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Original Article

Physiotherapy Section

Relationship between Body Mass Index and Physical Fitness among Medical Students of Gujarat, India

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ABSTRACT

Introduction: Body Mass Index (BMI) is commonly used as a marker for adiposity. Physical fitness refers to a series of physical characteristics that are directly related to the ability of an individual to perform physical activity or exercise. Physical fitness tests measure the efficiency of muscular and cardiovascular systems.

Aim: To assess the relationship between BMI and physical fitness in college students of a medical university at Gujarat, India.

Materials and Methods: This was an observational study, conducted in the Department of Physiotherapy at Sumandeep Vidyapeeth, India. The study was conducted from September 2019 to January 2020 and included 180 participants of which 105 were females and 75 were males aged between 18 to 30 years. Height and weight were measured and physical fitness tests i.e. push-up test for upper body strength, sit-up test for abdominal strength, queens college step test for cardiorespiratory endurance were performed. Kolmogorov-Smirnov test of normality showed the data to be normally distributed. Association between variables was seen using Chi-square test and correlation was found using Pearson's coefficient. A p-value <0.05 was considered statistically significant.

Results: Out of total 180 students, 26.1% people were underweight and 32.2% were of normal weight. The mean age of the participants was 19.7±1.99 years and mean BMI was 21.9±5.14 kg/m^2. There was no statistically significant association between BMI and abdominal strength (p-value=0.64), BMI and upper body strength (p-value=0.75) and BMI and cardiorespiratory endurance (p-value=0.47). Males performed better than females in all the tests although it was statistically significant (p-value=0.001) only for the sit-up test and not for push-up test (p-value=0.16) and queens college step test (p-value=0.47).

Conclusion: Performances on fitness tests varied with weight status. Higher BMI was generally associated with lower physical fitness. There is a great need to organise fitness programme in colleges on large scale to overcome the health problems in young age.

Keywords: Abdominal strength, Cardiorespiratory endurance, Upper body strength

INTRODUCTION

Body Mass Index (BMI) is the most widely used measure of weight status in individuals and population surveys [1,2]. It is documented as weight measured in kilogram (kg) and height in squared meters (m^2) [2]. In 2004, World Health Organisation (WHO) classified BMI into five categories i.e, underweight <18.5 kg/m^2, normal weight- 18.5-22.9 kg/m^2, overweight- 23.0-24.9 kg/m^2 and obese ≥25 kg/m^2 based on the revised guidelines for Asian Indians [3]. With the increase in the number of overweight and obesity among youth and its implications on fitness and skill of movement, studies have focused on comparing overweight and obese individuals to normal weight individuals [4-12] where the former show low physical fitness levels [4].

Physical fitness refers to a series of physical characteristics which are directly related to the ability of an individual to perform physical activity and exercise and is considered an indirect marker of a person's health [13,14]. Physical fitness tests measure the efficiency of muscular and cardiovascular systems [1]. Muscular endurance is the ability to exercise muscle groups over an extended period of time at moderate intensity utilising aerobic energy and to resist fatigue. Sit-ups and push-ups are clinically used tests to increase upper body strength and to investigate the effect of treatment. They are often used to investigate muscular endurance and different aspects of physical performance. Modified versions of push-up are used for females as they tend to be weaker than males and also have different weight distribution [15]. Cardiorespiratory fitness is directly related to efficiency of Cardiorespiratory system and the rate of maximum oxygen consumption of an individual, is primarily assessed by Maximal Oxygen Uptake (VO_2 max) during exercise test [16-18].

Unhealthy behaviour changes like increased sedentary behaviour and decreased physical activity are seen during the transition from secondary school to university where 40 to 50% of college students are physically inactive [19,20]. Excessive sedentary behaviour can be associated with higher risk of obesity, poor health, increased risk of depression and weak cognitive functioning. Higher physical activity levels are associated with lower health risks including overweight and obesity related diseases. Obesity which is increasing quickly in both developed and developing countries, decreases the physical exercise capability and reduces health related fitness, such as cardiorespiratory fitness and speed of movement [19,20].

