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Original Article

Physiology Section

A Study on the Correlation Between the Body Mass Index (BMI), the Body Fat Percentage, the Handgrip Strength and the Handgrip Endurance in Underweight, Normal Weight and Overweight Adolescents

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ABSTRACT

Introduction: The handgrip strength and endurance have evolved as an important tool for the assessment of the nutritional status and as a marker of the muscle quality. In underweight as well as overweight individuals, there is the possibility of a change in the muscle quality. So, we undertook this study to find out the correlation between the BMI, the Body Fat percentage and the Hand grip strength and endurance.

Materials and Methods: One hundered eighty students in three BMI ranges- underweight (BMI≤ 18.49), normal weight (BMI- 18.5- 24.99) and overweight (25-29.99) were included according to the WHO guidelines. The body fat percentage was measured by using a bioelectric impedance. The handgrip strength and the handgrip endurance were recorded by using an INCO handgrip dynamometer. The statistical correlation was done by using ANOVA.

Results: In males, the handgrip endurance was better in normal weight individuals, but among the females, the underweight females had a better handgrip endurance, but the difference was statistically insignificant ($p>0.05$). In both males and females, there was a statistically significant difference in the handgrip endurance, with the maximum grip endurance in the normal weight group and the minimum grip endurance in the overweight group ($p< 0.05$). The correlation between the BMI, the body fat percentage and the handgrip endurance was complex and different for males and females.

Conclusion: The underweight and overweight groups had a lower grip strength and endurance than the normal weight group in males, but not in females. The correlation was weak and it suggested that on both sides of the normal BMI, the hand grip endurance tended to decrease in males as well as in females. The increase in the body fat percentage might decrease the handgrip endurance but not the handgrip strength.

Key Words: BMI, Body fat percentage, Handgrip strength, Handgrip endurance

INTRODUCTION

The Indo-Asian countries are facing a unique challenge of growing overweight/obesity and a persistent burden of under nutrition [1]. The handgrip strength has evolved as an important tool for the assessment of the nutritional status; it is being considered as a reliable marker of the muscle quality [2,3].

The nutritional status can influence the muscle quality and so, the muscle strength [3]. The association between the muscle strength and underweight and the muscle strength and overweight/obesity were studied separately by many researchers, but very few studies have investigated the longitudinal assessment of the BMI with the muscle strength/ muscle endurance in various BMI ranges [4,5]. Most of these studies were done in either the adult or the old population [6]; only few were done in children or adolescents.

The decreased muscle strength in underweight 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 [3,7]; whereas the status of the muscle strength/endurance in the overweight /obese population has yet to be clearly understood [4,5]. Our study was planned to address this grey area. We studied the longitudinal association between the BMI, the body fat percentage, the hand grip strength and the handgrip endurance in three groups - underweight, normal weight and overweight adolescents with the hypothesis that there might be a decrease in the muscle strength as well as endurance on both the sides of a normal BMI.

MATERIAL AND METHODS

In this study, 180 subjects; 90 boys and 90 girls who were in the age group of 18- 21 years and from our institute, were recruited. The study protocol was ethically approved by the institutional ethical committee. An informed consent of the volunteers was taken on an approved proforma.

The experimental protocol

This study was conducted on the first year and second year M.B.B.S. students from our institute. The ages of the subjects were recorded from their dates of birth in their school leaving certificates in completed years. All the participants were selected on the basis of inclusion and exclusion criteria.

The students with cardiovascular and respiratory disorders, those who were involved in active muscle training exercises and those

who had a history of fracture in the past 3 months or a deformity in the upper arms were excluded. The students who were between the ages of 18-21 years, those who had a BMI below 30 and those with no history of smoking or alcoholism were included in the study.

Measurement of the anthropometric parameters

The standing heights of the subjects were recorded with the same stadiometer while they were without footwear, with heels together; with their heels, calves, buttocks and preferably their backs touching the stadiometer, to the nearest centimetre. Their weights were measured do the nearest to 0.1 kg, with them in the standing position before lunch, with light clothes and without footwear, by using a standardized weighing scale [2,4].

Their Body Mass Index (BMI) was calculated by using the Quetlet's index [8]. Depending on their BMI, the subjects were classified into three groups. The subjects with a BMI of less than 18.5 were classified as underweight, the subjects with a BMI which was between 18.5 to 24.99 (kg/m2) were classified as the normal weight group which served as the healthy controls and those who had a BMI of between 25 to 29.99 (kg/m2) were classified as overweight [9]. There were 30 boys and 30 girls in each group.

