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RELATIONSHIP BETWEEN BMI AND PHYSICAL FITNESS IN COLLEGE-AGE MALES: A CROSS-SECTIONAL STUDY

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ABSTRACT

The purpose of the study was to analyse the association between BMI and fitness performance. The 117 male college students were divided into four groups according to their BMI: Underweight (UWG), normal weight (NWG), overweight (OVWG) and obese (OBWG). They performed five tests: One minute Sit-Up test (SU), one minute Push-Up test (PU), Standing Long Jump test (SLJ), 4x10 Shuttle Run test (SHR) and 1km Run test (1KM). OBWG scores were poorer than OVWG scores, whilst OVWG scores were poorer than those attained by UWG and NWG. There were only significant differences between UWG and NWG in PU. BMI correlated negatively with SU, PU, SLJ and 1KM, and positively with SHR. The BMI peak performance for each test was, SU (19.35±3.39); PU (17.63±1.49); SLJ (20.15±3.1); SHR (20.71±3.03); KM (20.62±3.63). College age males with a BMI lower than 25 have a better fitness level than overweight and obese counterparts. Hence, fitness test standards should be designed considering not only age and gender, but also BMI.

Keywords: BMI; Physical fitness tests; College-age males.

INTRODUCTION

At present, globalisation, digitalisation, rural exodus to the city, sedentary lifestyles and changes in nutritional habits have led to a drastic increase in overweight and obese people in all age groups, to the extent that it is becoming pandemic (Dietz, 2017). To mitigate this public health problem, one of the professionals, whose daily work can have a positive impact to reverse this drastic situation, is the physical education teacher (Kahan & McKenzie, 2015). To this end, it is necessary to design adequate physical education unit plans centred on improving physical fitness, due to its potential to improve health conditions and quality of life (Gu *et al*., 2016).

Parallel to implementing these physical fitness lesson plans, it is also necessary to design evaluation criteria that are properly adapted to students' characteristic profiles. In this regard, it should be noted that in order to prevent bias or unfair assessments, some fitness test standards have been designed based on students' age and gender, to ensure a greater individualisation (Hobold *et al*., 2017).

To continue advancing along this individualisation path, it would be necessary to consider other biological and personal characteristics when designing fitness test standards. In fact, some authors consider that aspects, such as BMI can affect the students' physical performance (Mayorga-Vega *et al*., 2012). It is important at this point, to indicate that the relationship between BMI and performance in physical fitness test has been extensively studied in the case of elementary and secondary school students. However, few studies analysing the possible statistical correlation between both aspects have been conducted in adults in general, and university students in particular.

In this context, the objective of the present study was to examine the association between BMI and physical performance in college-aged males.

METHODOLOGY

Participants

The 117 male college students (age: 18.72±1.34; height: 1.77±5.92; weight: 84.27±25.2; BMI: 26.90±7.65) were enrolled at Prince Sultan University participated in this cross-sectional study. The selection of participants was made using a probabilistic approach. A representative sample of all students enrolled in the Preparatory Year Programme was used. The sample size was calculated using the following formula: n=Z2p * q N / e2 (N-1) + Z2p * q (n=sample size, N=population size, Z=confidence level, p=probability of success, q=probability of failure, e=sampling error) (Naing *et al*., 2006).

None of the subjects suffered from chronic diseases or injuries. Additionally, none of them practised regular or structured physical exercise any day of the week, and they were not engaged in any federated sports. To rule out that the study participants suffered from any medical condition, which might prevent them from performing the selected test battery in safety conditions, they were required to complete the PAR-Q test (Thomas *et al*., 1992).

All measurements were administered during their physical education class time. Before performing the tests, participants received a theoretical session with detailed information about the benefits and risks involved in participating in this research project and information about fitness test protocols. Similarly, they were required not to modify their diet and physical activity habits in the four weeks leading up to performing the tests. After the theoretical session, one class was devoted to the administration of the anthropometric measurements. Once the BMI was calculated for each participant, they were assigned to one of the corresponding groups: (a) Underweight group/UWG): BMI<18.5kg/m^2; (b) Normal Weight group/NWG: 18.5≥BMI<25kg/m^2; (c) Overweight Group/OVWG: 25≥BMI<30kg/m^2; (d) Obesity group (OBG: ≥30kg/m^2.

