RESEARCH ARTICLE

Effect of Anthropometric and Physical Activity Levels on Endurance Strength: A Cross-sectional Study of University Practice Senior High School, Ghana

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Abstract

Background: The aim of this study is to determine how anthropometric variables (body weight, body height, upper and lower limb length), Body Mass Index (BMI) and physical activity (PA) levels affect the number of cycles completed in 3-Minute Burpee Test (3-MBT) among male and female teenagers of University Practice Senior High school.

Materials and methods: Thirty-two (32) males and 28 females aged 15-17 years engaged in low and moderate physical activity levels took part in the studies. International Physical Activity Questionnaire (IPAQ) short form was used to assess physical activity levels and 3-MBT was used to evaluate students' endurance strength capacity. Participants' limb lengths (for upper and lower) were measured and their BMI was calculated from their measured body height and weight according to standardized guidelines. The results were processed statistically using Pearson's correlation, independent sample t-test and simple linear regression.

Results: In both sexes, only body mass and BMI were bound by negative significant correlation ($p < 0.05$) with the number of cycles completed in the 3-MBT. Significant differences were noted between males and females engaging in 3-MBT ($p < .001$). Physical activity levels in MET significantly predicted endurance strength scores ($p < .001$) as assessed by 3-MBT. On the average, males completed 48.34 cycles/3 min and females scored 38.50 cycles/3 min. More cycles were completed by male and female students with moderate levels of physical activity compared to those characterized by low levels of PA. Males were characterized by higher anthropometric measurements excluding body mass index than females.

Conclusion: Body mass, BMI and physical activity levels in MET were the only analyzed variables that significantly had influence on endurance strength (3-MBT) of both sexes.

Keywords: Endurance strength, 3-MBT, Physical activity, Anthropometric

Introduction

Musculoskeletal fitness becomes an important act of daily living as one ages [1] and an important part of the whole-body system [2]. According to Ortega (2008) et al. [3], a potent marker of future health during childhood and adolescence is physical fitness. Endurance strength is a component of health-related fitness which helps to identify individuals who are at risk of having reduced health benefits and exercise capacity. Human health as well as biological and motor developments are influenced by physical fitness as one of its key indicators [4]. According to Rafique et al [5], the body's health status is improved by activities relating to fitness and health and in effect,

the protection obtained from these activities has its own independent effects on other health related outcomes. It is believed that fundamental motor ability is strength as it aids to start, continue or stop movement of a body as well as setting another body in motion [6]. Therefore, it is of relevance studying factors including anthropometrics and physical activity levels that can affect endurance strength abilities in adolescents. Previous works have focused on participation of athletes in sport and various group of individuals where there are established relationships between anthropometric features and endurance strength abilities [7-8]. These studies relate to previous work with the measure of selected anthropometrics and physical activity level demonstrated by other researchers using different

population samples. Muscular strength and endurance abilities are components of physical fitness that provide health benefits [9]. Obese, overweight, and underweight teenagers do not have higher physical fitness, such as speed, agility, muscular strength, or cardiorespiratory fitness, than those who are of normal weight, according to research [10-13]. Endurance strength has been defined as a type of strength that is demonstrated in tasks that demand a reasonably extended period of muscular tension with low efficiency loss [14].

An increase in body height and mass contributes to muscular strength [15], however, studies have found that endurance, relative strength and physiological capacity development are rather reduced [16,17]. Body mass, body mass index (BMI), and body height are all found to be significantly adversely linked with 3-Minute Burpee Test (3-MBT) scores among female university students, as well as average heart rate of 181.92 b.min-1 was determined where 3-MBT was regarded as a highly intense physical activity [17-18]. Low levels of physical activity have been linked to an increased risk of weight gain in females aged 25 to 55 who have a sedentary or inactive lifestyle [19]. There has been an established correlation between body mass and height and 3-MBT performance in 7-9 years old children been demonstrated [20] with similar findings for university female students [18]. According to the Oxford Dictionary, the Burpee test was developed in the 1930s and is named after American psychologist Roual H. Burpee. The exam, which consists of a sequence of so-called "burpies" – physical exercises including a squat thrust that begins and ends in a standing posture – was initially meant to assess agility and coordination [18]. The test has been popular in various sport discipline and varied version of the test has been developed [17] which has been utilized in people of all ages and genders, and last but not least in people of varying levels of physical fitness [21].

