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RESEARCH ARTICLE

Assessing Aerobic Capacity using Three Minutes Step Test and Its Association with Body Mass Index of Undergraduate Students: An Analysis

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ABSTRACT

This study aimed to assess the aerobic capacity of undergraduate students using the Three-Minute Step Test and to investigate its association with body mass index (BMI). A total of 132 undergraduate students participated in the study. This research study used a quantitative cross-sectional study. Aerobic capacity was determined by measuring heart rate and calculating VO2max using standardized formulas, and BMI was calculated based on height and weight measurements. Pearson correlational analysis was used to validate the daily step counts and test the association of the demographic profiles, BMI, and the VO2 max predicted by the Queen's College Step test equation. The results indicated significant gender differences in aerobic capacity and BMI. Males exhibited higher levels of aerobic capacity compared to females. Additionally, a positive correlation was found between BMI and VO2 max, suggesting that individuals with higher BMI tend to have higher aerobic capacity. However, the relationship between age and VO2max was not statistically significant. The findings of this study emphasize the importance of regular physical activity in maintaining optimal health and fitness. It is recommended that physical education teachers create programs with specific needs and fitness levels and promote healthy lifestyle behavior, including regular physical activities and balanced diets as part of good health and fitness. Additionally, further research might investigate the nature of these factors affecting gender differences in aerobic capacity hormonal, muscle composition, and training adaptations.

INTRODUCTION

Aerobic capacity, one of the most significant components of optimal health, measures the individual's exercise limited by the cardiorespiratory process (Basso et al., 2022). As described by the World Health Organization, it is linked with a lowered risk of chronic diseases such as cardiovascular diseases, type 2 diabetes, some types of cancer, and others. BMI – body mass index is a body composition measure associated with other health characteristics, including disease risks (Borga et al., 2018). Nevertheless, there is still a lack of studies examining the association between aerobic capacity and BMI, especially amongst the vulnerable group, undergraduate students who are at peril of both a sedentary lifestyle and weight problems. University students have been identified as being under high stress, resulting in overeating or lack of exercise (Choi, 2020). Further, since most undergraduate learners have tight academic calendars, they have inadequate time for physical activities and a healthy diet (Sogari et al., 2018)

There are several ways of predicting aerobic capacity. One of the most common and easy to perform is the three-minute step test (3MST) (Lo et al., 2018). The 3MST exercise requires the individual to mount and dismount a step with the recorded cadence for three minutes and a one-minute rest period to record heart rate. The heart rate recovery is then applied in order to predict VO2max. This

test has been used frequently as it is easy to conduct, thus important in evaluating aerobic fitness across various populations (Harber et al., 2024).

Additionally, obesity and physical inactivity are now at pandemic levels in today's global setting (Gupta & Garg, 2020) and have immediate effects on the overall health of the population (Kansra et al., 2021). Obesity has become an emerging concern in many countries, including the Philippines. It has been reported that obesity rates, especially among the younger generations, have skyrocketed ((Leonard et al., 2022); DOH, 2023). Therefore, it raises the possibility of developing noncommunicable diseases, as well as putting pressure on healthcare avenues (Kassa & Grace, 2020).

The literature review also shows few studies that explored obesity and physical inactivity among the Filipino population, where Ngo et al. (2022) revealed the concern. However, existing literature needs to provide research on the relationship between aerobic fitness and the BMI of undergraduate students. Due to this research gap, the unique health-related difficulties beseech this population group still need to be defined and, therefore, fail to support the efficient adoption of effective interventions. Further, they revealed that higher aerobic capacity is associated with better cognitive ability (Qasemy et al., 2018), better mental health (Yao et al., 2021), and minimized risk of chronic diseases (Yao et al., 2021).

This study was thus undertaken to fill this knowledge gap by assessing the aerobic capacity of undergraduate students using the 3MST, examining its association with BMI, and adding available information on the health of undergraduate students in the Philippines. The conclusions and recommendations of this research will hence expand the current knowledge on aerobic capacity, BMI, and other predictors of poorly healthy undergraduate students; affirm and/or refute the hypothesis; and guide the formulation of theory-based interventions to improve the physical activity of undergraduate students.

