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A STUDY ON CORRELATION OF FATIGUE AND BODY MASS INDEX (BMI) AMONG YOUNG ADULTS

Physiology

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ABSTRACT

Introduction Fatigue is defined as an inability to maintain required amount of force. The recent change in the lifestyle of human beings has resulted in increased prevalence of obesity among various age groups. Overweight and obesity result from an imbalance between energy consumed (too much) and energy expended (too little). Changes in the muscle function such as contractility, relaxation rate and endurance may precede body composition changes and may help detect functional impairment at subclinical levels. **Methodology** Cross sectional study was conducted among 129 study subjects between the age of 18 – 24 years. Weight of the subjects were measured in kilograms up to an accuracy of 100 grams using a portable standard weighing machine. Height of the subject was measured using stadiometer. BMI was calculated using the Quetelet's index. Mosso's Ergograph was used to determine the fatigue measured in kg.m2/s2. Pearson's Correlation and One- Way ANOVA were used and a p value <0.05 was considered statistically significant. **Results** The mean BMI of males and females were 22.66 ± 3.49 kg/m2 and 21.03 ± 2.74 kg/m2 respectively and was significantly different (p = 0.005). The mean work done by the study population was found to be 2.901 ± 1.285 kg.m2/s2. There was positive correlation between BMI and work done (correlation coefficient, r = 0.020). **Conclusion** Subjects with higher BMI are seen more among males, while females tend to have lower range of BMI. Males tend to do more work compared to the females which can be attributed to the difference in genetic make-up and hormonal differences. Work done or fatigue increases with increase in BMI.

KEYWORDS

Body Mass Index, Fatigue, Muscle function, Obesity, Work done.

INTRODUCTION

Muscles are the only tissues in the body with the ability to contract and hence produce movement. The strength of any given muscle, in terms of force exerted on the skeleton depends upon length, shortening speed, cross-sectional area, sarcomere length, myosin isoforms and neural activation of motor units.[1] Physical activity is the one important factor which affects the skeletal muscle function.[2]

Fatigue is a universally experienced phenomenon which occurs in day-to-day life. It is associated with a variety of physiological and psychological conditions. Fatigue is seen in both healthy people as well as in various patient groups such as those with depression, rheumatoid disorders, multiple sclerosis, congestive heart failure and cancer.[3] Fatigue is defined as an inability to maintain required amount of force.[4] Fatigue may arise as a result of decreased rate of energy supply to meet the demands. It may be classified as acute and chronic fatigue. Acute fatigue is temporary and is relieved with rest. However, chronic fatigue may be pathological and may not be relieved even after rest.[5,6]

There are various mechanisms explaining the cause of muscular fatigue, including the accumulation of intracellular lactate and hydrogen ions causing impaired function of the contractile proteins, effects of ionic changes on the action potential, failure of sarcoplasmic reticulum Ca2+ release by various mechanisms, and the effects of reactive oxygen species.[7]

The recent change in the lifestyle of human beings has resulted in increased prevalence of obesity among various age groups. Fatigue is also a frequent complaint in obese people. Excessive body fat has harmful effects on the immune system, facilitated via raised levels of circulating inflammatory cytokines.[8,9] A reliable indicator for body fat is Body Mass Index (BMI).[10] The BMI is an attempt to quantify the amount of tissue mass (muscle, fat, bone) in an individual and then categorize that person as underweight, overweight or obese based on that value. Overweight and obesity is when a person is too heavy for his or her height. Abnormal or excessive fat accumulation can impair health. Overweight and obesity result from an imbalance between energy consumed (too much) and energy expended (too little).

Changes in the muscle function such as contractility, relaxation rate and endurance may precede body composition changes and may help detect functional impairment at subclinical levels. Physical inactivity contributes to weight gain in adults. Muscle function testing is used to measure muscle contraction, fatigue, endurance, strength and physical capacity under varying conditions. During exercise, it has been observed that defects in Ca^{2+} release from the sarcoplasmic reticulum impairs muscle function. Andrew M. Bellinger et al in 2008 suggested a possible mechanism by which Ca^{2+} leak via calstabin1-depleted Ryanodine (RyR1) channels leads to defective Ca^{2+} signalling, muscle damage and impaired exercise capacity.[11]

The prevalence estimates of fatigue in the general population have been based mostly on single-item measures or questionnaires without considering diverse domains of fatigue symptoms. With this background, the present study was carried out to correlate Body Mass Index (BMI) and muscle fatigue in young adults.