This study aimed to assess the relationship between BMI and physical fitness levels in college students as the data available on young Indian adults is scarce to none. If a relation is found, screening of college students can be done at entry level and physical fitness programs can be incorporated in colleges or universities. This can decrease the health problems associated with decreasing physical activity and sedentary lifestyle.

MATERIALS AND METHODS

This observational study was conducted on 180 students presented in the Department of Physiotherapy, Sumandeep Vidyapeeth, Vadodara, Gujarat, India, from September 2019 to January 2020. The above study was registered with CTRI (CTRI/2019/09/021339) and approved by Sumandeep Vidyapeeth Institutional Ethics committee (SVIEC/ON/Phys/BVMPT18/019018).

Inclusion criteria: All male and female college students between 18 to 30 years of age.

Exclusion criteria

- Any history of pain in upper limb and lower limb in the past six months which can affect the performance of the test.
- Subjects with any neurological and cardiorespiratory conditions which can affect the performance of the test.
- Elite athletes (individuals training/competing at a high level).

Sample size calculation: Sample size was calculated by using formula:

$n=Z^2\times(1-r^2)/r^2$

where, Z=value from normal table=2.802

r=correlation coefficient=0.3

Thus, n=79.36=79

Procedure

A written informed consent was obtained from those who were willing to participate and a participant information sheet was given to them. Students fulfilling inclusion criteria were recruited for the study.

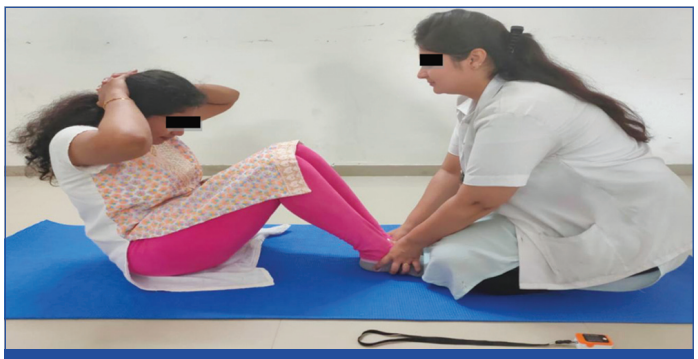
A stadiometer was used to measure height of the subjects in centimeter in the standing position. Participant stood with their back, buttocks and heels against a stadiometer with their shoes removed. By placing the headboard firmly down the vertex with the subject looking ahead, height was measured. Body weight was measured using weighing scale, without support, with weight distributed evenly on both feet, with hands by their side. Shoes and excess clothing were removed and the weight was recorded and BMI was calculated [15].

Sit-up test (assessing abdominal strength)

Sit-up test has very high reliablility (r-value=0.98). Students started in the lying position with his/her back flat on the mat, knees flexed 900, feet firmly on the mat, hands at the side of their head with the elbows pointing straight forward. To do a correct sit-up the elbows should touch the knees and then go back so the shoulders touch the floor. As soon as the therapist started the stopwatch and said "GO", the student began performing sit-ups. The student's feet were held down so that he/she did not raise them upwards and this made the sit-up easier. The number of sit-ups completed by the students in 1 min was documented. The test was terminated/stopped if two consecutive repetitions were unsuccessful or if the participant was unable to continue [15] [Table/Fig-1]. The values for the sit-up test were graded as [21]:

- Excellent
- Good
- Above average
- Average
- Below average
- Poor
- Very poor

For sit-up test 18-25 years age group was considered.



[Table/Fig-1]: Sit-up test for males and females.

Push-up test (assessing upper body strength)

The push-up test is highly reliable (r-value=0.98). The Minimal Detectable Change (MDC) was two repetitions [22]. The students adopted a prone position on the floor with the hands placed shoulder-width apart, fingers pointing forward, and elbows pointing backward. From the starting position the student pushed up to full arm extension with the body straight, such that a straight line could be drawn from the shoulder joint to the ankle joint (this was the up position). The students then lowered until all of the body from the chest to the thighs made contact with the floor. The student then pushed up to full arm extension, keeping the body straight. A push-up was counted when the student was in the up position. Number of repetitions performed by participants for 1 min were documented. No rest was allowed between repetitions. Test was terminated if the pace of push-up changed. For males, the test was performed with extended legs and for females it was performed with bent-knees [15].