REVIEW OF RELATED STUDIES

Introduction

Cardiovascular endurance is an indispensable aspect of physical fitness because it is an index of the aptitudinal fitness of the cardiopulmonary systems for providing oxygen at a rate adequate for muscle demands during sustained work. Evaluating aerobic fitness is particularly important among the research subjects because the students' aerobic capacity changes due to their inevitably altering way of life. It has become relatively easy to recommend the Three Minutes Step Test (3MST) as a practical and valid measure of aerobic capacity. This review aims to compare the aerobic variables, 3MST, regarding Body Mass Index (BMI) among undergraduate students.

Aerobic capacity and its importance

Aerobic capacity is the ability of a specific individual to use oxygen during intense exercise or stamina, which is generally represented by VO2 max. Therefore, aerobic fitness has numerous benefits, as it reduces the risk of several chronic diseases and improves mental well-being and academic achievement (Anderson & Durstine, 2019). It was also found that physical fitness, as well as aerobic fitness, are relevant to student's cognitive abilities, mood, and psychological well-being (Tamayo Acosta et al., 2022)

The three minutes step test

3MST, a widely used test of aerobic capacity, is affordable, incorporates time to complete the test, and is suitable to be applied to different groups of people, including students. The test entails stepping on and off the platform and maintaining the set rhythm for three minutes, after which the heart tells us the recovery rate (Kieu et al., 2020). This has been supported by Raza and others, confirming that the 3MST is a valid predictor of aerobic fitness and hence should be used by educators (Raza et al., 2021).

Validity and reliability of the 3MST

Some prior works have quantified the validity and reliability of the 3MST. For instance, Dwyer and his associates revealed that 3MST produced a high degree of correspondence with the laboratory-identified VO2 max, suggesting that the test is useful in determining aerobic capacity in the field. This

test is especially useful with large groups such as undergraduates, where access to the laboratory is restricted.

Body Mass Index and its implications

Body Mass Index (BMI) measures an individual's weight and height and, therefore, assesses body fatness. BMI is an indirect measurement of body fat, and it is employed as a screening index that partitions people into underweight, normal weight, overweight, and obesity classes (World Health Organization, 2024). Studies show that an increase in BMI levels is common in lower aerobic fitness, especially among the youth (Dewi et al., 2021).

Association between aerobic capacity and BMI

Several researchers have undertaken studies on the relationship between aerobic capacity and BMI, with a special focus on university students. For instance, (Listiandi et al., 2020) presented that students with higher BMI had significantly lower aerobic capacity based on the 3MST. Likewise, another study conducted showed that there is a reduction in the aerobic exercise capacity with the increase in BMI meaning that achievement of high fitness levels depends on the maintenance of a healthy weight (Vincent et al., 2020)

Conclusion

According to the literature, the aerobic capacity based on the Three Minutes Step Test is paramountly correlated with Body Mass Index among undergraduate students. In essence, students, especially those with regular Body Mass Index, should ensure they are fit in aerobic fitness so that they may be able to improve their overall health and academic achievements. Since universities encourage physical exercise among students, the application of early assessment tools such as the 3MST can help identify the susceptible persons to health complications due to low aerobic capacity and high BMI.

METHODOLOGY

This study was a quantitative cross-sectional research study. Cross-sectional study designs are further categorized as observational research, where the outcomes and exposures are taken at the same time, hence offering an effective way to determine prevalence and association (Setia, 2016). This design enables an index of the distinct variables at a single point in time; thus, it is useful for studies employing a hypothesis to establish the correlation between aerobic capacity and BMI of undergraduate students (Koju et al., 2019).

The study participants were chosen from among the first-year undergraduate students of Nueva Ecija University of Science and Technology – San Isidro Campus, Nueva Ecija, Philippines, in the academic year 2024-2025. A total of 132 participated in the study. Informed written consent was sought from all the subjects before they participated in the study. Selection criteria include (1) students who are at least 18 years of age at the time of screening; (2) individuals who answered "No" in any of the questions given in the Physical Activity Readiness Questionnaire (PAR-Q); and (3) subjects who understood the nature and purpose of the test and voluntarily participated and those who signed the consent form. The exclusion criteria are those with certain health conditions that may hinder aerobic capacity or BMI, and Pregnant or lactating females will not be taken as subjects for this study.

