Original Article

CORRELATION OF BODY COMPOSITION WITH HAND GRIP STRENGTH AND BLOOD PRESSURE INDICES IN DIFFERENT GRADES OF OBESITY.

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ABSTRACT

OBJECTIVES: To find out whether there is any correlation of body mass index, body composition, blood pressure indices and hand grip strength and to find out how body composition measures like body fat percentage and lean body mass are correlated to hand grip strength and blood pressure indices in different grades of obesity.

Materials and Methods: Three hundred and eighty-one obese participants between the age group of 20-50 years with no history of systemic illness, musculoskeletal disorder, hand pain or deformity were selected. Informed consent was obtained. Biodata and anthropometric measurements were documented in a proforma. HGS is taken from the dominant hand were measured using a hand-held dynamometer. Blood pressure was recorded using a mercury sphygmomanometer. Data on BMI was sub grouped according to the World Health Organization defined cutoff values for BMI among Asian population as following: Obese Class I 30-35 kg/m2, Obese Class II 35-40 kg/m2, Obese Class III > 40 kg/m2 to compare the HGS among them. Body composition is taken by skin fold calliper according to 7 site Jackson and pollock formulae.

Results: There was a statistically significant negative correlation between BMI and HGS ($r = -0.513$; $P < 0.01$), BMI and grip strength ratio ($r = -0.750$; $P < 0.01$). Statistically significant decrease in HGS was found among Grade III obese participants (29.36 ± 7.01), Obese grade II participants (26.18 ± 5.45) and obese grade I participants (20.48 ± 3.12) with Kruskal–Wallis value $\chi 2 = 14.231$. Furthermore, a statistically significant positive correlation was found between BMI and systolic blood pressure ($r = 0.603$; $P < 0.01$), BMI and diastolic blood pressure ($r = 0.514$; $P < 0.01$), BMI and pulse pressure ($r = 0.228$; $P < 0.01$) and between BMI and mean arterial pressure ($r = 0.572$; $P < 0.01$).

Conclusion: BMI was found to be negatively correlated with HGS and positively correlated with blood pressure indices. This can influence as an important predictor of morbidity and mortality. Determinants such as grip span, hand span, skeletal muscle bulk, and arm and calf muscle circumference are to be considered for further research to improve the endurance of obese individuals.

INTRODUCTION

"A sound mind in a sound body." The English translation of a famous quotation by the Socratic Greek philosopher Thales of Miletus shows the close links between physical exercise, mental equilibrium, ability to perform and to enjoy life.

Physical fitness has increasingly been recognised as an important predictor of morbidity and mortality. Fast food consumption and gadgets simplifying life can lead to physical inactivity leading to obesity, which influence the cognitive, affective and psychomotor applications. However, it will be impaired by their physical unfitness. Hence an assessment of physical endurance and proper guidance is necessary among the obesity individuals. The relationship between physical fitness and cardiovascular health has also been well documented in obese individuals. Muscular fitness, as indicated by handgrip strength, has become an important cardiometabolic marker in obese individuals. Although muscular fitness is overall associated with cardiometabolic health in obese, some have questioned the association between muscular strength and cardiometabolic risk. In terms of Blood Pressure and Body Composition recent studies have demonstrated that high muscle strength is associated with low Blood Pressure however, with conflicting results in different grades of obesity.[1]

Anthropometric measurements and body composition are the important tools to evaluate the health status and nutritional pattern. Also, different components of body composition reflect energy balances with the functional and metabolic parameters of the body, but are highly associated with the cardio respiratory health.

Body Mass Index (BMI) is an acceptable tool for measuring thinness and fatness and is directly linked to health risks and death rates.[2] It is a better index of body fatness compared to Waist-Hip Ratio.

Body Mass Index (BMI) over 30kg/m^2 is associated with health risks which are overlapped with obesity including hypertension, dyslipidaemia, type-2 diabetes, coronary heart disease, stroke, gall bladder disease, osteoporosis, sleep apnoea, respiratory and other systematic conditions.