Ethical clearance

The present investigation was carried out respecting the ethical principles contained in the Helsinki Declaration. This research also had the approval of the Institutional Review Board of the Bio-ethics Committee at Prince Sultan University in Riyadh, Saudi Arabia (ethical clearance number: PSU IRB-2020-010026).

Measures

Kinanthropometric assessment

Weight and height were measured with the subject barefoot and using a *Seca digital column scale* 769 (Hamburg, Germany). Body weight was recorded to the nearest 0.1kg, and the height to the nearest 0.1cm. Subsequently, the BMI was calculated with the following formula: BMI=Weight/Height^2.

Fitness assessment

Five fitness tests were administered during the physical education class on two different days, with a 48-hour rest period between them. Day One was allotted to Standing Long Jump Test, 4x10 shuttle run test and one minute push up test. Day Two included the one-minute sit-up test and 1km run test. Prior to the testing, participants undertook a 10-minute warm-up consisting of two phases, namely Phase 1 consisting of five minutes of running and Phase 2 including five minutes of head to toe dynamic mobility exercises that included, neck mobility, arm swings, trunk and shoulder girdle movements, hip circumduction, leg swings and ankle bounce. While the tests were conducted, all subjects were encouraged to perform at their best.

One-minute Sit-Up test (SU): The SU was used to measure the muscular endurance of trunk and hip flexors. The materials used were a Delta Fitness mat (Falastin, Mishrifah, Jeddah, Saudi Arabia) and a Casio Digital Stop Watch HS-3V-1BRDT (Mathura, New Delhi, India). The initial position was as follows: lying in the supine position on the mat, with knees bent at 90 degrees and arms folded on the chest, while an assistant held the athlete's feet to the ground. On the command "Go!" the stopwatch was started and participants had to lift their trunk touching their knees with their elbows and then, returning to the initial position. The participants had to perform as many sit-ups as possible in one minute. Subjects were allowed only one attempt, and only the correctly performed repetitions were recorded. Thus, they had to touch the mat with their scapulae when extending the trunk and touching their elbows on the knees when flexing the trunk (AAHPERD, 1980).

One-minute Push-Up test (PU): The PU test was used to measure upper body muscular endurance. The materials used were the same as in the previous test. The initial position was as follows: In the prone position, the upper body and legs were aligned in a straight line, with hands and toes touching the mat. The hands were shoulder-width apart, and the elbows were extended. On the teacher's signal, the athlete had to bend at the elbows as many times as possible in one minute while keeping the body straight. Only one attempt was allowed, and only the properly performed repetitions were recorded. Hence, participants were required to fully extend their arms when raising the trunk and flex their elbows at a 90° angle when lowering the body (Hashim *et al*., 2018).

Standing Long Jump test (SLJ): SLJ was used to measure the lower body explosive power. The material used was a standing long jump testing mat. Subjects stood behind the starting line on the mat, with their feet slightly apart. After bending their trunk and legs and balancing with their arms, they had to jump as far forward as possible. Two trials were allowed, and only the best was recorded. The scores were recorded in cm, measuring the distance between the take-off line of the mat and rear back of the shoe. The jump was considered invalid if the participant: (a) jumped again after taking off; (b) stepped on the white line in the take-off; (c) did not jump or land on both feet simultaneously (Reid *et al*., 2017).

4x10 Shuttle Run test (SHR): This test was used to measure speed and agility on a non-slip basketball court. Two lines 10 metres apart were marked with tape on the court. Two wooden blocks (10 x5 x5cm) were placed on the furthest line, and the participant had to stand behind the opposite starting line. On the teacher's signal, the subject runs to pick up one block and return to the starting line and place the block on it. Immediately turn around and repeat the same procedure with the second block. The test had to be performed as quickly as possible. The time was recorded in seconds, by using the same chronometer utilised in the first and second test. Each subject was allowed only one timed attempt (Kolimechkov *et al*., 2019).