All participants used the Physical Activity Readiness Questionnaire (PAR-Q) to determine their general health status. This questionnaire was designed to test general health awareness (Warburton et al., 2020). It assesses for possible risk factors during moderate exercise and checks up on the family history and level of disease intensity. If a participant shows cardiovascular disease characteristics and falls under the category of high risk, they are to be excluded from the study. The demographic questionnaire consisted of two parts. The first part was about participants' age and sex. The second part of the questionnaire measured variables such as height, weight, and body mass index, which were also measured and recorded by the researchers. The height of the participants was measured using a tape meter with defined and standard conditions, and the weight was measured using a digital scale. The BMI was calculated by dividing the reported body weight (kg) by the squared height (m^2) (WHO, 2010). The BMI was evaluated by following categories and classified as underweight (<18.5), normal weight (18.5-24.9), Pre-obesity (25.0-29.9), obesity class I (30.0-34.9), obesity class II (35.0-39.9), and obesity class III (≥40.0) (Table 1.). The VO_{2max} was estimated indirectly based on the

Queen's College Step Test method, and the following was done. As a part of this three-minute step test, the aerobic capacity and fitness level were determined regarding how early the heart recovers from the exercise (Kieu et al., 2020). This test begins with a two-minute resting phase in a chair in a quiet room where the temperature and humidity are always controlled. Participants are expected to step up and down on a 16.25-inch height box or bench in three (3) minutes (step up, up, down). The stepping frequency is determined using a metronome with male participants set at 96 counts per minute and the female at 88 counts per minute. After completing the test, the participants immediately stop, sit, and remain still. After five (5) seconds, the subjects' pulse rate was recorded for 15 seconds and converted to beats per minute (PR x 4). The VO2 max was calculated using the equation below (Katch & Barbara, 2011).

For males : VO_{2max} = 111.33 – [0.42 x PR (beats/min)] [ml/kg/min]

For females : VO_{2max} = 65.81 – [0.1847 x PR (beats/min)] [ml/kg/min]

The VO_{2max} was stratified by sex with the following groups (ml/kg/min); for the male, excellent (≥53), good (44-52.9), average (34-43.9), fair (25-33.9), poor (≤24.9). For the female category, the groups established were excellent (≥49), good (39–48.9), average (31–38.9), fair (24–30.9), and poor (≤ 23.9) (Table 2).

Table 1: WHO body mass index (BMI) Classification (WHO, 2010) .

Classification	BMI (kg/m²)	Risk of comorbidities
Underweight	<18.5	Low
Normal Weight	18.5-24.9	Average
Pre-Obesity	25.0-29.9	Mildly increased
Obesity Class I	30.0-34.9	Moderate
Obesity Class II	35.0-39.9	Severe
Obesity Class III	≥40.0	Very severe

Table 2: Normative Data for VO_{2max} (ml/kg/min) (Katch & Barbara, 2011) (Koju et al., 2019)

VO_{2max} (ml/kg/min)	Male	Female
Poor	≤24.9	≤23.9
Fair	25-33.9	24-30.9
Average	34-43.9	31-38.9
Good	44-52.9	39-48.9
Excellent	≥53	≥49

Statistical Package for Social Science (SPSS) software version 20 collected, compiled, and analyzed the data. Descriptive statistics such as frequency, percentage, mean, and standard deviation were used for the analysis of the demographic characteristics of the participants, the distribution of aerobic capacity, and BMI. Pearson correlation analysis was used to validate the daily step counts and test the association of the demographic profiles, BMI, and the VO2max predicted by the Queen's College Step test equation. Statistical significance was assessed at $p<0.05$.

RESULTS

1. Demographic characteristics of the participants

Demographic information of the participants is provided in table 3, stratified by Gender: Male and Female. The parameters measured from the physical variables used for the analysis of the data involve age, height, weight, BMI, pulse rate, and $VO_{2\,max}$. The mean age of male and female participants was 19.00 (SD=2.00) and 18.70 (SD=2.16) respectively. The mean height of males was 62.61 cm and of females 49.46 cm. The same was true for the average weight; it was 1.70 kg for males and slightly less for females – 1.57 kg. In agreement with height and weight measurements, male subjects had a somewhat higher average BMI (21.74 kg/m²) than female subjects (19.99 kg/m²). A slight variation was observed in the pulse rate, where the female group had a relatively higher rate of 137.23 beats/min than the male group, which had an average rate of 131.84/ min. However, even within each group, the variability in pulse rate was relatively high as measured by the standard deviation. More significant difference was found in VO2 max a parameter of aerobic capacity. Males had

significantly higher VO2max than the female individuals, 55.95 ml/kg/min and 40.46 ml/kg/min, respectively.