The 3-Minute Burpee Test (3-MBT) has been used to assess endurance strength skills in a variety of age groups, including elementary school kids, early education instructors, and university students [4,18,22]. Only a few studies have looked at the relationship between physical activity and 3-MBT performance [21]. However, studies by [23] presented that only physical activity levels significantly influenced strength endurance in 3-MBT performance among male and female university students. Between the ages of five and thirteen years old, a linear rise in muscular endurance has been found in males, followed by a rapid increase, but in girls, a continuous linear increase has been observed [24]. Research about the reliability and effectiveness of Burpee as exercise in sport and functional training has been demonstrated [25]. Few studies have been done to see how physical activity levels affect the number of cycles completed in the 3-MBT. Inferring from the research findings above, it is observed that endurance strength abilities and physical activity levels are of great importance. However, there is a paucity in literature regarding the study of the effect of selected anthropometric variables and physical activity levels among adolescent students in their late stage on endurance strength abilities. The purpose of this study is to see how anthropometric factors (body mass, height, upper and lower limb length), BMI, and physical activity levels affect the number of completed cycles in the 3-MBT among teenage male and female students in their late adolescent years.

Materials and Methods

2.1. Research design

A cross-sectional descriptive research design was employed to conduct the study. The research was conducted in the Central region of Ghana at University Practice Senior High School located within the University of Cape Coast. The study was conducted from September to October (2020)

2.2. Participants

This study enrolled a total of 60 healthy adolescents, comprising 32 males and 28 females aged (15-17) of University Practice Senior High School, who did not attended obligatory physical education class. The study included 1) adolescent students between 15-17 years of age not performing any type of regular physical activity for the duration of the study other than the obligatory physical education classes, 2) adolescent students not having any medical condition that could influence the collection or interpretation of the data, and 3) adolescent students with low and moderate physical activity levels only. Students were divided into segments (level of study) in the beginning, and then a separate random sample of equal size from each stratum was selected. All participants were taught how to perform the 3-minute burpee test prior to the test.

2.3. Measurements

The techniques of International Standards for Anthropometric Assessment [26] was adopted for all the body measurements. Body mass (to the nearest 0.1kg) and body height (to the nearest 0.1cm) were measured using a portable electronic bathroom weighting scale and a well calibrated wooden meter and the results were used to calculate the BMI of all participants. Upper and lower limb length was measured with a flexible non-elastic tape. The endurance strength of the body was measured using the hybrid 3-minute burpee test and a stop watch as adapted from Podstawski et al [18]. The Procedure of the 3-MBT is as follows: Starting in a standing posture, the participant will be encouraged to go into a supported squat with both hands on the floor. The feet were held back into a plank posture with arms extended, starting from a supported squat. After that, the participant returned to a supported squat from the plank position. Finally, the participant stood up and clapped their hands with their arms stretched over their heads. The participants should complete the cycle as many times as possible under a three-minute time restriction. All participants were taught how to perform the 3-minute burpee test, where sufficient time was given for the participants to practice. Furthermore, before the test, the participants were allowed to do a 10-minute active warm-up.

International Physical Activity Questionnaire (IPAQ) short version (which comprises of four short generic items assessing walking, moderate-intensity and vigorous intensity activities and sitting time that people do as part of their daily lives) was used to assess levels of physical

activity and extensive validity and reliability has been undertaken among college students [27]. The energy expenditure associated with the task was computed and represented in Metabolic Equivalent of Task (MET) units where students were placed into three groups based on their PA levels: low (L < 600 METs-min/week), moderate (M < 1500 METs-min/week) or five or more days of any combination of walking, moderate intensity or vigorous intensity activities achieving a minimum total physical activity of at least 600 MET minutes a week and high (H ≥ 1500 METs-min/week) or seven or more days of any combination of walking, moderate intensity or vigorous intensity activities achieving a minimum total physical activity of at least 3000 MET minutes a week. [28]. The students with low and moderate physical activity levels were included in the study.

