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RESEARCH ARTICLE

Comparative study of body mass index, hand grip strength, and handgrip endurance in healthy individuals

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ABSTRACT

Background: Handgrip strength (HGS) and handgrip endurance (HGE) are the important parameters to assess the upper extremity muscular strength. Only a few previous studies have shown varying correlation between BMI, HGS and HGE. **Aims and Objectives:** To record HGS and hand grip endurance (HGE) in healthy individual and to compare BMI with HGS and ET. **Materials and Methods:** Two hundred and one individuals were included in our study, comprising both males and females of age group 20-45 years. BMI was calculated using Quetelet index. Based on BMI, participants were then categorized into three groups as normal weight BMI 18.5-24.9 kg/m^2, overweight BMI 24.9-29.9 kg/m^2, and obese >30 kg/m^2. HGS was measured using a handgrip dynamometer and maximum isometric tension, T_{max} in kg was recorded. ET was measured by the time of onset of fatigue for 70% of the in T_{max} and expressed in seconds. **Results:** Our result shows that there was a significant correlation between HGE and overall BMI, with $P = 0.001$ which is highly significant. There was a highly significant difference in HGS between male and female groups, $P < 0.0001$. We also noted that BMI and HGS are negatively correlated among normal BMI male participants and weakly negatively correlated among obese males. In overweight females, the HGS and BMI were also weakly negatively correlated and had no correlation in normal and obese female participants. HGE was weakly negatively correlated among overweight and obese males. **Conclusion:** There is correlation between BMI, HGS, and HGE. HGS and HGE depend on various factors such as age, sex, built, strength of muscle, arm span, and diet. A further study in a larger population is required with multiple factors taken into consideration.

KEY WORDS: Physical Fitness; Body Mass Index; Hand Grip Strength; Hand Grip Endurance; Overweight; Obesity

INTRODUCTION

Physical fitness is the major mantra today and may it be yoga, aerobics, gym, etc.; many people around the world are conscious about their fitness. At the same time, many are suffering from diseases such as diabetes, hypertension and coronary artery disease, which are mainly due to sedentary lifestyle and unhealthy eating habits. The main aim of all the physical activities, diet, and lifestyle measures are to maintain normal range of body mass index (BMI). BMI is calculated as weight in kilograms divided by height in meters squared (kg/m^2). BMI is easy to obtain as a measure of relative weight. It is an acceptable measure for thinness and fatness and has been directly related to health risks and death rates in many populations.[1] Handgrip strength (HGS) and handgrip endurance (HGE) are the important parameters to assess the upper extremity muscular strength of an individual.[2] Evidence has shown that there were strong

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correlations between grip strength and various anthropometric parameters, such as weight, height, hand length, and BMI reported by some earlier studies.[3-5] HGS is a physiological variable which is affected by a number of factors such as age, gender, and body size among others.[6,7] Measurement of HGS is cheap and simple, and it is often used to evaluate muscle strength. As some of the studies show a negative correlation between BMI and HGS, some show a positive correlation between BMI and HGE. Furthermore, only a very few studies are done in this direction; hence, we took a study to compare and correlate BMI with HGS and endurance time (ET).

Aims and objectives of the study are to calculate the BMI of the subjects, to record HGS and ET in them, and to compare BMI with HGS and ET.

MATERIALS AND METHODS

Two hundred and one participants were included in our study, comprising both males and females of age group 20-45 years. We considered this age group because this age group is physically active group. Before 20 years, physical development will be taking place, and from 45 years onward, the mortality rate begins to increase. This study is a cross-sectional study done in the Department of Physiology, Hassan Institute of Medical Sciences, Hassan, after obtaining the Ethical Clearance (Dated 08-06-2015, IEC No: 32), and informed consent was obtained from the participants. The duration of our study was 4 months. The following are the inclusion and exclusion criteria. Healthy males and females of age group of 20-45 years were included in our study. Those suffering from hypertension, diabetes, any neuromuscular disorders, paralysis or hemipariesis, history of smoking or alcoholism, and history of intake of any drugs were excluded from the study. Body height was measured standing against a wall without shoes using a measuring tape in meters. Body weight was obtained with light indoor clothing in kilograms. BMI was calculated using Quetelet index. According to the WHO classification of BMI, participants were then categorized into three groups as normal weight BMI 18.5-24.9 kg/m^2, overweight BMI 24.9-29.9 kg/m^2, and obese >30 kg/m^2.