Table 3: Demographic characteristics of the participants

Parameters	Mean ± SD (Male, n=49)	Mean ± SD (Female, n=83)	Mean ± SD (n=132)
Age (years)	19.00 ± 2.00	18.70 ± 2.16	18.81 ± 2.10
Height (m)	62.61 ± 14.97	49.46 ± 8.85	54.34 ± 13.11
Weight (Kg)	1.70 ± .064	1.57 ± .074	1.62 ± .09
BMI (Kg/m^2)	21.74 ± 4.99	19.99 ± 3.64	20.64 ± 4.26
Pulse rate (beats/min)	131.84 ± 28.10	137.23 ± 32.38	135.23 ± 30.87
VO2max (ml/kg/min)	55.95 ± 11.80	40.46 ± 5.98	46.21 ± 11.39

2. Body Mass Index (BMI kg/m2) Classification of the participants

In Table 4, the participants' BMI was also categorized according to the WHO index. It also presents participants into various groups depending on their BMI and examines the likelihood of comorbidities in these groups. The most significant portion of respondents was within a normal weight range – 50.8% of participants had a BMI of 18.5-24.9. A high percentage (35.6%) of the respondents were categorized as underweight body (Mean BMI<18.5). 9.8% of subjects were pre-obese (BMI 25.0-29.9), and only 3.8% belonged to the obese category (classes I-III).

Table 4: Body Mass Index (BMI kg/m^2) classification of the participants (n=132)

BMI (kg/m^2)	Male n (%)	Female n (%)	Total n (%)	Risk of comorbidities
Underweight (<18.5)	14 (28.6)	33 (39.8)	47 (35.6)	Low
Normal Weight (18.5-24.9)	25 (51.0)	42 (50.6)	67 (50.8)	Average
Pre-Obesity (25.0-29.9)	7 (14.3)	6 (7.2)	13 (9.8)	Mildly increased
Obesity Class I (30.0-34.9)	3 (6.1)	2 (2.4)	5 (3.8)	Moderate
Obesity Class II (35.0-39.9)	0	0	0	Severe
Obesity Class III (≥40.0)	0	0	0	Very severe
Total	49	83	100	

3. Aerobic capacity VO2max (ml/kg/min) of male and female participants using the Queen's College Three-Step Test

Table 5 presents the aerobic capacity results measured by $VO_{2\ max}$ in participants and their gender distribution regarding the performance rating of poor, fair, average, good, and excellent. The results showed that gender had a reasonably large effect on, and was significantly associated with $VO_{2\ max}$ level. Of all the individuals in the current study, a much higher percentage of the male category was attributed to having had excellent aerobic capacity, with only 1.2% of the females capable of this. On the other hand, a comparatively higher percentage of females were categorized under the combined unfairly aerobic capacity (fair aerobic capacity 10.8% and average aerobic capacity 19.3%) than males (4.1% and 2.0% respectively). 71.4% of males had excellent aerobic capacity, 18.4% had good, 4.1% had fair, and 4.1% had poor aerobic capacities. Most of the females had good aerobic capacity with 68.7%, while the other rural females were fairly (10.8%) and average (19.3%), while none of the rural females had poor aerobic fitness levels.

Table 5: Aerobic capacity VO_{2max} (ml/kg/min) of male and female participants

Male		Female	
VO_{2max} (ml/kg/min)	n (%)	VO_{2max} (ml/kg/min)	n (%)
Poor (≤24.9)	2 (4.1)	Poor (≤23.9)	0
Fair (25-33.9)	2 (4.1)	Fair (24-30.9)	9 (10.8)
Average (34-43.9)	1 (2.0)	Average (31-38.9)	16 (19.3)
Good (44-52.9)	9 (18.4)	Good (39-48.9)	57 (68.7)

Excellent (≥53)	35 (71.4)	Excellent (≥49)	1 (1.2)
Total	49 (100)	Total	83 (100)

4. Correlational analysis of different parameters with aerobic capacity VO2max (ml/kg/min)

The table provides the values of correlation coefficients (r) and the levels of significance (p) between age, sex, height, weight, BMI, pulse rate, and aerobic capacity ($VO_{2\ max}$). There are also significant correlations between aerobic capacity and gender ($r = -0.659$, $p < 0.001$). Aerobic capacity is positively related to taller stature ($r = 0.391$), increased body weight ($r = 0.406$), and higher BMI ($r = 0.253$), all of which are significant at < 0.05. Age correlates with $VO_{2\ max}$ in a positive small manner, though it is not significant ($r = 0.093$, $p = 0.288$). Those people with lower resting pulse rates have higher aerobic fitness levels (Pearson's correlation, $r = -0.746$, $p < 0.001$).