The values were graded as [23].

- Needs improvement
- Fair
- Good
- Very good
- Excellent

Participants age 20-29 years was the cut-off used for push-up test [Table/Fig-2].

[Table/Fig-2]: Push-up test for males and females.

Queen's college step test (assessing cardiorespiratory endurance)

The queens college step test is highly reliable (r-value=0.98). The queens college step test was performed on stepper of step height, 41.3 cm or 16.25 inches. Student's previtals were documented before the start of the test by pulse oximeter. Then students were asked to step up and step down for the duration of 3 min, at the stepping rates of 22 and 24 steps/min, respectively for women and men which was set by metronome. After completion of the test again post vitals were documented by pulse oximeter. The test was terminated if the student was fatigued or wanted to stop and the vitals were documented [Table/Fig-3]. VO_2 max was calculated by using following formula: [18].

- For males:

VO_2 max(mL/kg/min)=111.33-(0.42×heart rate)

- For females:

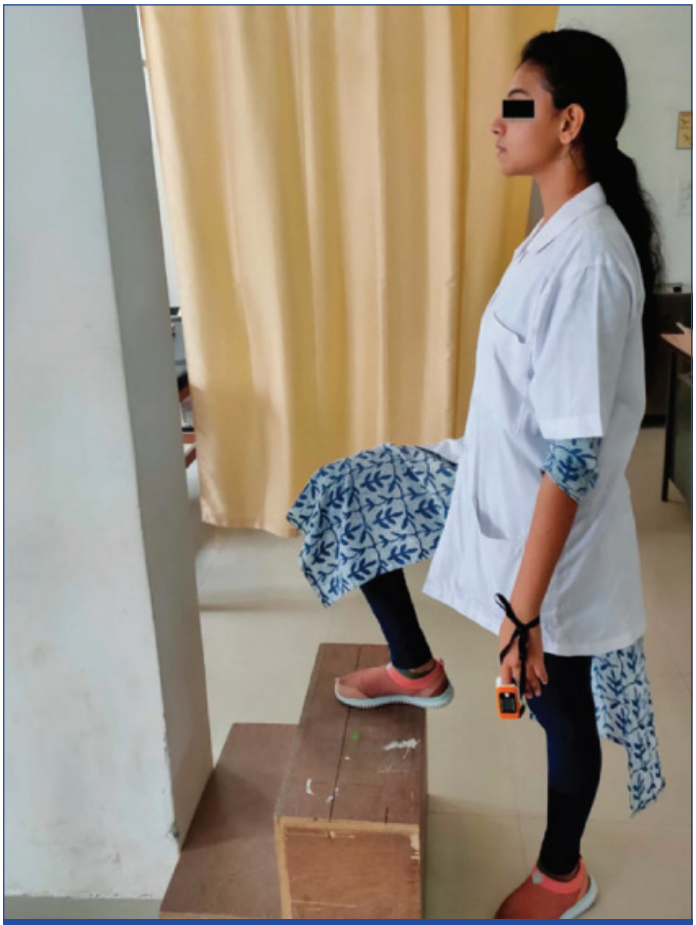
VO_2 max (mL/kg/min)=65.81-(0.1847×Heart rate)

The values were graded as [24]:

- Superior
- Excellent
- Good
- Fair
- Poor
- Very poor

The age group used as reference was 20-29 years as the cut-off values start from 20 years only.

No adverse events were reported during the performance of any of these tests.



[Table/Fig-3]: Queens college step test for males and females.

STATISTICAL ANALYSIS

Statistical Package for Social Sciences (SPSS) for windows, version 20.0 was used to perform statistical analysis. Nominal variables were expressed as mean±standard deviation. Kolmogorov-Smirnov test of normality showed the data to be normally distributed. Association between variables was seen using Chi-square test and linear regression and correlation was found using Pearson's coefficient. Level of significance was set at p-value <0.05. Confidence Interval (CI) was kept at 95%.