1km run test (1KM): The 1KM run was used to measure the maximal oxygen consumption (VO_2max). The participants had to complete 1km as fast as possible. The test was performed on a Cybex 625T treadmill (Rosemont, Illinois, USA). The subjects themselves were responsible for selecting the speed of the treadmill. To calculate the VO_2max, the following formula was used: VO_2max= 672.17 – T / 6.762 (Aranda, 2018).

Amongst all the commonly used tests to assess physical fitness, the five above-mentioned tests were selected on the basis of the following criteria: validity, reliability, objectivity, clarity in implementation of the protocol, standardisation and economical use of resources (Sánchez-Pay *et al*., 2011). The same researcher made all measurements and received the support of one assistant. Participants performed the SU, PU, SLJ and SHR tests in pairs, whereas the 1KM was performed in groups of six people.

Statistical analysis

The results are presented as means and standard deviations. Data normality was verified using the Kolmogorov-Smirnov test, and homoscedasticity was examined with Levene's test. Because most of the variables did not follow a normal distribution, and in addition, the size of the test groups was unequal, non-parametric tests were used. The Kruskal-Wallis H test was computed to make comparisons among the BMI categories.

The Spearman test was performed to estimate the association between variables, and results were interpreted as follows: r_s=0 no correlation; 0.01≤r_s ≤0.09 *very weak*; 0.10≤ r_s ≤0.29 *weak*; 0.30≤ r_s ≤0.49 *moderate*; 0.50≤ r_s ≤0.69 *strong*; r_s≥ 0.70 *very strong*. The effect-size (ES) was calculated using the Mann-Whitney U test. An ES of 0.2 was considered small, ES of 0.5 moderate and ES of 0.8 large (Kornacki *et al*., 2017). Finally, to determine the BMI peak performance, 50th and 90^{th} percentiles for each test were calculated. Statistical significance was set at $p<0.05$. The statistical analysis was performed using SPSS software version 22.0 (SPSS, Inc., Chicago, IL, USA).

RESULTS

As shown in Table 1, there were only significant differences between the results obtained by UWG and NWG in the PU (p=0.083, ES=0.27). However, the ES was small. Conversely, the results attained by UWG were significantly better than those obtained by OBG in all the tests performed, namely SU: p=0.0000, ES=0.71; PU: p=0.0000, ES=0.74; SLJ: p=0.0000, ES=0.71; SHR: p=0.001, ES=0.51; 1KM: p=0.0000, ES=0.55. UWG also achieved marks significantly better than OVWG in the following four tests, PU: p=0.0001, ES=0.68; SLJ: p=0.0004, ES=0.54; SHR: p=0.0135, ES=0.37; 1KM: p=0.0008, ES=0.27.

The NWG obtained significantly better results than OBG in all the tests where SU: p=0.0000, ES=0.61; PU: p=0.0000, ES=0.76; SLJ: p=0.0000, ES=0.65; SHR: p=0.0000, ES=0.55; 1KM: p=0.0000, ES=0.7. NWG also attained marks significantly better than OVWG in all the tests, namely SU: p=0.0098, ES=0.9; PU: p=0.0000, ES=0.55; SLJ: p=0.0027, ES=0.42; SHR: p=0.0000, ES=0.55; 1KM: p=0.0000, ES=0.7). Finally, OVWG achieved better results than OBG in the following tests where SU: p=0.0000, ES=0.74; PU: p=0.002, ES=0.38; SLJ: p=0.008, ES=0.33; 1KM: p=0.0085, ES=0.33.

Table 1. **RESULTS OF PHYSICAL FITNESS TESTS FOR FOUR GROUPS**

Measures	**UWG** (n=17)	**NWG** (n=36)	**OVWG** (n=26)	**OBG** (n=38)
BMI	17.19±0.81	21.75±1.88	27.17±1.17	35.93±5.15
SU (reps)	38.35±3.31	38.56±4.35	36.81±3.69 +	30.50±3.88 * + #
PU (reps)	28.90±4.89	26.72±5.72 *	19.40±7.56 *+	12.45±7.39 * + #
SLJ (cm)	185.58±21.05	175.55±20.09	158.31±22.73 * +	139.39±24.53 * + #
SHR (sec)	12.10±1.29	11.94±0.93	12.61±0.84 * +	13.30±1.25 * +
1km VO_2max ($ml/kg/min^{-1}$)	28.04±5.71	31.12±2.79	24.42±5.58 * +	19.97±6.15 * + #