The Asian countries are facing a unique challenge of growing overweight/obesity and a persistent burden of under nutrition. The Hand Grip Strength and Body Composition have evolved as an important tool for the assessment of the nutritional status, it is being considered as a reliable marker of the muscle quality. The nutritional status can influence the muscle quality and so, the muscle strength. The correlation between the muscle strength and obesity were studied separately by many researchers, but very few studies have investigated the longitudinal assessment of the body mass index (BMI) with the muscle strength/ muscle endurance in various body mass index (BMI) ranges/groups. Most of these studies were done in either the adult or the old population, only few were done in obese individuals. The decreased muscle strength in obese individuals can be explained on the basis of the energy deficiency. There are studies which have stated that the muscles of obese persons will have a fatty infiltration and a change in the distribution of the type I and type II muscle fibres, which will alter the muscle strength and endurance whereas the status of the muscle strength/endurance in the obese population has yet to be clearly understood. [5]

Muscle strength is directly related to the functional activities and assessing muscle strength will help to identify individuals at higher risk of impaired mobility. Hand Grip Strength (HGS) is a quick and inexpensive way to measure an individual's muscle strength and studies have shown that it highly correlates with the total muscle strength.[3] The previous studies have shown that increasing body mass index (BMI) is associated with reduced grip strength.[4] A possible explanation for this finding could be deposition of excess fat in the muscle leading to a change in the distribution of Type 1 and Type 2 muscle fibres thereby altering the muscle strength and endurance.[5]

So, Hand Grip Strength (HGS) is used as an indicator for overall physical health, hand and forearm muscles functions, as a measure of functional index of nutritional status and physical fitness in normal adults and in obese individuals. Hand Grip Strength is a variable affected by factors like hand size or hand span, age, gender, posture, grip, muscle length, insertion, angle of tendon at time of contraction, nutritional status, body mass index (BMI), fatigue tendencies, hand dominance, pain threshold, cooperation of the patient, sensory loss, hip/waist circumference, body size, arm and calf circumferences and various subcutaneous skin folds.

Pre-hypertension is another condition prevalent among obese individuals. This could be because of psychological stress.[6] Studies have shown that high body mass index (BMI) is also associated with increasing blood pressure in addition to declining grip strength.[7] The physiological basis for this observation could be that hand grip is an example of isometric contraction wherein tension is generated without change in muscle length. Therefore, when muscle contracts in an isometric fashion, blood flowing through the vessels and arteries get interrupted and pressure develops inside the circulatory system. If the blood pressure of the individual is already elevated, then this interruption of blood flow will affect the muscle contraction and thereby grip strength.[8]

The present study is an endeavour to assess the health status of obese individual in terms of body mass index (BMI) and to find out whether there is any correlation between body mass index (BMI) with hand grip strength (HGS) and Blood Pressure Indices. Assessment of grip strength and blood pressure indices in individuals with different body mass index (BMI) can be used to identify those individuals with poor muscle strength. Thus, lifestyle changes such as adoption of resistance and strength training exercises can improve the muscle strength and tone. Furthermore, practicing the intake of healthy nutritious diet can help in building muscle mass which, in turn, can help to improve their Blood Pressure Indices.

MATERIALS AND METHODS

After obtaining Institutional Research Committee and Ethics Committee approval, the study was conducted in the Department of Physiotherapy, Nizam's institute of medical sciences, Hyderabad, from March 2024 to October 2024.

Study design

Sample size was calculated using G-Power software. Sample size was calculated based on the study by Ravisankar et al [9]. Accordingly, 381 Obese participants of both sexes between the age group of 20-50 years were selected as study participants and written consent were obtained.

PROCEDURE

Subjects were instructed to take their last meal at least two hours before conducting the test to prevent the specific dynamic action of food. All the tests and measurements will be taken at room temperature. Sufficient rest will be given to all subjects before each procedure to get accurate result.

The assessment is one time, three trials for grip strength readings on a hand-held dynamometer, seven site skin fold measurements with calliper, and weight and height will be noted of each participant. Blood pressure will be measured by mercury sphygmomanometer to know the systolic and diastolic pressure. Blood pressure indices (Pulse Pressure and Mean Arterial Pressure) will be calculated.

Height will be measured using a stadiometer attached to the wall. Reading will be taken in centimetres and expressed in meters. Weight will be recorded using a digital platform weighing scale and expressed in kilograms with participants standing barefoot and looking straight. BMI will be calculated using the formula: - BMI = Weight in kilograms/ (Height in meters)2 and categorised according to the World Health Organization defined cutoff values for BMI among Asian population as following:

Obese Class I 30-35 kg/m2

Obese Class II 35-40 kg/m2

Obese Class III > 40 kg/m2

Hand grip strength (HGS) is assessed by JAMAR hand held dynamometer (dominant hand). The participants will be instructed to keep their dominant hand on the table with the angle in the elbow maintained at 90° and they will be asked to press the handle of the dynamometer with maximum strength. The HGS will be quantified in kilograms from the maximum voluntary contraction sustained for at least 3 s. A verbal instruction and demonstration of the test will be given to each participant before stating the assessment. Three readings will be taken with brief pauses of 10–20 s and the best result will be taken for the analysis.