Measurement of HGS was done using a handgrip dynamometer (Jagson India make). HGS was measured in participants in seated position with elbow by their side and flexed to right angles and a neutral wrist position and provision of support underneath the dynamometer. In this position, the participant is asked to compress the HGS dynamometer with maximum strength. HGS can be quantified by measuring the amount of static force that the hand can compress/squeeze around a dynamometer. The mean of three trials of grip strength is taken. This is referred to as maximum isometric tension, T_{max} in kg and ET is measured by the time of onset of fatigue for 70% of the in T_{max}[8-12] expressed in seconds.

Statistical Methods

A *t*-test was used for comparisons between BMI, HGS, and HGE. Pearson's correlation coefficients were used to establish the correlations of BMI with HGS and HGE. $P \leq 0.05$ is taken as a significant value.

RESULTS

Our study group consisted of 201 participants, of which 100 were male and 101 were female. Table 1 and Figure 1 show age-wise distribution of participants: 29% were of the age group 20-24 years, 43% were of the age group 25-29 years, 58% were of the age group 30-34 years, 35% were of the age group 35-39 years, and 36% were of the age group 40-44 years. Table 1 shows statistical analysis of height, weight, and BMI of all the participants expressed as mean and standard deviation. The average height was 1.62 ± 9.16 m, the average weight was 63.14 ± 9.94 kg, and average BMI was 23.8 ± 2.73 kg/m^2.

Tables 2-4 show correlation between overall BMI of the participants with HGS and HGE, and our result shows that there was a significant correlation between HGE and BMI, with $P = 0.001$ being highly significant, but there was no significant correlation between BMI and HGS.

Table 5 depicts the HGS and HGE in male and female participants. The HGS in male was 34.64 ± 7.52 kg and in female was 24.18 ± 5.67 kg. There was a highly significant difference in HGS between male and female groups, $P < 0.0001$. The HGE in male and female was 79.77 ± 39.56 s and 54.35 ± 22.98 s, respectively. The HGE was also highly significant in male as compared to female, $P < 0.0001$.

Table 1: Physical data of the participants

Parameters	Number	Total
Males	100	201
Females	101	
Parameters	**Number**	**Mean±SD**
Height	201	1.62±9.16
Weight	201	63.14±9.94
BMI	201	23.8±2.73

BMI: Body mass index; SD: Standard deviation

Table 2: Pearson's correlation coefficient between BMI with HGS and HGE

Parameters	Correlation coefficient value (r)	*P*
HGS	0.1	*P*=0.16*
HGE	0.24	*P*=0.001*

HGS: Handgrip strength, HGE: Handgrip endurance, BMI: Body mass index, *P*<0.05

Table 6 depicts the various *r* and *P*-value in male and female participants, whose BMI was further classified into normal, overweight, and obese. Our results show that normal BMI males had a significant negative correlation between BMI and HGS ($P < 0.046$). Obese males had negative correlation between BMI and HGS, but it was not significant. Overweight females also had negative correlation between BMI and HGS, but it was not significant.

DISCUSSION

The results in our study show HGS was highly significant in males compared to females ($P < 0.0001$). Similar findings were noted by Das and Dutta,[2] Shetty et al.,[5] Manjuanth et al.,[13] Rolland et al.,[14] Ravisankar et al.,[15] and Leyk et al.[16] Muscle strength is determined largely by muscle girth; a muscle with a larger cross-sectional area can generate more force and therefore lift more weight than one with a smaller cross-sectional area. As the male hormone testosterone enlarges muscles, men tend to be stronger than women.[17] The greater muscle strength in males has been to a large extent attributed to differences in muscle mass.[18]

Table 3: Correlation between BMI and HGS

Parameters	Mean±SD		n
BMI	23.82±2.73		201
HGS	29.38±8.46		201
	Correlations	**BMI**	**HGS**
BMI	Pearson correlation	1	0.100
	Significant (two-tailed)		0.157
	n	201	201
HGS	Pearson correlation	0.100	1
	Significant (two-tailed)	0.157	
	n	201	201

There is no correlation between BMI and HGS (P=0.157), HGS: Handgrip strength, HGE: Handgrip endurance, BMI: Body mass index, SD: Standard deviation