*=Significant difference regarding Under Weight Group +=Significant difference regarding Normal Weight Group
#=Significant difference regarding Over Weight Group. OBG= Obese Group

As for the association between variables (Table 2, on page to follow), BMI had a very strong negative correlation with PU and a strong negative correlation with SU, SLJ and 1KM. However, BMI had a strong positive correlation with SHR. Besides, there was a strong positive correlation between SU results and PU and SLJ, but a strong negative correlation with SHR and 1KM scores. PU results indicated a strong positive correlation with SJL and 1KM, but a strong negative correlation with SHR. SLJ scores maintained a strong negative correlation with SHR results and a strong positive correlation with 1KM scores. Finally, SHR results had a strong negative correlation with 1KM scores. Figure 1 (on page to follow) illustrates that the BMI peak performance for each of the five tests was SU=19.35±3.39; PU=17.63±1.49; SLJ=20.15±3.1; SHR=20.71±3.03); KM=20.62±3.63. Similarly, the peak relative performance for each BMI category is shown in Table 3.

Table 3. **PEAK PERFORMANCE (M±SD) FOR EACH BMI CATEGORY**

Category	**SU**	**PU**	**SLJ**	**SHR**	**1KM**
UWG	17.32±1.17	16.81±0.89	17.28±0.68	17.22±1.03	17.22±1.18
NWG	22.04±0.25	21.68±2.11	20.72±1.49	21.38±1.09	19.52±1.09
OVWG	26.46±0.85	27.04±1.39	27.16±0.96	26.8±1.22	27.04±1.19
OBG	33.84±3.07	32.39±1.83	32.91±2.09	33.58±1.94	33.72±1.83

BMI=Body Mass Index; SU=Sit-Ups; PU=Push-Ups; SLJ=Standing Long Jump; SHR= Shuttle Run; 1KM=1km Run

DISCUSSION

Based on the comparisons among the four groups, it can be inferred that underweight individuals only perform better than normal-weight subjects in PU. In contrast, both UWG and NWG attained better results than OVWG which in turn, obtained better results than OBG. Thus, it has been demonstrated that subjects with a BMI of 25 or above, have lower physical fitness. Therefore, they have a generally poorer health status. This circumstance has also been confirmed through the correlation analysis between BMI and the scores obtained by the students in the five tests performed, since the correlation coefficients found were strong or very strong in all cases.

Table 2. **RANK CORRELATIONS AMONG VARIABLES STUDIED**

	M±SD	BMI r_s	BMI p	SU r_s	SU p	PU r_s	PU p	SLJ r_s	SLJ p	SHR r_s	SHR p
BMI	26.90±7.68										
SU	35.52±5.26	-0.68	<0.001								
PU	20.70±9.33	-0.76	<0.001	0.66	<0.001						
SLJ	161.43±28.19	-0.67	<0.001	0.55	<0.001	0.65	<0.001				
SHR	12.55±1.21	0.51	<0.001	-0.54	<0.001	-0.56	<0.001	-0.69	<0.001		
1KM	24.94±6.14	-0.59	<0.001	-0.50	<0.001	0.59	<0.001	0.62	<0.001	-0.52	<0.001

BMI=Body Mass Index SU=Sit-ups PU=Push-ups SLJ=Standing Long Jump SHR= Shuttle Run 1KM=1km Run