The participants answered a Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) (comprises of seven general health questions and follow up questions about medical conditions when one has an issue(s) with one of the first seven general health questions) which was used to screen out individuals who have underlying medical conditions which prevented them from taking part in the study. This questionnaire has underwent validation and was found to have good measurement reliability, sensitivity, and specificity [29].

2.4. Statistical analysis

IBM Statistical Package for Social Sciences (SPSS) software Version 26 for Windows was used to compute and analyze the data obtained. The alpha level for rejecting or failing to reject the hypothesis was set at 0.05. Means, minimum and maximum values, percentages and standard deviation for independent variables (body height, body mass, BMI, length of upper and lower limbs), METs, and dependent variables (number of cycles completed in burpee test) were calculated using descriptive statistics. Pearson's correlation was used to analyze the influence of anthropometric measurements on endurance strength abilities. The association between physical activity levels in MET and the performance of the 3-minute burpee test was determined using simple linear regression. Independent sample t-test was used to compare mean differences between endurance strength abilities among the genders with low and moderate physical activity levels.

2.5. Ethical consideration

The study was approved by the Head of Department of Sport and Exercise Science (UCC), as well as the University of Cape Coast's Institutional Review Board (UCC). The study followed the principles of the Declaration of Helsinki on human subject research. Volunteers' rights were protected, as all participants were able to withdraw from the study without repercussions and were not forced to participate. Prior to the study, a written informed consent form was issued to the participants and they were briefed about the confidentiality of the study, test procedures, purpose, benefit and risks involved in the study.

Results

The average values of anthropometric measures and the number of cycles completed in 3-minute Burpee test among adolescents are presented in Table 1. The correlation between anthropometric variables and endurance strength for both genders are presented in Table 2. From Table 1, the average evaluated anthropometric measurements and metabolic equivalent task (MET) excluding body mass index (BMI) were not significantly higher in males than in females. The average BMI was within the normal range for both males (M=22.43, SD=2.64) and females (M=24.21, SD= 2.90). Males completed 48.34 cycles and females 38.50 cycles on average in the 3-MBT. The average physical activity level (MET) was in the middle range of moderate PA level for males (M=1807.09, SD=624.91) and in the lower range of moderate physical activity level (MET) for females (M=785.97, SD=538.15). Males completed more cycles in the 3-MBT compared to females.

The correlation between anthropometric variables and number of cycles completed in 3-MBT were statistically significant for body mass and body mass index for both genders excluding body height and upper and lower limb lengths from Table 2. A weak negative correlation was noted between BMI and the number of completed cycles in 3-MBT for both genders. However, (BMI) and number of completed cycles in 3-MBT was moderately negatively correlated, r(28) = -.57, p < .01 for females. From the Table 2, body mass, followed by BMI were the major factor limiting the number of cycles completed in 3-MBT. For females, BMI was noted as a major factor, followed by body mass.

Figure 1 is a representation of the scatter plot of the tested variables. A strong positive linear relationship is observed between the two variables (males/females) which was confirmed from the Pearson's correlation coefficient of 0.743 in Table 3. The relationship between PA levels in

Table 1. Anthropometric data, MET and motor ability for Males (N=32) and Females (N=28)

Parameter	Males			Females		
	Mean (±SD)	Min.	Max.	Mean (±SD)	Min.	Max.
Body mass (kg)	62.62±5.90	50.40	77.50	61.43±6.71	48.45	75.50
Body height (cm)	166.90±8.48	153.00	188.00	159.44±6.58	146.00	170.00
Body mass index (kg/m2)	22.43±2.64	17.16	26.64	24.21±2.90	19.62	29.20
Upper limb length (cm)	61.28±4.67	51.00	70.00	57.54±4.62	49.00	65.00
Lower limb length (cm)	95.00±6.38	81.00	109.00	89.32±5.87	79.00	103.00
Burpee test (No of cycles/3min) (N)	48.34±5.17	38.00	58.00	38.50±3.33	34.00	46.00
PA level (MET) units (MET-min/week)	1807.09±624.91	411.00	2904.00	785.97±538.15	247.50	2212.00

Table 2. Correlation between anthropometric variables and the number of cycles completed in 3-MBT for Males (N=32) and Females (N=28)