Table 4: Correlation between BMI and ET

Parameters	Mean±SD		n
BMI (kg/m^2)	23.82±2.73	201	
HGE (s)	93±63	201	
	Correlations	BMI	HGE
BMI	Pearson correlation	1	0.241**
	Significant (two-tailed)		0.001
	n	201	201
HGE	Pearson correlation	0.241**	1
	Significant (two-tailed)	0.001	
	n	201	201

**Correlation is significant at the 0.01 level (two-tailed), There was positive correlation between BMI and ET (P=0.001), HGS: Handgrip strength, HGE: Handgrip endurance, BMI: Body mass index, ET: Endurance time, SD: Standard deviation

In addition, it was found that testosterone increases type II fibers,[19] which are the fast fibers with high glycolytic enzyme activity. The type II fibers are in high proportion in males. Increase strength in males is also attributed to increased bone mineral density in males,[13] thus males having higher HGS than females in our study.

When BMI was classified into normal, overweight, and obese, we found that male participants with normal BMI had a significant negative correlation with HGS ($r = -0.257$, $P = 0.046$). Massy-Westropp et al. in their study noted a very weak positive relationship between higher BMI and right HGS in the youngest and oldest age groups in the sample. They also noted that BMI was negatively correlated with HGS in age groups of 4th, 5th, and 6th decades.[20] Our study group consisted of age group between 20 and 45 years, which comes between youngest and oldest group, and hence, as noted in the previous study, in our study also, we noted a significant negative correlation between BMI and HGS. Disparity exists in previous studies over the relationship between HGS and

Table 5: Comparison of HGS and HGE in males and females

Parameters	n	Mean±SD	
HGE-male	100	79.77±39.57	
HGE-female	101	54.35±22.98	
HGS-male	100	34.64±7.52	
HGS-female	101	24.18±5.67	
Valid *n* (listwise)	100		
	Males (mean±SD)	**Females (mean±SD)**	***P***
HGS (kg)	34.64±7.52	24.18±5.67	<0.0001
HGE (s)	79.77±39.56	54.35±22.98	<0.0001

Both HGS and HGE in males were highly significant compared to females (P<0.0001), HGS: Handgrip strength, HGE: Handgrip endurance, SD: Standard deviation

Table 6: Comparison between BMI and HGS and HGE in males and females expressed as Pearson's correlation coefficient

BMI	HGS		HGE	
	r	*P*	*r*	*P*
Male				
Normal	−0.257	0.046*	0.017	0.896
Overweight	0.048	0.782	−0.06	0.730
Obese	−0.563	0.437	−0.274	0.726
Female				
Normal	0.09	0.422	−0.015	0.895
Overweight	−0.112	0.659	0.241	0.335
Obese	0.00	1.0	0.00	1.0

*There was a significant negative correlation between normal BMI and HGS in males, HGS: Handgrip strength, HGE: Handgrip endurance, BMI: Body mass index

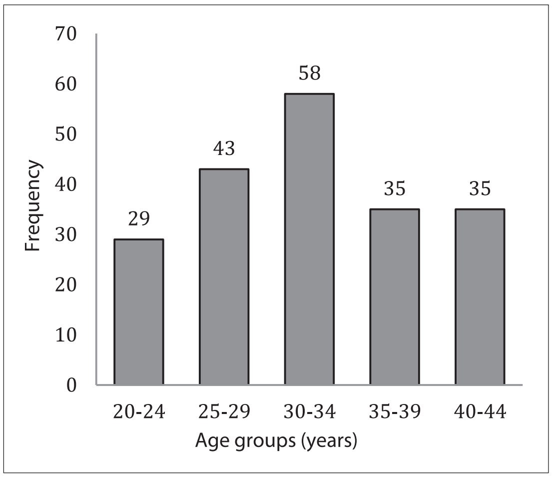

Figure 1: Age wise distribution of participants

BMI, many studies claiming a positive relationship between grip strength and BMI in both males and females and all age groups, while others found no relationship.[21-24] These studies involved participants of different age groups, genders, ethnicity, types of work, and food habits.

A negative correlation was noted between BMI and HGS though not significant in some study.[2,5] There was no correlation between BMI with HGS and ET in overweight. Normal BMI males showed non-significant positive correlation between BMI and HGE and a non-significant negative correlation between BMI and HGE in overweight and obese males.