To avoid the potential bias effect of body weight on estimation of HGS, grip strength ratio will be calculated from HGS and weight of the participant. In males, HGS more than or equal to 35 kg is considered as normal HGS and below 35 kg is considered as reduced HGS. In females, HGS more than or equal to 19 kg is considered as normal HGS and below 19 kg is considered as reduced HGS.

After a period of rest for about 5 min, blood pressure will be recorded on the right arm in sitting posture using a mercury sphygmomanometer and expressed in millimetres of mercury. Three readings will be taken at an interval of at least 5 min and the average of the three readings will be used for analysis. Pulse pressure (PP) is calculated as the difference between systolic and diastolic blood pressure (DBP). Mean arterial pressure (MAP) is calculated as DBP +1/3 PP.

The assessment consists of measuring body composition by skinfold measurement method using Jackson and Pollock's seven site formula. Seven-Site Formula (sites: chest, midaxillary, triceps, subscapular, abdomen, suprailiac and thigh) will be measured by skin fold calliper.

Body density

Women = Db = 1.097 - 0.00046971 (sum of seven skinfolds) + 0.00000056(sum of seven skinfolds) 2 - 0.00012828 (age).

Men = Db = 1.112 - 0.00043499(sum of seven skinfolds) + 0.00000055(sum of seven skinfolds)2 - 0.00028826(age).

Total Body Fat Percentage = 495/Body Density – 450.

Fat Mass (FM) = current BW x (% BF / 100%).

Fat Free Mass (FFM) = BW – Fat Mass.

Target Body Weight = FFM/ 1 – (desired % BF/100).

The data were analysed by SPSS version 28.0 Results were summarised in tables and figures. Comparison of variables between male and female participants was done using unpaired t-test. Comparison of variables among different BMI groups was done using one-way analysis of variance. Correlation of BMI with handgrip parameters and blood pressure indices was assessed by Pearson Correlation coefficient. Kruskal–Wallis test and Chi-square test were done to find out the statistical difference in HGS among different BMI groups. $P < 0.05$ was considered statistically significant.

RESULTS

Among 381 healthy medical students (159 male and 222 females obsess participants), 81 (21%) were Grade I obese, 186 (49%) were Grade II obese and 114 (30%) were Grade III obese. These results demonstrate that nearly half of the participants were of Grade II obese, while the rest were either Grade

I and Grade III. The mean BMI among males and females were 22.83 ± 3.44 and 23.29 ± 3.64, respectively (P ≥ 0.215). There was statistically significant difference in Handgrip parameters and Blood pressure indices among different BMI groups. Correlation between BMI and handgrip strength is summarised in [Figures 1]. A statistically significant difference in HGS was found among all grades III of obesity. ($\chi 2 = 14.231$, P ≤ 0.001). Furthermore, there was a statistically significant difference in HGS between all grades of obesity participants. [Tables 1]. However, there was no statistically significant difference in HGS between grades I of obesity ($\chi 2 = 3.656$, P ≥ 0.056). There was significant positive correlation between BMI and all BP indices (systolic blood pressure [SBP], DBP, PP, and MAP) [Table 2]. Correlation between BMI with Fat mass free mass, BMI with Fat mass showed positive significant changes. [Table 3 and 4]

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Figure 1: Statistically significant negative correlation between body mass index (BMI) and grip strength (HGS) ratio with Pearson correlation coefficient r = −0.750; P < 0.01.

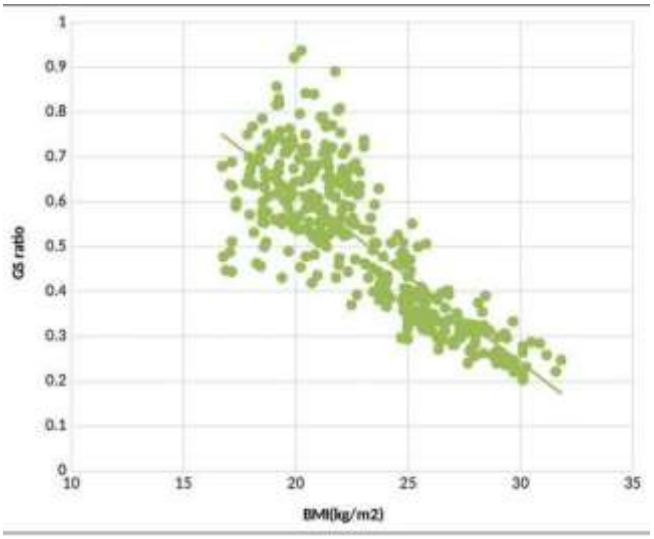

Table 1: Association between HGS and BMI in different grades of obesity participants.

