [25].

In this study, a positive significant correlation of height with muscle endurance was observed but could not find any significant correlation with any other parameters. But in a study conducted by Lad UP et al., found weak correlation of BMI with endurance and concluded that individuals on either side of normal BMI that is either overweight or underweight tended to have low endurance [26]. Another study undertaken in Jammu, also found similar result as of this study and concluded that both height and weight parameters are significantly correlated with endurance but could not find any correlation of BMI with endurance. The association of height with endurance can be explained as more height may lead to longer arms also, long arms may act as great lever for force generation, and potent force may be the cause of effective endurance time [27].

All these findings of present study carry practical importance in clinical practice. As anthropometric parameters like height and weight influence muscle strength and height has impact on endurance, so proper standardisation should be done before setting normalised values of muscle strength and endurance for a particular group of people.

Limitation(s)

Limitation of this study was small sample size and also, authors could not use the advanced digital dynamometer. Moreover, strength and endurance of only right hand of right-handed persons were examined. Studies in different age group with a larger sample size, using advanced digital dynamometer, on both hands of both right and left-handed individuals, can be conducted in future.

CONCLUSION(S)

The results of this study, showed that anthropometric parameters like weight, height were positively correlated with handgrip muscle

strength and height positively correlated with muscle endurance. Increase in weight handgrip muscle strength will also increase and with increase in height both strength and endurance will increase. As such these parameters should be considered before measuring handgrip muscle strength and endurance.

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