Measurement of the body fat percentage

The body fat percentage was measured by a bioelectric impedance method 5 by using an Omron hand held bioelectric impedance analyzer which measures the hand to hand impedance. The heights, weights and ages of the subjects were entered into the instrument and they were asked to hold the instrument in both hands, after which the observer pressed the start button on the instrument and the digital readings of the body fat percentage were recorded.

Measurement of the Hand grip Strength and endurance

The handgrip strength and endurance of the dominant hand was measured by using a handgrip dynamometer (INCO India Ltd. Ambala). The participants were advised to keep their hand on a table with the angle in the elbow being maintained at 90 degrees and they were asked to press the handle of the dynamometer with maximum strength. The maximal voluntary contraction was sustained for at least 3 seconds and it was recorded as the handgrip strength in kilograms (kg). Three readings were taken with a gap of 10 minutes and the maximum reading was taken for analysis. The hand grip endurance was determined by asking the subject to maintain 1/3rd of maximal voluntary contraction for as long as he/she could and the time was recorded in seconds by using a stop watch [6,10,11].

STATISTICAL METHODS

The data was expressed in mean±SD and it was analyzed by using the SPSS (Statistical Package for Social Sciences) ver [10]. statistical software with an ANOVA correlation and the Z test. ANOVA was applied for the three groups of BMI in the entire study. The handgrip strength and endurance were correlated with the BMI and the body fat percentage. The significance level was set at $p < 0.05$ and it was considered as significant.

RESULTS

The average age, height and weight of the underweight group in mean ±SD were 19.03±0.96 years, 165.34±4.6 centimetres and 49.4± 2.8 kg respectively, those of the normal weight group were 19.4±0.76 years, 167.23±3.4 centimetres and 60± 1.54 kg respectively and those of the overweight group were 19.6±0.86 years, 166.34±3.67 centimetres and 69.76± 2.43 kg respectively and girls was 19±0.9 respectively.

The BMI and the body fat percentage of the overweight males and females were higher than those of the normal weight and the underweight groups. This difference was statistically significant [Table/Fig-1].

The hand grip strength of the normal weight males was more than those of the overweight and the underweight males, but this difference was not significant statistically. In females, the underweight group had more grip strength than those of the normal weight and the overweight groups. In both males and females, there was a statistically significant difference in the hand grip endurance, with the maximum grip endurance in the normal weight group and the minimum in the overweight group [Table/Fig-2]. The underweight males showed a significant positive correlation between the body

BMI(Kg/M2)					
Group	Underweight	Normal weight	Overweight	F Value	P Value
	Mean±SD	Mean±SD	Mean±SD		
Male	16.82±1.05(n=30)	21.49±1.39(n=30)	27.56±1.22(n=30)	573.96	<0.0001
Female	17.15±0.17(n=30)	20.90±1.35(n=30)	27.13±1.59(n=30)	496.68	<0.0001
Body fat percentage(%)					
Male	12.15±1.91(n=30)	14.40± 1.45(n=30)	21.23± 1.79(n=30)	225	<0.0001
Female	21.1± 0.89(n=30)	25.24± 1.16(n=30)	31.21± 2.57(n=30)	232.62	<0.0001

[Table/Fig-1]: Shows Comaparison of BMI and Body Fat Percentage in three groups

Handgrip Strength (Kg)					
Group	Underweight	Normal weight	Overweight	F Value	P Value
	Mean±SD	Mean±SD	Mean±SD		
Male	33.1±4.29(n=30)	33.33±2.58	31.16±2.06	3.03	>0.05
Female	27.07±4.50	26.8±3.25	24.5±6.37	2.54	>0.05
Handgrip endurance (Sec)					
Male	132±54.92	199.73±29.09	109.67±48.22	31.97	<0.0001
Female	115.3±45.77	140.8±28.35	101.73±50.75	6.47	<0.002

[Table/Fig-2]: Shows comparison of handgrip strength and handgrip grip endurance of three groups

Correlation between	'r' Value		
Males (n=76)**	Underweight	Normal weight	Overweight
BMI and handgrip Strength	0.18	0.14	0.22
BMI and Handgrip endurance	0.11	0.29	-0.09
Body fat % and handgrip Strength	0.33*	0.14	0.15
Body fat % and Handgrip Endurance	0.49**	0.10	-0.19