RESULTS

A total of 180 participants were included in the study. There were 105 (58.3%) females and 75 (41.7%) males in the study. Out of total, 26.1% people were underweight and 32.2% were of normal weight. The mean age of the participants was 19.7±1.99 years and mean BMI was 21.9±5.14 kg/m^2. The mean values of sit-up test, push-up test and Queens college step test were 16.0±7.46 counts/min, 13.0±6.94 counts/min and 49.0±7.65 mL/kg/min [Table/Fig-4-5].

BMI categories	Number of males	Number of females	Total
Underweight	13 (17.3%)	34 (32.3%)	47 (26.1%)
Normal	28 (37.3%)	30 (28.5%)	58 (32.2%)
Overweight	18 (24%)	18 (17.1%)	36 (20%)
Obese	16 (21.3%)	23 (21.9%)	39 (21.7%)
Total	75	105	180

[Table/Fig-4]: Body mass index distribution according to gender.

Variable	Minimum	Maximum	Mean±SD
Age (years)	18	26	19.7±1.99
BMI (kg/m^2)	13.7	38	21.9±5.14
Sit-up test (count/min)	02	40	16.0±7.46
Push-up test (count/min)	02	50	13.0±6.94
Queens college step test (mL/kg/min)	39.7	68.9	49.0±7.65

[Table/Fig-5]: Mean and SD of the physical fitness tests.

[Table/Fig-6] showed the gender wise difference for the different physical fitness test. Significant difference was found with respect to sit-up test (p-value=0.001). [Table/Fig-7] showed the association between BMI and various physical fitness tests. There was no significant difference was found for all the three tests.

Physical fitness tests	Males (Mean±SD)	Females (Mean±SD)	p-value
Sit-up test (count/min)	49.34±16.26	42.86±16.58	0.001
Push-up test (count/min)	38.3±17.39	36.45±17.01	0.16
Queen's college step test (mL/kg/min)	57.37±7.65	43.14±7.6	0.47

[Table/Fig-6]: Gender wise difference for the different physical fitness test. Independent t-test; p-value <0.05 was considered as statistically significant

Physical fitness tests	Category of BMI (Mean±SD)				
	Underweight	Normal	Overweight	Obese	p-value
Sit-up test (count/min)	44.62±16.7	47.88±15.58	44.39±16.31	44.36±16.11	0.64
Push-up test (count/min)	39.23±16.54	37.65±17.49	36.08±17.37	35.23±18.13	0.75
Queens college step test (mL/kg/min)	46.47±7.67	50.23±7.81	50.49±7.62	48.88±7.71	0.47

[Table/Fig-7]: Association between BMI and various physical fitness tests. Independent t-test; p-value <0.05 was considered as statistically significant

[Table/Fig-8] showed the association of BMI and abdominal strength using sit up test. No significant association was found. [Table/Fig-9] showed the association between BMI and upper body strength using the push up test. No significant association was found. [Table/Fig-10] showed the association between BMI and cardiorespiratory endurance using Queens college step test. No significant association was found.

DISCUSSION

The results of present study revealed a weak positive correlation (r-value=0.07) between BMI and abdominal strength which was statistically not significant (p-value=0.64). Most of the students, 68.9%, fell in poor category (i.e. for males 25-30 count/min and for females 18-24 count/min) [21], 24.5% students fell in below average category (i.e. for males 31-34 count/min and for females 25-28 count/min) and 3.3% fell in good and average category (i.e. for males 38-44 count/min and for females 34-40 count/min) [21]. Students in the normal BMI category had better performance than underweight, overweight, obese students. Association between gender and sit-up test was statistically significant (p=0.001) with males performing better than females. In a study on physical fitness and weight status in adolescents, boys performed significantly better in sit-ups than girls. There was decreasing performance from normal