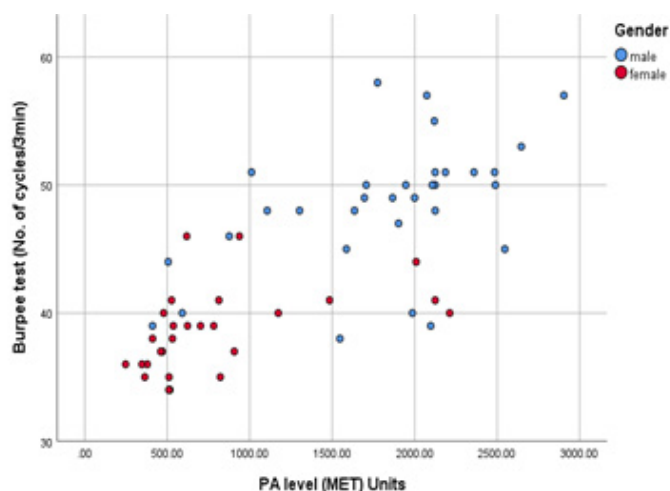| Parameter	Burpee test (No. of cycles/3 min) (N)	
Body mass (kg)	**-0.396*(s)**	**-0.381*(s)**
Body height (cm)	0.010	0.288
Body Mass Index (BMI) (kg/m2)	-0.365*(s)	-0.571**(s)
Upper limb length (cm)	-0.266	-0.025
Lower limb length (cm)	-0.196	0.137
Lower limb length (cm)	95.00±6.38	81.00
*p < .05, **p < .01 s = significant		

Figure 1. Scatter Plot representation of PA level (MET) Units and Burpee test (No. of cycles/3 min)
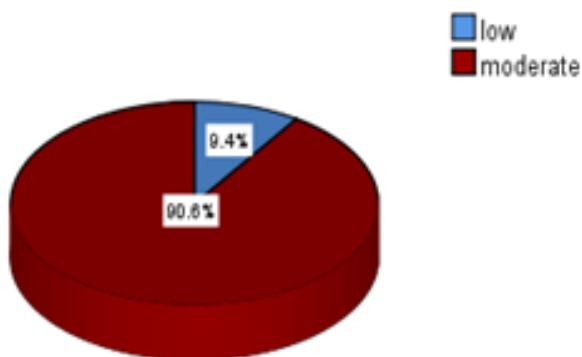

Figure 2. Number of males with low and moderate physical activity level

MET units and endurance strength (assessed by the 3-MBT) is presented in Table 3. It is evident from the table that PA levels in MET explain a significant proportion of variance in endurance strength scores, R^2= 0.55, $F_{(1, 58)}$ =71.39, $p < .001$. The R^2 value shows that 55% of variation in endurance strength can be explained by the model containing only PA levels in MET. From Table 4, PA levels in MET significantly predicted endurance strength scores, b=0.006, $t_{(1, 60)}$ =8.49, $p <.001$. The mean value of PA levels in MET was 1330.57 and 43.75 for endurance strength. The Pearson's correlation coefficient R between the two variables revealed a strong positive correlation of 0.743. From the result, it is evident that there is significant relationship between adolescent PA levels in MET and endurance strength.

The significant difference between adolescents' endurance capacity as assessed by the 3-MBT is presented in Table 5. The results show that mean score of males (M = 48.34, SD = 5.17) was significantly higher than that of females (M = 38.50, SD = 3.33), $t_{(58)}$ = 8.63, $p < .001$ regarding the number of cycles completed in 3MBT.

It is evident from table 6 and figures 2 and 3 that with moderate PA level, the evaluated males had the majority number (90.6%) compared to females (46.4%). Majority of female adolescents (53.6%) were characterized by low PA level compared to males (9.4%). Females who were characterized by low PA levels had the lowest number of cycles in the 3-MBT compared to males who scored 39 - 44 for their minimum and maximum number of cycles in 3-MBT. Moreover, females had the lowest record of number of cycles in 3-MBT characterized with moderate levels of physical activity with a maximum and minimum cycle of 35 and 46 compared to males (38 and 58 cycles). Only 3 males were characterized by low physical activity compared to 15 females. Males had the highest number of individuals with moderate PA level compared to females with 13. The result shows that males are more active compared to females.