Table 6: Correlational analysis of different parameters with aerobic capacity VO2max (ml/kg/min)

Parameters	r-value	p-value
Age	.093	.288
Sex	-.659**	.000
Height	.391**	.000
Weight	.406**	.000
BMI (Kg/m^2)	.253**	.003
Pulse rate (beats/min)	-.746**	.000

*Correlation is significant at the 0.05 level (2-tailed)

DISCUSSION

The study was undertaken to analyze aerobic capacity using the three-minute step test (VO_{2max}) and its association with body mass index. The study demonstrates significant differences between males and females in various physical parameters, including height, weight, BMI, and VO2max. While there are physical differences, the age distribution of male and female participants is relatively similar, suggesting that the observed variations are primarily due to gender.

The demographic characteristics of the participants in this study align with those reported in previous research on young adult populations. The observed gender-based differences in height, weight, and VO2 max are consistent with established physiological variations. Research consistently shows that males typically have greater muscle mass and strength compared to females, contributing to increased size and physical performance (Bassett et al., 2020). The physiological advantages in men include larger body size, more skeletal muscle mass, lower body fat percentage, and greater anaerobic and aerobic energy delivery (Sandbakk et al., 2018). These factors contribute to an 8-12% average performance gap average performance gap between male and female athletes in most events. However, the strength difference may disappear the strength difference may disappear when normalized for fat-free body mass (Sandbakk et al., 2018). In older adults (≥60 years), resistance training leads to more significant absolute strength gains in males, but more significant relative strength improvements in females (Hawley et al., 2023).

Analysis of the BMI distributions indicated that there were significant sex differences. A significantly higher density of female students was rated as underweight compared to male students, 39.8% and 28.6%, respectively. On the other hand, comparatively more males were pre-specified as pre-obese (14.3% and 3.8%) compared to females (7.2% and 2.4%, respectively).

The correlation coefficient (R-values) and p-values between several variables (age, sex, height, weight, BMI, and pulse rate) and aerobic capacity (VO2 max) of the study participants are presented. A negative correlation was significant between Total VO2 max and Sex ($r = -.659$**/ $p – 0.001$). This indicates that females have been strongly related to lower aerobic capacity than males. The results found were positive correlations with height, weight, BMI, and VO2MAX – this means that the higher the subjects, the heavier they were, and the higher their BMIs, the higher their aerobic capabilities. All of this correlation was significant at $p < 0.05$ level. A rather low correlation coefficient of 0.093 was obtained for the relationship between age and VO2max, and it was statistically insignificant at 0.288. This may indicate that although there is a slight tendency of aerobic capacity in older people than in the young, the relationship is not significantly correlated. Pulse rate was, thus, negatively

correlated with VO2max with an observed value of r=-0.746 and p<0.00l. This shows that people with slower resting heart rate levels have higher aerobic fitness levels.

CONCLUSION AND RECOMMENDATION

The Three Minute Step Test was used to assess the aerobic capacity of undergraduate students, and its association with body mass index (BMI) was studied. Results revealed gender differences in physical parameters such as height, weight, BMI, and VO2 max. This is related to the physiological differences between males and females, with males, on average, having higher levels of aerobic capacity than females, for example, due to increased muscle mass and greater metabolic rate. The sex showed a strong negative correlation to VO2 max, which means, in general, females have lower aerobic capacity than males. These positive correlations were also seen between VO2max and height, weight, and BMI — taller and heavier people with higher BMI have higher aerobic capacity. Yet the relationship between age and VO2 max was found not to be statistically significant, suggesting that age may play little role in determining aerobic capacity in these subjects. It is recommended that physical education teachers create programs for students with specific needs and fitness levels and promote healthy lifestyle behavior, including regular physical activities and balanced diets as part of good health and fitness.

Further research might be directed toward investigating the nature of these factors affecting gender differences in aerobic capacity of hormonal, muscle composition, and training adaptations particularly. More research is needed to establish a relationship between body composition, especially body fat percentage, and aerobic capacity. Understanding these factors will help researchers devise better strategies to increase physical fitness and general health, particularly in young adults.

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