MATERIALS AND METHODS

This was a cross sectional study conducted among young adult males and females between the age of 18 – 24 years, who were not on any medications, free from illness and addictions. Any subject with neuromuscular disorders or neurological problems were excluded from the study. A total of 100 subjects were studied based on the sample size calculated with 90% power and data obtained from the study conducted by Mohan et al.[12]

Study was initiated following the ethical committee approval and written informed consent from the study population. Weight of the subjects were measured in kilograms up to an accuracy of 100 grams using a portable standard weighing machine. Height of the subject was measured using stadiometer. BMI was calculated using the Quetelet's index. WHO classification of BMI was used to categorize the study subjects into underweight (<18.5 kg/m^2), normal (18.5 – 24.9 kg/m^2), overweight (25 – 29.9 kg/m^2) and obese (>=30 kg/m^2). Mosso's Ergograph was used to determine the fatigue. In the Mosso's Ergograph, a spring-loaded writing ball point pen and a paper on the platform underneath was arranged. With the help of clamps the forearm of the subject was fixed on the ergograph. The ergograph consists of a loop to be pulled in which the middle finger was placed and a fixed metal tube in which the index and the ring fingers were inserted. The subject's position was adjusted at various adjustable points in the ergograph is such a way that the subject's forearm was properly fixed and at the same time the subject was comfortable. With the middle finger extended, a weight of 1.5 kgs was suspended on the ergograph. The subject was asked to make a series of maximal contractions without moving the shoulder. The contractions were continued until fatigue was so great that weight could no longer be lifted. The fatigue was measured in kg.m^2/s^2.

The data was collected using Microsoft Excel and analysed using Statistical Package for Social Sciences (SPSS) version 20.0. Descriptive statistical methods such as frequencies and percentage were used for categorical variables and mean with standard deviation or median with interquartile range were used for continuous variables. To correlate BMI and muscle fatigue, Pearson's Correlation was used. One- Way ANOVA was used to analyze any statistically significant differences between the means of different categories of BMI i.e., underweight, normal, overweight and obese, in both males and females separately and also combined. A p value of <0.05 was considered statistically significant.

RESULTS

A total of 129 subjects were studied with a mean age of 20.49 ± 1.024 years. There were 87 (67.4%) females and 42 (32.6%) males in this study. The mean BMI of the males were 22.66 ± 3.49 kg/m^2 and that of females were 21.03 ± 2.74 kg/m^2. Males in this study had higher body weight, height as well as BMI compared to the females. This difference was statistically significant (Table 1).

Table 1: Mean anthropometric measurements of the study population.

Mean	Males	Females	P value
Body weight (Kg)	68.14 ± 13.12	52.77 ± 7.17	0.000*
Height (m)	1.73 ± 0.06	1.58 ± 0.06	0.000*
BMI (kg/m2)	22.66 ± 3.49	21.03 ± 2.74	0.005*

* P value <0.05; Hence statistically significant

Considering nutritional status of the study subjects it was observed that majority of them had normal BMI. Around 23.8% of the study subjects were overweight among males and 12.6% of the females were overweight. Females tend to have BMI on the lower side of the spectrum while males on the higher side of the scale. This difference was statistically significant as well (Table 2).

Table 2: Nutritional status of the study subjects

Nutritional status	Males	Females	P value
Underweight	3 (7.1%)	20 (23.0%)	0.030*
Normal (adequate)	22 (52.4%)	50 (57.5%)	
Overweight	10 (23.8%)	11 (12.6%)	
Obese	7 (16.7%)	6 (6.9%)	
Total	42 (100.0%)	87 (100.0%)	

* P value <0.05; Hence statistically significant

The mean work done by the study population was found to be 2.901 ± 1.285 kg.m^2/s^2. The work done by males were found to be on the higher side compared to the females. Females were prone for fatigue at an earlier stage compared to the males (Table 3). But this difference in mean work done or fatiguability between males and females were not statistically significant.

Table 3: Work done by the study participants.

	Males	Females	P value
Mean work done (kg.m2/s2)	3.178 ± 1.293	2.768 ± 1.268	0.090

The subjects with normal BMI showed higher mean work done followed by the obese and overweight individuals (Table 4). Fatiguability was found to be more among the underweight, followed by overweight and the obese individuals. Fatiguability was least among the individuals with normal BMI.

Table 4: Association between BMI and work done.

