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The Association between Body Mass Index and Physical Fitness in Adolescents

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Abstrak

Gaya hidup dan pola makan masyarakat modern saat ini dapat menyebabkan kelebihan berat badan dan obesitas. Obesitas dan kelebihan berat badan pada saat ini mulai mengkhawatirkan. Penelitian ini bertujuan untuk memberikan gambaran tentang kondisi Indeks Masa Tubuh (IMT) dan kebugaran jasmani remaja di Kepulauan Bangka Belitung pada tahun 2017 dan bagaimana keterkaitan antara IMT dan kebugaran jamani. Pertisipan pada pnelitian ini adalah 105 remaja yang terdiri dari 90 remaja laki -laki dan 15 remaja perempuan dengan usia rata-ratae ± 18 tahun. Tes antropometri dilakukan untuk mengidentifikasi IMT. Sedangkan tes performa dilakukan untuk mengidentifikasi komponen-komponen kebugaran jasmani yang terkait dengan kesehatan. Tes performa yang diberikan adalah lompat vertikal (power tungkai), lari cepat 60 meter (kecepatan), *push-up* (daya tahan kekuatan lengan), *sit-up* (daya tahan kekuatan otot perut), dan berlari / berjalan jarak 1000/1200 meter (daya tahan kardiorespirasi). IMT memiliki korelasi yang signifikan dengan daya tahan kekuatan otot lengan. IMT memiliki korelasi yang signifikan dengan power tungkai. IMT berkorelasi secara signifikan dengan kecepatan. CRE hanya berkorelasi signifikan terhadap data tahan kekuatan perut. Kegemukan dan obesitas dapat dicegah melalui pemberian program aktivitas fisik yang tepat.

Abstract

The lifestyle and dietary habit of the modern society can lead to overweight and obesity. Overweight and obesity are now beginning to worry. This study was aimed at providing a description of the condition of Body Mass Index (BMI) and physical fitness among adolescents in Bangka Belitung Islands in 2017 and how BMI and physical fitness are associated. 105 adolescents were participated in this study, consisting of 90 male and 15 female adolescents. Participants were at age ± 18 years in the year when the study was conducted. Anthropometry test was conducted to identify participants' BMI. Performance tests were conducted to identify the components of health related to physical fitness. The performance test included vertical jump (leg power), sprint 60 meter (speed), push-up (strength and endurance of arm muscle), sit-up (strength and endurance of abdominal muscles), and run / walk for 1000/1200 meters (cardiorespiratory endurance). BMI has a significant correlation with the strength and endurance of arm muscle . BMI has a significant correlation with leg power. BMI correlates significantly with speed. CRE is only significantly correlated with abdominal muscle strength and endurance. Overweight and obesity can be prevented through the provision of a program of physical activity.

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INTRODUCTION

Obesity, poor physical fitness of children and their causal dependency are associated with many preventable diseases and present a serious current and future public health problem (Starc & Strel, 2012). Nowadays physical fitness is considered as a powerful marker of health and quality of life in childhood (Dobosz, Mayorga-Vega, & Viciana, 2015). Children's health and well-being is highly correlated with their physical fitness (Golle, Muehlbauer, Wick, & Granacher, 2015). Unfortunately, the importance of physical fitness tests as significant diagnostic information about the health status of children is commonly ignored (Dobosz et al., 2015). Physical fitness should be considered as a useful health marker already in childhood and adolescence, reinforcing the need to include physical fitness testing in health monitoring systems (Ortega, Ruiz, Castillo, & Sjöström, 2008).

The prevalence of obesity and obesity increases at an alarming rate. Obesity is associated with the addition of physiological risk factors and behaviors. The results of Hunt et al., show children with high body fat levels have low respiratory resistance (Hunt, Shield, Cooper, Ness, & Lawlor, 2011). Huang & Malina, (2010) revision on their study results that body mass index has a strong relationship with the strength of limbs of children and adolescents, and has a negative effect on the strength of limbs of children and adolescents with the category of overweight and obesity. Previous studies conducted by Sadhan, Koley, & Sandhu, (2007) suggest a word based on linear regression analysis shows the percentage of fat and fat mass has strong strength against VO2max in boys. Other studies have no significant difference in respiratory resistance between men and women (Ramsbottom, Currie, & Gilder, 2010).

Body functions (skeletomuscular, cardiorespiratory, hematocirculatory, psychoneurological and endocrine-metabolic) are involved in the performance of daily physical activity and / or physical exercise (Ortega et al., 2008). In addition, physical exercise is also important in relation to brain health, in particular the increased exercise volume reduces demansia in older men and maintains cognitive performance in older women (Abbott et al., 2004). Schools are a great place for health promotion programs, the current evidence suggests that school-based interventions are most effective for improving adolescents physical activity (Andrade et al., 2014).

Schools are the most suitable settings to identify children with poor levels of physical fitness and to promote healthy behaviors (Dobosz et al., 2015). The school is considered an excellent place to provide students with the opportunity of daily physical activity, teach the importance of regular physical activity to health, and build the skills that support active lifestyles (Aboshkair, 2012). Nevertheless, it is still not a priority concern of the Indonesian education stakeholders. These reference values constitute undoubtedly an important tool in the educational setting (Dobosz et al., 2015). The Information of physical fitness level allows physical education (PE) teachers to detect students with health problems early and provide improvement interventions against these conditions.

Physical fitness is the body's ability to function efficiently and effectively (Corbin et al., 2008). The ability to meet the ordinary as well as the unusual demands of daily life safely and effectively without being overly fatigued and still have energy left for leisure and recreational activities (Hoeger & Hoeger, 2008). Physical fitness as the ability to carry out daily tasks with vigor and alertness, without undue fatigue, and with ample energy for leisure-time pursuits, and to meet unforeseen emergencies (Aboshkair, 2012).