[Table/Fig-3]: Correlation BMI with handgrip strength and Handgrip endurance in males of three groups

Correlation between	'r' Value		
Males (n=76)**	Underweight	Normal weight	Overweight
BMI and handgrip Strength	0.27*	0.30*	0.33*
BMI and Handgrip endurance	0.05	0.36*	-0.04
Body fat % and handgrip Strength	0.15	0.45**	0.35*
Body fat % and Handgrip Endurance	0.15	0.61**	-0.07

[Table/Fig-4]: Correlation BMI with handgrip strength and Handgrip endurance in females of three groups

fat percentage and the handgrip endurance. Such a significant correlation was absent in the normal weight and the overweight males [Table/Fig-3]. The normal weight females showed a significant positive correlation between the BMI and the hand grip strength as well as endurance. This correlation was stronger with the body fat percentage. The underweight females showed a significant positive correlation between the BMI and the hand grip strength only. The overweight females showed a significant positive correlation between the BMI and the handgrip strength, as well as between the body fat percentage and the handgrip strength [Table/Fig-4].

DISCUSSION

In our study, we found that the handgrip strength was more in the normal weight group and that it was least in the overweight group, both in males as well as females, but this difference was statistically insignificant across the groups. This suggested that the overweight population had less hand grip strength than the normal weight and the underweight populations [Table/Fig-2]. Similar results were found by Ravisankar P et al., [11].

Males showed a statistically insignificant positive correlation between the BMI and the handgrip strength. This was similar to the findings of Ravisankar et al., [11]. In females, the BMI showed a significant positive correlation with the handgrip strength in all the three groups. Our results were in coherence with those of S. Pieterse et al., [6]. They also found a positive correlation between the BMI and the handgrip strength, but their study was done in the older population, while our study was done on healthy adolescents. Our findings suggested that with increasing BMI, there will an increase in the handgrip strength in all the BMI ranges. In our study, there were no obese participants and so we cannot comment on how far this correlation will be sustained in persons with a BMI of > 30. A further study is advocated to study this correlation in detail.

The correlation between the body fat percentage and the handgrip strength was significantly positive in the underweight and normal weight males as well as in the overweight females. This association explains that an increase in the body fat percentage does not have a detrimental effect in the overweight and normal weight females. Our results were in agreement with those of Hulens et al., [5].

The association between the BMI, the body fat percentage and the handgrip strength can be explained on the basis of the fact that the BMI 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 [12,13]. Our study population was healthy adolescents and none of them was extremely underweight or obese. The underweight population might have had a good muscle mass and the overweight population might have had more of muscle mass than fat [3]. A further study of the muscle biopsy and the quality of the muscle fibres might throw light on this, as the results of many studies are confounding.

The second aim of our study was to find out whether there was any association between the BMI, the body fat percentage and the handgrip endurance; we found that the normal weight males and females had a higher handgrip endurance than the underweight and the overweight groups and this difference was statistically significant. Our results were in agreement with those of Bovet P et al., [14].

There was a statistically non significant, positive correlation between the BMI and the handgrip endurance in underweight and normal weight males and a negative correlation in overweight males. In females, the correlation was significantly positive in the normal weight group only, while in the overweight females, it was negative but not significant. Our results were similar to those of Bovet P. et al., [14]. They also found an inverted, J shaped association between the physical fitness and the body weight.

The correlation between the body fat percentage and the handgrip endurance was significantly positive in the underweight group of males; the females showed a significant positive correlation only in the normal weight group. Our findings suggested that though the underweight group had a lesser absolute handgrip strength, their endurance was better than that of the overweight group and that a small amount of excess fat would be of benefit for their performance. The overweight group showed a non-significant, negative correlation with the handgrip endurance. This suggested that excess fat was a limitation for the endurance of the overweight participants and that it was expected to become significant with the increasing body fat percentage. A major limitation of this study was the small sample size and only students from one institute were recruited in this study. A study with a larger sample size which is inclusive of different age groups and subjects from different socioeconomic statues and wide geopolitical areas, is advocated , to come to a conclusion.

CONCLUSION

The correlation between the BMI, the body fat percentage and the hand grip strength was not very clear. The correlation between the BMI, the body fat percentage and the handgrip endurance was negative, but it was not significant in the overweight population.

This correlation might become significant if the obese population is included in the study in a larger population. In the overweight population, the absolute handgrip strength might not be hampered with, but the handgrip endurance will start declining with increasing body fat percentage but not with increasing body weight.

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