In obese males, both HGS and ET were negatively correlated but not significant. In obesity, it is mainly due to impairment of muscle strength by accumulation of fat; also, obese participants have fewer type I and more type IIb muscle fibers than their lean counterparts. Fat mass is inversely correlated with type I fibers and is positively correlated with type II fibers.[25-28] The muscle function is not significantly different between lean and obese participants when adjusted for their age, height, physical activity, pain, depression, and appendicular skeletal muscle mass.[29] Obese women have lower muscle strength of both upper and lower extremities when compared to lean women, which is explained by their lower degree of activity.[30] In overweight females, there was insignificant negative correlation observed between BMI with HGS. The study conducted by Podstawski et al.[31] revealed that overweight female students had a significantly lower level of endurance strength abilities than their underweight or normal peers. Das and Dutta,[2] in their study, found that males had higher HGS and endurance than females and a significant correlation between BMI and HGS and endurance in overweight and underweight participants. Shetty et al.[5] found that significant negative correlation between HGS and BMI in overweight males and significant positive correlation between HGE and BMI only in underweight males. There was positive correlation between BMI and ET in all the 200 subjects irrespective of sex and BMI (r = 0.241 and $P < 0.001$), which was highly significant. In our study, males showed a statistically insignificant positive correlation between the BMI and the HGE in normal weight group and statistically insignificant negative correlation between the BMI and the HGE in overweight and obese participants. Podstawski et al.[31] in their study noted that those in the higher BMI range are expected to perform worse in relative endurance-strength trials, such as 3-min Burpee test. Hulens et al.[32] reported that there was a statistically non-significant, positive correlation between the BMI and the HGE in underweight and normal weight males and a negative correlation in overweight males. In females, the correlation was insignificantly positive in the overweight group only.

CONCLUSION

In our study, we found that BMI and HGS are negatively correlated among normal BMI male participants and weakly negatively correlated among obese males. In overweight females, the HGS and BMI were also weakly negatively correlated and had no correlation in normal and obese female participants. HGE was weakly negatively correlated among overweight and obese males. HGS and HGE depend upon various factors such as age, sex, built, strength of muscle, arm span, and diet. A further study in a larger population is required with multiple factors taken into consideration such as waist circumference, waist to hip ratio, abdominal fat, and skin fold thickness, in addition to BMI for better conclusions.

REFERENCES

1. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004;363(9403):157-63.
2. Das A, Dutta M. Correlation between body mass index and handgrip strength and handgrip endurance among young healthy adults. J Evid Based Med Healthc. 2015;2(27):3995.
3. Häger-Ross C, Rösblad B. Norms for grip strength in children aged 4-16 years. Acta Paediatr. 2002;91(6):617-25.
4. Koley S, Kaur SP. Correlations of handgrip strength with selected hand-arm-anthropometric variables in Indian inter-university female volleyball players. Asian J Sports Med. 2011;2(4):220-6.
5. Shetty CS, Parakandy SG, Nagaraja S. Influence of various anthropometric parameters on handgrip strength and endurance in young males and females. Int J Biol Med Res. 2012;3(3):2153-7.
6. Lindblad1 A, Dahlin-Ivanoff S, Bosaeus I, Rothenberg E. Body composition and hand grip strength in healthy community-dwelling older adults in Sweden. J Aging Res Clin Pract. 2015;4(1):54-8.
7. Baskaran C, Arindam G, Chandan P, Bidhan C. Anthropometric traits predict hand grip strength in healthy normal. Springer J Hand Microsurg. 2010;2(2):58-61.
8. Fess EE. Grip strength. In: Casanova JS, editor. Clinical