Discussion

This study was designed to determine how anthropometric variables (body weight, body height, upper and lower limb length), BMI and PA levels affect the number of cycles completed in 3-MBT among male and female teenagers. The major findings of this study showed that BMI and body mass were the limiting factor in completing 3-MBT for endurance strength assessment. Moreover, a strong positive correlation was observed between PA levels in MET and endurance strength. Moreover, a significant difference was observed between males and females regarding their endurance strength as assessed by 3-MBT.

There are several factors that influences endurance strength among adolescents. These factors are associated with the number of cycles completed in the 3-minute burpee test among adolescents of both gender [30]. International Physical Activity Questionnaire (IPAQ) short form, inelastic measuring tape,, Physical Activity Readiness Questionnaire, a digital stop watch, wooden meter and an electronic bathroom weighting scale, used in the assessment helped to determine participants anthropometric measurements, physical fitness level, health status and endurance strength abilities.

The anthropometric measurements of participants (body mass, body height, upper and lower limb lengths) were

Table 3. PA levels in MET as a predictor of endurance strength (3-MBT)

R	R Square	Adjusted R Square	Std. Error of the Estimate		
0.743	0.552	0.544	4.461		
Analysis of Variance					
Model	Sum of Squares	Df	Mean Square	F	Sig
Regression	1420.90	1	1420.9	71.39	<0.001
Residual	1154.35	58			
Total	2575.25	59			
Note: Predictors (Constant): PA level in MET Unit Dependent Variable: Endurance strength (3-MBT)					

Table 4. Regression analysis of PA levels in MET as a predictor of Endurance strength

Model	N	Mean	SD	B	B	Df	T	Sig
PA level in MET	60	1330.568	775.65	0.006	0.743	59	8.449	0.000(s)
Endurance strength (3-MBT)	60	43.75	6.61					
p < 0.05 s = significant								

Table 5. Independent sample t-test result of endurance strength for males and females

Gender	n	M	SD	SE	Df	T	Sig
Male	32	48.34	5.17	0.91	58	8.63	0.00(s)
Female	28	38.50	3.33	0.63			
p < 0.05 s = significant							

Table 6. Descriptive statistics by group (compare means) of gender, physical activity level and endurance strength

Gender	PA level	Min	Max	N	% of Total N
Male	Low	39	44	3	9.4
	Moderate	38	58	29	90.6
Female	Low	34	41	15	53.6
	Moderate	35	46	13	46.4
	Total	34	46	28	100
Total	Low	34	44	18	63
	Moderate	35	58	42	137
	Total	34	58	60	200

higher in males compared to females excluding body mass index (BMI) which could be attributed to the general observation. In the present study, the correlation observed between the numbers of cycles completed in the 3-minute burpee test and anthropometric variables is in agreement with the results of research findings in other studies. Body mass and body mass index (BMI) had a significant negative influence on the number of cycles completed in the 3-minute burpee test in both genders excluding body height, upper limb and lower limb length in these studies. Studies by Podstawski et al. [31] compared physical fitness in pre-school, early school children, female university students and early education teachers. In their studies, body mass and body mass index (BMI) was correlated with strength abilities, however, the 3-minute Burpee test was negatively affected by these variables. A significant negative correlation was observed in female university students performing 3-minute burpee test with body mass (r = -0.867), body mass index (BMI) (r = -0.779) and body height (r = -0.254) respectively, however, body height was not significant in this present studies. This could be attributed to the small sample size used in these

studies. Recent studies by Podstawski et al. [30] reported correlations in their studies evaluating sex mediated differences and correlation between anthropometrics and motor abilities of university students preforming various motor test. In their studies, body mass, body height and body mass index (BMI) was significantly negatively correlated with the number of cycles completed in the 3-minute Burpee test in females (r = -0.19, -0.13, -0.11). However, body height was not significantly correlated in this current study. Moreover, significant correlation was observed for body mass and BMI excluding body height for males in the same study (r = -0.13, -0.14, 0.00) [30] which is consistent with the findings of this current studies. The results in this present study demonstrates that body mass and body mass index (BMI) decreases endurance strength as assessed by the number of cycles completed in the 3-minute Burpee test. Studies have demonstrated that high body mass and high body mass index (BMI) has a significant impact on reducing cardiorespiratory fitness and endurance [15-16]. Moreover, body mass has a significant influence on the role of relative strength in endurance training [32-33]. As a result, overcoming resistance is influenced by both