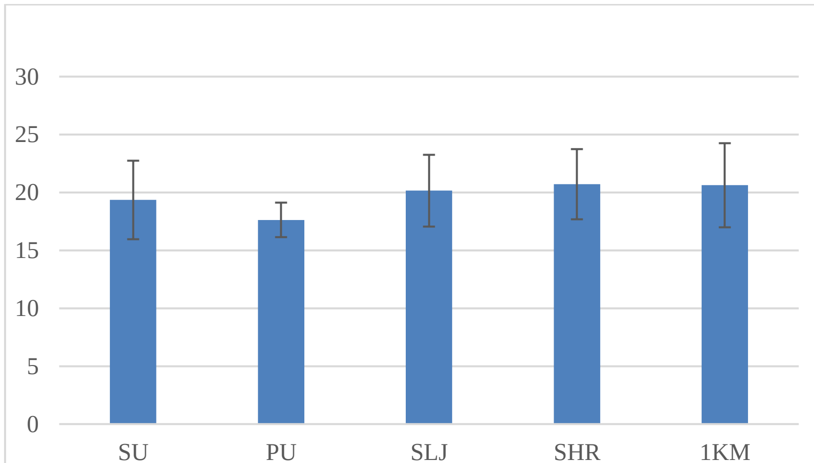

Figure 1. **BMI PEAK PERFORMANCE FOR EACH TEST**

These results are consistent with most of the studies that analysed the relationship between physical condition and BMI for children and adolescents (Hernández *et al*., 2015; Caamaño *et al*., 2016; Muros *et al*., 2016; Cigarroa *et al*., 2017; Mondal & Mishra, 2017; Patricio-Zúñiga *et al*., 2018). Nevertheless, some scientific research has concluded that this relationship is not entirely clear. Such is the case of the study with adolescents by Garcia-Rubio *et al*. (2015) in which no correlation was found between BMI and physical fitness. Delgado *et al*. (2015b), in another research project carried out also with adolescents, found significant differences between the BMI categories and the fitness tests in only one of the six tests performed.

Vásquez-Gómez *et al*. (2018), through longitudinal and cross-sectional research verified an increase of fatty tissue and SLJ scores over the years, and a decreased performance on sit-ups and flexibility. The research findings of the study conducted by Nikolaidis *et al*. (2019) with Futsal players of different age groups were very interesting. They only observed significant differences in fitness performance between the overweight and normal weight categories in children, but not in the fitness performance of adults.

Another relevant aspect of the present study is the result of the correlation analysis among the fitness test scores. In this respect, it was verified that students who obtain good marks in SU, also perform well in PU, SLJ, SHR and 1KM. This means that, subjects with high levels of muscular endurance in the upper body, also have aerobic endurance, speed, agility and high levels of explosive strength in the lower body.

The strong correlation observed between fitness test scores and the different tests suggests that, having a normal weight or even being underweight is essential to perform well in strength, endurance and agility tests, despite the fact that some fitness components are different and even opposite in nature. Therefore, in young adults who do not participate in competitive sports, modifiable environmental factors, such as physical activity and nutrition are key elements to be in good physical shape and consequently enjoy good health.

The correlation among the fitness test scores is consistent with the results obtained in the study conducted by Domínguez *et al*. (2015) in which it was verified that subjects with high levels of endurance, were also faster and displayed a better jumping ability. It must be noted that there were two tests (SU and SHR), where the results slightly deviated from the expected. In the case of SU, there were no significant differences between UWG and OVWG. It was interpreted that performing well on the mentioned test, does not require very high levels of relative strength, unlike the PU. As for the SHR, no significant differences were observed between the OVWG and the OBG. This could be the case because, apart from the BMI, muscle twitch plays an important role in better performance on agility tests.

Conducting fitness tests also provide the opportunity to compare the scores obtained by the participants of the present study, with age-matched counterparts with a similar BMI. However, this possibility is not entirely straight forward. On the one hand, there are studies where the same tests were used, but the study participants' scores are not provided (Aires *et al*., 2008; Chen *et al*., 2020). On the other hand, some research does provide the scores obtained in the fitness test. However, those marks are not classified by BMI category (Patricio-Zúñiga *et al*., 2018). Therefore, comparisons cannot be made in these cases. There is one study conducted with Chilean college-age individuals where the results are comparable with the scores obtained by the NWG of the present study (Vásquez-Gómez *et al*., 2018). The participants of the above-mentioned study achieved better scores than those included in the present study in the following tests: SU (53±12.8 vs. 38.56±4.35) and SLJ [(182.7±35.1 vs. 175.55±20.09). This discrepancy could be due to the limited physical culture, lack of awareness about physical activity health benefits and prevalence of physical inactivity in Saudi Arabia (Alahmed & Lobelo, 2018).