		GRADE I (n=81)	GRADE II (n=186)	GRADE III (n=114)
Reduced HGS (%)		20% (5)	62.5% (35)	40% (46)
Normal HGS (%)		80% (20)	37.5% (21)	60%(68)

Table 2: Correlation of BMI with blood pressure indices.

	r-value	P-value
SBP	0.603**	0.000
DBP	0.514**	0.000
PP	0.228**	0.000
MAP	0.572**	0.000

BMI: Body mass index, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, PP: Pulse

pressure, MAP: Mean arterial pressure, **P < 0.01.

Table 3: Correlation between BMI and FAT FREE MASS

Grade of obesity	BMI versus FAT FREE MASS "r"	p value
I	-0.04	0.862
II	0.09	0.775
III	0.59	0.128

Table 4: Correlation between BMI and FAT MASS

Grade of obesity	BMI versus FAT MASS "r"	p value
I	0.24	0.287
II	-0.17	0.573
III	0.26	0.542

DISCUSSION:

The main objective of this study was to find out the correlation of Body Mass Index with Hand Grip Strength, blood pressure indices and body composition. This was found to be statistically significant by Kruskal Wallis test (P < 0.05). A statistically significant positive correlation was seen between Body Mass Index and hand grip parameters.

It was found that the Hand Grip Strength between different grades of obesity were statistically significant. The study by Thong-Ngam *et al*., had shown that subjects with higher Body Mass Index tended to have less muscle strength indicating the negative impact of obesity on physical performance apart from increasing the risk of various diseases. With declining physical performance, they tend to have functional limitations, to be less physically active, and will consequently gain more weight.

The correlation between Body Mass Index, Blood Pressure (Systolic Blood Pressure and Pulse Pressure) has been inconsistent, with some reporting an inverse correlation while others a positive correlation. Dong *et al.* reported that handgrip strength was positively correlated with Blood Pressure after adjustment of stratified by Body Mass Index. Demmer *et al.* reported similar results in both males and females.

All these findings, along with ours, are in contrast to the findings of an inverse correlation by Diez-Fernandez *et al.* showing that the inverse correlation is mediated by Body Mass Index. The positive correlation we observed is in accordance with the studies of Dong *et al.* and Demmer *et al.* i.e., there is a correlation between muscular fitness (Handgrip Strength) with other cardiometabolic risk factors, particularly in obese individuals.[1]. The study highlights complex interplay between handgrip strength, blood pressure, and obesity.

Research indicates that higher levels of handgrip strength are associated with an increased risk of hypertension, especially among obese individuals mainly men. In a study analysing data from the National Health and Nutrition Examination Survey (NHANES), increased handgrip strength was linked to higher diastolic blood pressure (DBP) and a significant association with hypertension risk was observed, with an odds ratio of 1.31 in obese individuals mainly men after adjusting for confounding factors like age and Body Mass Index.

Although some research suggests conflicting evidence shows that positive relationship between blood pressure and handgrip strength, other research suggests that, especially in groups with visceral adipose dysfunction, a higher relative handgrip strength may actually lower the risk of hypertension. High relative handgrip strength was linked to a lower incidence of hypertension in large-cohort research conducted in Korea, which is independent of visceral fat problems.

Obesity is a known risk factor for hypertension, and it complicates the interpretation of the handgrip strength-Blood Pressure relationship. Increased body mass index (BMI) correlates with both lower grip strength and higher Blood Pressure. This suggests that while stronger grip strength might be beneficial in some contexts, in obese individuals, it could also be indicative of greater cardiovascular risk.

The implications of these findings raise questions about the role of resistance training in managing hypertension among obese individuals. Although resistance training is generally beneficial for muscle strength, its effects on arterial compliance and stiffness may counteract some cardiovascular benefits, particularly in those with obesity.

Similar results were seen in the study of Shetty *et al*. which suggested that physical activity hindered the accumulation of body fat and extensive use of hand and finger muscles which enable to achieve greater strength.

Hand Grip Strength was another parameter that was found to be significantly correlated with Body Mass Index. Our results were in agreement with those of Bovet *et al*.

Lad *et al*. in their study suggested that increase in body fat percentage might decrease the Hand Grip Endurance but not the Hand Grip Strength.[5] Systolic Blood Pressure, Diastolic Blood Pressure and Mean Arterial Pressure were highest in grade III obese individuals. This could be possibly due to differences in sympathetic tone of the obese participants.