Nutritional status (BMI in Kg/m2)	Mean work done (kg.m2/s2)	P value
Underweight (<18.5)	2.647 ± 1.024	0.557
Normal (adequate) (18.5 – 22.9)	3.020 ± 1.423	
Overweight (23 – 24.9)	2.705 ± 1.115	
Obese (>=25)	2.901 ± 1.285	

There was positive correlation between BMI and work done (correlation coefficient, r = 0.020), but this was not statistically significant (p = 0.821)

DISCUSSION

In recent years, humans, especially the young generation has resorted to static lifestyle and decreased physical activity. This has led to emergence to a modern epidemic of obesity among these young adults. The incidence of various non communicable diseases is on the rise as a result of this inactivity. BMI plays a significant role in everyone's health and is an independent risk factor for many non-communicable diseases as well as nutritional disorders. This study focused on the effect of BMI on fatigability of an individual. This study was conducted among healthy individuals with varying BMI.

In this study we found that, there was significant difference in body weight, height and BMI, between males and females of the same age. The majority of the study subjects had normal BMI in this study among both males and females. Overweight and obese subjects were more compared to underweight subjects among males, while underweight was more among the females compared to overweight and obese. This difference was statistically significant as well. The mean BMI in this study was found to be 22.66 ± 3.49 kg/m^2 among males and 21.03 ± 2.74 kg/m^2 among females. In the study conducted by Gropper et al., the mean BMI was found to be 23.5 ± 3.9 kg/m^2 among males and 22.4 ± 4.4 kg/m^2 among females.[13] They also studied first year college students similar to this study. This difference in BMI can be attributed to the difference in the geographical distribution of the study subjects.

The mean work done in this study was found to be more among the males (3.178 ± 1.293 kg.m^2/s^2) compared to the females (2.768 ± 1.268 kg.m^2/s^2). This difference was not statistically significant though. The study conducted by Smisha Mohan et al., concluded that higher muscle strength was seen among males in both extremities compared to females. This could be mainly to genetic factors and hormonal differences between both sexes. Higher muscle function could be achieved by training of the muscles.[14] The work done was found to be high among the normal BMI group (3.020 ± 1.423 kg.m^2/s^2) followed by the obese group (2.901 ± 1.285 kg.m^2/s^2). This means that, the fatigue settled in earlier in the obese group compared to the subjects with normal BMI. In the study conducted by Mishra et al., the obese individuals had the highest work done (3.84 ± 1.29 kg.m^2/s^2), followed by overweight (3.78 ± 1.68 kg.m^2/s^2) and normal BMI (3.54 ± 1.67 kg.m^2/s^2) groups.[1] This result is in fact, contrary to the result that we obtained in our study. Here the fatigue was more prominent in the normal BMI group and fatigue reduced with increase in BMI. This may be due to the fact that, BMI measurements may erroneously label a muscular person as obese.

There was a positive correlation between the BMI and work done (r = 0.020) in this study. In the study conducted by Hasan et al., a positive correlation was found between work done and BMI (r = 0.44).[15] In the study conducted by Mishra et al., there was positive correlation between work done and BMI in normal (r = 0.05) as well as obese (r = 0.21) subgroups.[1] In a study conducted by Lim et al., univariate analysis did not show any significant association between BMI and physical fatigue.[3] In the study conducted by Resnick et al., they looked at reported fatigue and BMI and found that self-reported fatigue is associated with higher body mass index in adults aged 20 to 59 years.[16] According to Y Kim et al study, linear regression revealed strong inverse associations for Body Mass Index and waist circumference, and positive associations for grip strength with follow-up physical activity. More pronounced obesity and poor strength at baseline independently predict lower activity levels at follow-up.[17] Hence various studies have shown that there is positive correlation between work done and BMI.

Skeletal muscle function indices have been advocated for the assessment of nutritional status.[18] Changes in the muscle function such as contractility, relaxation rate and endurance may precede body composition changes and may help detect functional impairment at subclinical levels.[19] In the study conducted by Mehta et al., strength and fatigue-related strength loss remained comparable across BMI groups in both males and females in task-specific conditions. They concluded that relationship between obesity and fatigability is task dependent.[20]

CONCLUSION

Subjects with higher BMI are seen more among males, while females tend to have lower range of BMI. Males tend to do more work compared to the females which can be attributed to the difference in genetic make-up and hormonal differences. Work done or fatigue increases with increase in BMI.

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