As for the BMI peak performance, it should be noted that the peak value in PU (BMI=17.63) is in the underweight category. This result is consistent with the fact that UWG performed significantly better than NWG in this test, which indicates the great importance of relative strength in PU. In all the other tests, the BMI peak performance was between 19.35 and 20.71, which corresponds to the normal weight category. These figures are slightly lower than those obtained by Sedeaud *et al*. (2014). In the mentioned study, the authors tried to identify the BMI peak performance in all track and field running events. They found that the peak values ranged between 24 (100m-sprinters) to 20 (long-distance runners). It is assumed that this discrepancy can be attributed to intensive sports training, which increases lean body mass in athletes.

Regarding each BMI peak performance category, it is not surprising that the peak performance of the UWG is relatively close to the upper limit of this category (18.5). Accordingly, the BMI peak performance of the OVWG and OBG is close to the lower limit of both categories (25 and 30 respectively). This fact reinforces the idea that those individuals with a BMI close to 18.5 (upper limit of the UWG and lower limit of the NWG) perform better. Additionally, it is noteworthy that 56% of the participating students presented a BMI greater than 25. This data coincides with other studies where high levels of being overweight or obese were also found, regardless of the geographical region and the age of the subjects (Delgado *et al*., 2015a; Hernández *et al*., 2015; Caamaño *et al*., 2016; Muros *et al*., 2016; Tian *et al*., 2016). It highlights as a matter of urgency, the need to implement intervention programmes aimed at preventing and treating obesity.

The results of this study also have important implications for assessment criteria in Physical Education. To conduct a fair evaluation, due to the strong correlation between physical fitness tests and BMI observed in this study, physical fitness test standards should be individualised. This means not only that age and gender should be considered, but that BMI might be considered as well. Another implication involves physical education classes. Mayorga-Vega *et al*. (2012) propose that physical education teachers should choose fitness tests where BMI does not significantly affect student scores. Another feasible solution would be to use formative or continuous evaluation instead of summative evaluation. In this way, the assessment will be based on the progress of the subjects. Thus, the students will be the protagonist of their evaluation process, and their personal characteristics, together with their social and cultural context, would be taken into account (Chng & Lund, 2018; Gallardo-Fuentes *et al*., 2020).

BMI allows physical education teachers to determine the obesity levels of their students in a quick, easy, non-expensive and non-invasive manner. However, it also has some limitations. It does not consider whether excessive weight is due to the presence of lean or fat tissue. The BMI measures excessive weight rather than excessive body fat. Additionally, factors, such as age, gender, ethnicity and muscle mass could alter the relationship between BMI and body fat (Centers for Disease Control and Prevention, 2009).

Finally, it is necessary to mention the limitations of the study. It would have been interesting to have analysed the correlation between the fitness test results and other kinanthropometric parameters, such as body fat percentage or waist-hip ratio. However, since all measurements were made during the normal physical education class schedule of the University, it was not possible to perform these assessments due to the amount of time this would have required. Moreover, in the present study, students belonging to four different BMI categories underwent the same tests. It should be taken into account that individuals with BMI higher than 30, especially those with a BMI greater than 40, may face difficulties performing certain fitness tests. This circumstance could compromise the validity of the OBG results. Therefore, to assess the physical fitness of obese individuals, some authors propose using adapted tests (Toulouse *et al*., 2020).

CONCLUSION

Underweight and normal weight college-age male students have better physical fitness than overweight students. In turn, overweight students have better physical fitness than obese students. This fact, together with the high prevalence of overweight and obesity found in the present study, implies that intervention programmes and public government-sponsored campaigns to prevent and treat this health problem, need to be implemented urgently. In fact, it should be noted that obesity is caused mainly by environmental factors, such as diet and lack of exercise, which fortunately are modifiable through education and physical training. As for the physical education assessment, BMI has a strong influence on the students' physical fitness test scores. Therefore, this circumstance should be taken into account when developing and validating physical fitness test standards to pursue fairer and more individualised evaluation standards.

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