body mass and body mass index, therefore individuals with higher values are expected not to perform well in endurance strength activities such as the number of cycles completed in 3-minute Burpee test. This could account for the significantly high negative correlations observed in females compared to males with the number of completed cycles in the Burpee test. Anthropometric characteristics of body mass and BMI characterized by obesity and overweight as reported by [18] previously in university females had a significantly negative impact on the number of completed cycles in 3-MBT.

On average, males and females' physical activity levels in MET were identified in moderate physical activity level with females occupying the lowest range and males the highest range of moderate physical levels ((M < 1500 METs-min/week or five or more days of any combination of walking, moderate intensity or vigorous intensity activities achieving a minimum total physical activity of at least 600 MET and below 3000 MET minutes a week). This observation is in agreement with the general observation that males have higher physical activity levels than females [34]. The results of the PA levels in MET predicting endurance strength (as assesses by 3-MBT) gives an indication that PA levels can be considered a good measure for assessing adolescents' fitness levels. The effects of PA levels in MET values on endurance strength is in concordance with studies by [3] demonstrating that performance of physical exercise or daily physical PA is influenced by physical fitness capacity. Moreover, Podstawski and Zurek [23] also demonstrated that physical activity levels have influence on performance capacity of individuals.

The 3-Minute Burpee Test (3-MBT) has been used to evaluate endurance strength and is suggested to be more reliable for measuring endurance strength compared to various variations reported in literature lasting 30s and 60s [4,6]. In a study evaluating the relationship between strength endurance, anthropometric features, body composition and physiological parameters among university students with low or moderate physical levels of physical activity performing extreme exercise, male students completed (48.34cycles/3 min) which is 1.12 more cycles completed in the 3-minute Burpee test than in the previous studies of male university students [21]. Moreover, females completed (38.50cycles/3 min) with a smaller difference of 0.7 more cycles than in the previous female university students. Recent studies by Podstawski et al. [30] reported that males students completed more cycles (57.8cycles/3 min) than in current studies with a difference of 9.46 more cycles. Female students also completed (47.9cycles/3 min) which is 9.4 more cycles than in current studies. Moreover, a significant difference was observed with lower mean scores of 38.50 for females and 43.34 cycles for men respectively. This could probably be attributed to the sample size used in this study.

In previous studies regarding university females [17], they completed 10.8 more cycles than in current studies and in early studies [18], the noted difference was 1.35 more cycles. Comparing the above scores, it suggests a decrease in endurance strength of both males and females' adolescents. In a previous study by Podstawski, et al. [35], university males and females characterized by moderate physical activity levels had the highest endurance strength abilities assessed by the 3-MBT than those typified with low PA levels. Our findings confirmed their observations. More cycles were completed during the 3-MBT with males having the highest scores compared to females.

The results of the 3-MBT were significantly influenced by physical activity levels as assessed by MET values, body mass and body mass index in this present study. The relationships, variations and correlations observed in present studies is an indication that low PA levels poses a risk that has an impact on health characterized by individuals living an inactive lifestyle and this has been reported in literature with physical activity associated with university students [17,18,21]. However, studies have shown that some selected health risk could be minimized when physical fitness is improved [36].

Limitations

Individuals with robust muscular development were privileged in the 3-MBT and the small sample size used in this study were the limitations of this study.

Conclusion

The findings of the study demonstrated that males were characterized by higher anthropometric measurements excluding body mass index than females. Body mass and BMI were significantly correlated with 3-MBT. In effect, the number of cycles that an adolescent can complete in 3-MBT can be predicted from the correlated variables. The significant difference observed in endurance strength capacity among both males and females were the reason for the difference observed in the performance scores of 3-MBT. Males and females characterized by moderate levels of PA completed more cycles than their sedentary counterparts. Physical education and well-planned physical fitness programs that would ensure that all students participate in physical activity to reduce risk factors associated with inactive lifestyle should be reintroduced in schools

Conflict of Interest

The authors declare no conflict of interest.

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