BMI categories	Sit-up grade							Total	p-value
	Excellent	Good	Above average	Average	Below average	Poor	Very poor		
Under weight	0	1 (2.13%)	0	1 (2.13%)	13 (27.66%)	32 (68.08%)	0	47	p-value=0.64, r-value=0.07
Normal	0	0	0	3 (5.1%)	16 (27.6%)	39 (67.2%)	0	58	
Over weight	0	2 (5.6%)	0	1 (2.8%)	7 (19.4%)	26 (72.2%)	0	36	
Obese	0	3 (7.7%)	0	1 (2.6%)	8 (20.5%)	27 (69.2%)	0	39	
Total	0	6 (3.3%)	0	6 (3.3%)	44 (24.5%)	124 (68.9%)	0	180	

[Table/Fig-8]: Association of BMI and abdominal strength using sit-up test.
Chi-square test was used to see the association; Pearson's coefficient was used to see the correlation; p-value <0.05 was considered as statistically significant

BMI category	Push-up grade					Total	p-value
	Needs improvement	Fair	Good	Very good	Excellent		
Under weight	38 (80.85%)	7 (14.89%)	2 (4.26%)	0	0	47	p-value=0.75 r-value=0.05
Normal	46 (79.31%)	6 (10.34%)	4 (6.89%)	01 (1.72%)	01 (1.72%)	58	
Over weight	29 (80.55%)	5 (13.88%)	2 (5.56%)	0	0	36	
Obese	33 (84.61%)	3 (7.69%)	2 (5.12%)	01 (2.56%)	0	39	
Total	146 (81.11%)	21 (11.66%)	10 (5.55%)	02 (1.11%)	01 (0.55%)	180	

[Table/Fig-9]: Association between BMI and Upper body strength using push-up test.
Chi-square test was used to see the association; Pearson's coefficient was used to see the correlation; p-value <0.05 was considered as statistically significant

BMI categories	Queens college step test						Total	p-value
	Superior	Excellent	Good	Fair	Poor	Very Poor		
Under weight	32 (68.1%)	15 (31.9%)	0	0	0	0	47	p-value=0.47 r-value=0.06
Normal	45 (77.6%)	13 (22.4%)	0	0	0	0	58	
Over weight	24 (66.7%)	12 (33.3%)	0	0	0	0	36	
Obese	27 (69.2%)	12 (30.8%)	0	0	0	0	39	
Total	128 (71.1%)	52 (28.9%)	0	0	0	0	180	

[Table/Fig-10]: Association between BMI and Cardiorespiratory endurance using Queens college step test.
Chi-square test was used to see the association; Pearson's coefficient was used to see the correlation

weight to both the extremes of BMI in the various physical fitness tests in both the sexes [25]. Lu YJ et al., [2014] demonstrated similar results in adults in all BMI groups, with men performing significantly better than women (p-value <0.05) [26].

There was a very weak positive correlation (r-value=0.05) between BMI and upper body strength which was statistically not significant (p-value=0.75). Students in the underweight BMI category performed better than overweight, normal, obese students. Although males performed better than females, association between gender and upper body strength was not statistically significant (p-value=0.16). Males are reported to have a larger vital capacity and relatively larger heart and lungs than females. The muscles become stronger and larger than females with physical maturity particularly in the upper body. Such physical differences give an advantage to males in physical activity [27,28].

There was a weak positive correlation (r-value=0.06) between BMI and cardiorespiratory endurance which was statistically not significant (p-value=0.47). Most of the students 128 (71.1%), in queens college step test fell in superior category (i.e. for males 54-61 ml/kg/min and for females 50-55 mL/kg/min). Total 52 (28.9%) students fell in excellent category (i.e. for males 54-61 mL/kg/min and for females 50-55 mL/kg/min. A 52 (28.9%) students fell in excellent category (i.e. for males 50-54 mL/kg/min and for females 44-49 mL/kg/min) [24]. Students in the normal and overweight BMI category performed better than underweight, normal, obese BMI students. There was no statistically significant (p-value=0.47) difference between gender and cardiorespiratory endurance, although males performed better than females. Apart from physical differences, males are more biologically capable of vigorous physical activity due to their cardiovascular physiology than females. They have low heart rates when engaged in similar rates of exercises, higher VO_2 max levels relative to body mass, high red blood cells per unit volume of plasma, wide airways and greater lung diffusion capacity. When placed under cardiovascular stress, males respond by increasing vascular resistance, and blood pressure, whereas in women there is increase in heart rate [27,28].