A study by Ahad and Nowreen *et al*. also showed a positive significant correlation between Blood Pressure indices and both Body Mass Index and neck circumference.[14] Body Mass Index was consistently associated with Systolic Blood Pressure and Diastolic Blood Pressure in obese individuals and gender matched groups.

Ibhazehiebo *et al*. found both diastolic and systolic hypertension (12%) in obese individuals (BMI >30 kg/m2) that positively correlated with Body Mass Index.[19] There are also reports of isolated diastolic or systolic hypertension in obese individuals correlating positively with Body Mass Index.

In obese individuals, the relationship between handgrip strength and Blood Pressure might differ compared to non-obese individuals. For instance, the benefits of increased muscular strength might be overshadowed by the negative effects of obesity on Blood Pressure. Conversely, improved strength could potentially offer protective benefits against Blood Pressure increases due to obesity.

Simran and Vidushi have observed that there is impaired function of both sympathetic and parasympathetic divisions of autonomic nervous system in obese individuals.

Males who are obese showed a statistically insignificant positive correlation between the Body Mass Index and the handgrip strength. This was similar to the findings of Ravisankar *et al*.,

In females, the Body Mass Index showed a significant positive correlation with the handgrip strength in all the three grades of obesity. The results of this study are also in positive correlation and coherence

with those of S. Pieterse et al., they also found a positive correlation between the Body Mass Index and the handgrip strength, but their study was done in the older population, while our study was done on obese individuals.

The relationship between Body Mass Index and handgrip strength is complex and varies based on factors like age, sex, and obesity. In young adults, there is a statistically significant negative correlation between Body Mass Index and handgrip strength in the elderly, the relationship is more controversial. Some studies show handgrip strength increases with increasing Body Mass Index and waist circumference, although the relationship is weak. Low Body Mass Index is correlated with lower muscle strength, while high waist circumference is correlated with lower handgrip strength.

The association between the Body Mass Index, the body fat percentage and the handgrip strength can be explained on the basis of the fact that the Body Mass Index is an indicator of the body mass it does not take the fat percentage into account and as an index, it is unable to differentiate between the weight changes which are due to an increase or decrease in the muscularity and the body fat percentage.

The obese population might have had more muscle mass than fat. A further study of the muscle biopsy and the quality of the muscle fibres might throw light on this.

The aim of our study was to find out whether there was any correlation between the Body Mass Index, body fat percentage, handgrip strength and the blood pressure indices. We found that the grade I obese individuals had a higher handgrip strength than grade II and grade III obese individuals and this difference was statistically significant. Our results were in agreement with those of Bovet P *et al*.,

There was a statistically non-significant, positive correlation between the Body Mass Index and the handgrip strength in different grades of obesity. Our results were similar to those of Bovet P. *et al*., They also found an inverted, J shaped association between the Body Mass Index and the blood pressure indices. The correlation between the body fat percentage and the handgrip strength was significantly positive in grade I obesity and grade II obesity showed a significant positive correlation.

Our findings suggest that though the grade I obese participants had a lesser absolute handgrip strength, body composition was better than that of the other grades and that a small amount of excess fat would be of benefit for their performance. The groups showed a non-significant, negative correlation with the handgrip strength. This suggested that excess fat was a limitation for the strength of the obese participants and that it was expected to become significant with the increasing body fat percentage.

In this study our results demonstrated a significant change in the correlation of body composition with hand grip strength and blood pressure indices in different grades of obesity. Our study is an endeavour to assess the health status of obese individual there is a correlation between BMI with HGS and Blood Pressure Indices. Thus, lifestyle changes such as adoption of resistance and strength training exercises can improve the muscle strength and tone. Furthermore, practicing the intake of healthy nutritious diet can help in building muscle mass which, in turn, can help to improve their Blood Pressure Indices.

CONCLUSION:

By the results of the study based on the statistical analysis we can conclude that Increased Body mass index is related to both low hand grip strength and high blood pressure indices and high fat mass among obesity individuals which is statistically proven. Hence, Hand grip strength can be used as a measure of physical endurance among obesity individuals which is consistent with those of Bovet et al. [17] Accordingly, we can motivate them to do remedial physical fitness and yoga programmes. Thus, lifestyle changes such as adoption of resistance and strength training exercises can improve the muscle strength and tone. Furthermore, practicing the intake of healthy nutritious diet can help in building muscle mass which, in turn, can help to improve their physical fitness.

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