Assessment Recommendations. 2nd ed. Chicago: American Society of Hand Therapists; 1992. p. 41-5.
9. Adam C, Klissouras V, Ravazzolo M, Renson R, Tuxworth W. EUROFIT: European Test of Physical Fitness. Rome, Italy: Council of Europe, Committee for Development of Sport; 1988.
10. Bassey EJ, Harries UJ. Normal values for handgrip strength in 920 men and women aged over 65 years, and longitudinal changes over 4 years in 620 survivors. Clin Sci (Lond). 1993;84(3):331-7.
11. Massy-Westropp NM, Gill TK, Taylor AW, Bohannon RW, Hill CL. Hand grip strength: Age and gender stratified normative data in a population-based study. BMC Res Notes. 2011;4:127.
12. Kaur N, Koley S. An association of nutritional status and hand grip strength in female labourers of North India. Anthropologist. 2010;12(4):237-43.
13. Manjuanth H, Venkatesh D, Rajkumar S, Taklikar RH. Gender Difference in hand grip strength and electromyogram (EMG) changes in upper limb. Res J Pharm Biol Chem Sci. 2015;6(4):1889.
14. Rolland Y, Lauwers-Cances V, Pahor M, Fillaux J, Grandjean H, Vellas B. Muscle strength in obese elderly women: Effect of recreational physical activity in a cross-sectional study. Am J Clin Nutr. 2004;79(4):552-7.
15. Ravisankar P, Madanmohan, Udupa K, Prakash ES. Correlation between body mass index and blood pressure indices, handgrip strength and handgrip endurance in underweight, normal weight and overweight adolescents. Indian J Physiol Pharmacol. 2005;49(4):455-61.
16. Leyk D, Gorges W, Ridder D, Wunderlich M, Rüther T, Sievert A, et al. Hand-grip strength of young men, women and highly trained female athletes. Eur J Appl Physiol. 2007;99(4):415-21.
17. Morehouse LE, Miller AT. Strength. In: Physiology of Exercise. 5th ed. London: The CV Mosby Company; 1967. p. 50-60.
18. Astrand PO, Rodahl K. Neuromuscular junction. In: Textbook of Work Physiology. International Student edition. Tokyo: McGraw-Hill Kogakusha Ltd.; 1970. p. 35-100.
19. Gutmann E, Hanzlíková V, Lojda Z. Effect of androgens on histochemical fibre type. Differentiation in the temporal muscle of the guinea pig. Histochemie. 1970;24(4):287-91.
20. Massy-Westropp NM, Gill TK, Taylor AW, Bohannon RW, Hill CL. Hand grip strength: Age and gender stratified normative data in a population-based study. BMC Res Notes. 2011;4:127.
21. Apovian CM, Frey CM, Wood GC, Rogers JZ, Still CD, Jensen GL. Body mass index and physical function in older women. Obes Res. 2002;10(8):740-7.
22. Koley S, Kaur N, Sandhu JS. A study on hand grip strength in female labourers of Jalandhar Punjab. India Life Sci. 2009;1(1):57-62.
23. Vaz M, Hunsberger S, Diffey B. Prediction equations for handgrip strength in healthy Indian male and female subjects encompassing a wide age range. Ann Hum Biol. 2002;29(2):131-41.
24. Chilima DM, Ismail SJ. Nutrition and handgrip strength of older adults in rural Malawi. Public Health Nutr. 2001;4(1):11-7.
25. Norman K, Stobäus N, Gonzalez MC, Schulzke JD, Pirlich M. Handgrip strength: Outcome predictor and marker of nutritional status. Clin Nutr. 2011;30(2):135-42.
26. Tanner CJ, Barakat HA, Dohm GL, Pories WJ, MacDonald KG, Cunningham PR, et al. Muscle fiber type is associated with obesity and weight loss. Am J Physiol Endocrinol Metab. 2002;282(6):E1191-6.
27. Kriketos AD, Pan DA, Lillioja S, Cooney GJ, Baur LA, Milner MR, et al. Interrelationships between muscle morphology, insulin action, and adiposity. Am J Physiol. 1996;270:R1332-9.
28. Mårin P, Andersson B, Krotkiewski M, Björntorp P. Muscle fiber composition and capillary density in women and men with NIDDM. Diabetes Care. 1994;17(5):382-6.
29. Rolland Y, Lauwers-Cances V, Pahor M, Fillaux J, Grandjean H, Vellas B. Muscle strength in obese elderly women: Effect of recreational physical activity in a cross-sectional study. Am J Clin Nutr. 2004;79(4):552-7.
30. Hulens M, Vansant G, Lysens R, Claessens AL, Muls E, Brumagne S. Study of differences in peripheral muscle strength of lean versus obese women: An allometric approach. Int J Obes Relat Metab Disord. 2001;25(5):676-81.
31. Podstawski R, Bernard K, Tomasz B, Michał B, Dariusz C. Relationship between BMI and endurance-strength abilities assessed by the 3 minute burpee test. Int J Sports Sci. 2013;3(1):28-35.
32. Hulens M, Vansant G, Lysens R, Claessens AL, Muls E, Brumagne S. Study of differences in peripheral muscle strength of lean versus obese women: An allometric approach. Int J Obes Relat Metab Disord. 2001;25:676-81.

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