A study by Malina RM, concluded that there is non linear relationship between body mass index and fitness parameters like push-ups, sit-ups and other performance measures like high jump, 1500 m run, and the 50 m freestyle swim in physically active young adult males [29].

A study found negative correlation between BMI and various indicators of physical fitness citing increased fat free mass and decreased physical activity levels in overweight and obese individuals for their low performance Also reported that low physical activity is indicated as a potential cause and consequence of obesity [30]. Various other studies have been discussed in [Table/Fig-11] [25-30].

Author's name and year of publication of study	Place of study	Number of subjects	Parameters assessed	Conclusion
Mak KK et al., (2010) [25]	Hong Kong	3,204	Anthropometric measures (height, weight) and health-related fitness (push-up, sit-up, sit and reach, 9-minute run).	The relation between BMI and health-related physical fitness was non linear in Hong Kong adolescents. Overweight/obese and underweight boys and girls had poorer performance in push-up and sit-up tests than their normal weight counterparts. Overweight/obese boys and girls and underweight boys were also poorer in the 9- minute run test. Underweight but not overweight/obese boys and girls performed poorer in the sit-and-reach test compared with normal weight.

Lu YJ et al., (2014) [26]	Anhui province, China.	3825 male 4062 female	Height and weight were measured by trained teachers and 50 meter run test was performed as Physical fitness index.	The relationship between PFI and BMI of adult men conforms to the quadratic model, and the influence of PFI by BMI is more serious in middle-age male than youth male
Sekulic´ D et al., (2005) [27]	Croatia	300 male	Three anthropometric variables (body weight, body height, and body mass index), and four motor-endurance variables (push-ups, sit-ups, standing high jump, 50 meters freestyle swimming, and 1500 meters run)	Simple linear and non linear regression procedures are to be used for the identification of linear and non linear predictors in non linear multiple regressions.
Rauner A et al., (2013) [28]	Review article	-	Only four studies analysed the interaction among physical activity, fitness and overweight in adolescents and reported inconsistent results. All other studies analysed the relationship between either physical activity and overweight, or between fitness and overweight	The small number of studies on the interrelationship of BMI, fitness and physical activity emphasises the need for longitudinal studies that would reveal: 1) the causality between physical activity and overweight / fitness and overweight and 2) the causal interrelationships among overweight, physical activity and fitness. These results must be carefully interpreted given the lack of distinction between self-reported and objective physical activity and that studies analysing the metabolic syndrome or cardiovascular disease were not considered. The importance of physical activity or fitness in predicting overweight remains unknown.
Malina RM (2014) [29]	Review article	-	10 questions on growth and maturation that have relevance to physical activity, performance, and fitness are presented.	The processes of growth, maturation, and development occur simultaneously and interact as boys and girls progress from infancy through childhood and adolescence into adulthood. Many factors can influence these processes.
Malina RM et al., (2016) [30]	India	-	They included outdoor play, organised and informal activity, biological maturation, tracking of activity, development of movement proficiency, and individual differences	A biocultural approach provides a more comprehensive framework that considers potential interactions of biological and societal demands with outcome variables of interest.
Present study (2022)	Gujarat, India	105 females 75 males	Sit-up test Push-up test Queens college step test	Performances on fitness tests varied with weight status. Higher BMI was generally associated with lower physical fitness. Physical fitness levels should be studied in college going students on a larger scale and fitness programs should be organised in colleges as the current generation is more sedentary due to addiction to smartphones, which may lead to health problems at a young age.

[Table/Fig-11]: Various studies showing association between BMI and physical fitness.

Limitation(s)

The limitation of the study was that the number of females were more than males and physical activity level was not assessed in the study.

CONCLUSION(S)

Performances on fitness tests varied with weight status. Higher BMI was generally associated with lower physical fitness. Males performed better than females in all the tests although it was statistically significant only for the sit-up test. Physical fitness levels should be studied in college going students on a larger scale and fitness programs should be organised in colleges as the current generation is more sedentary due to addiction to smartphones, which may lead to health problems at a young age.

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