Physical fitness is also mean a person's ability to perform a particular job quite well, without causing fatigue (Widiastuti, 2011). Physical fitness is generally achieved through exercise and is considered a measure of the body‘s ability to function efficiently and effectively in work and leisure activities, to be healthy, to resist hypokinetic diseases, and to meet emergency situations (Powell, 2011). Physical fitness is generally obtained through physical activity or exercise and consider a measure of the ability of the body to function efficiently and effectively in training and leisure activities, to be healthy, to prevent excessive fatigue, and for dealing with emergencies.

Physical fitness referred to in this study was the student's physical fitness both in carrying out their daily activities for learning and the development of physical fitness which has been obtained by student's through the national education system. The Student's physical fitness is the student's ability and the body's

ability adapt to the physical loading is given to him to learn in school activities without causing excessive fatigue, which means that students still have enough passion and energy to enjoy leisure time (Simbolon, 2016).

Physical activity has enhanced well-being and increasing physical functioning also in people with poor health (Häkkinen et al., 2010). Physical exercise is one of the main determinants (Ortega et al., 2008). In other words, their work more productive if increasing physical freshness. Physical fitness is classified into several sections. Hoeger classified physical fitness into health-related, skill-related, and physiological fitness (Hoeger & Hoeger, 2008). Physical fitness comprises two related concepts: general fitness (a state of health and well-being) and specific fitness (a task-oriented definition based on the ability to perform specific aspects of sports or occupations) (Powell, 2011). Physical fitness is classified into the health-related components and the skill-related components (Corbin et al., 2008). Each physical fitness consists of several components. The components of health-related physical fitness are: body composition; cardiovascular fitness; flexibility; muscular endurance; and strength, and the components of skill -related physical fitness are: agility; balance; coordination; power; reaction time; and speed (Corbin et al., 2008).

This study aims to provide an empirical information of the condition of Body Mass Index (BMI) and physical fitness among adolescents in Bangka Belitung Islands in 2017, and how BMI and physical fitness are associated. This study also showed how BMI and cardiorespiratory endurance (CRE) are associated, and how BMI and CRE are associated with the physical fitness components.

METHOD

The participants are adolescent aged 17-21 years. The participants are adolescents of equivalent high school graduates who take a physical test at the admission of new students of Physical Education, Health and Recreation department at STKIP Muhammadiyah Bangka Belitung in 2017. 105 adolescents were participated in the anthropometry and performance test. By sex the participant were consists of 90 male and 15 female.

The research was approved by the Institute of Research and Community Service of STKIP Muhammadiyah Bangka Belitung, Physical Education, Health and Recreation department of STKIP Muhammadiyah Bangka Belitung, and also known by the Institution STKIP Muhammadiyah Bangka Belitung, and also written approval from the sample and / or their parents / guardians.

Body mass index is calculated as body mass (kg) divided by squared body height (m2) and then participants are grouped into the 'normal' category (<24.9 kg/m2, including underweight), 'overweight' (25.0-29.9 kg/m2), and 'obesity' (> 30.0 kg/m2) (Hoeger, 2008). Participants' height and mass are measured by senior students trained in anthropometry related to admission of new students and have passed the evaluation course of learning physical education. Participants are barefoot and lightly dressed during anthropometry. The height and mass of the sample body were measured using a scale (kg) and a height meter (cm) that had been calibrated.

Push up and sit up test for 60 seconds was used to measure the strength and endurance of arm muscles and abdominal muscles (Widiastuti, 2011). All participants are instructed to perform the correct push up and sit up as much as possible within 60 seconds. Push-up test performance was correlated significantly with the criterion measure of absolute strength (Pate, Burgess, Woods, Ross, & Baumgartner, 1993). The number of correct movements is calculated and recorded. Based on the results of Nelson's study, Yoon, and Nelson suggest that push-up have significant levels of effectiveness and reliability and can be used as functional tests of upper body strength and endurance for men and women of school age to adulthood (Nelson, Yoon, & Nelson, 1991).

Vertical jumps was used to measure participants' leg power. Each participant was given three times a chance to make a vertical jump. Each participant was advised to jump as high and maximum as possible. The jump results are measured and recorded on a centimeter scale (cm). The highest jump distance was taken to predict the leg power (Widiastuti, 2011). Speed is measured by a 60 meter sprint performance test (Widiastuti, 2011). Each participant is given twice the opportunity to dash 60 meters. The time taken to complete a 60-meter dash was recorded and taken the fastest from the two given opportunities.

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1000 and 1200 meters Running / walking tests was used to measure the respiratory durability of the participants. The performance of field test run / walk medium-haul road 1200 meters for men and 1000 meters for the women (Widiastuti, 2011). All participants are instructed to complete the test as soon as possible. If they can't run, then allowed to walk. The time taken by the participants is recorded in minutes and seconds using a calibrated stopwatch.

Descriptive statistics are used to provide an overview of participant characteristics and research variables. Pearson's correlation was used to examine the relationship between body mass index and physical fitness included the respiratory durability of participants. Multiple linear regression modeling was used to determine the relative influence of physical fitness variables measured (speed, leg power, abdominal strength and endurance, arm strength and endurance, and cardiorespiratory endurance). The significance test using t test and the alpha level was set at 0.05 for all analyzes. All statistical analysis on this research data is assisted by using Microsoft Excel 2013 for windows 7.

Table 1. The Participant Characteristics

	All	Male	Female
n	105	90	15
Age (*years*)	18.4 ± 1.57	18.6 ± 1.62	17.3 ± 0.74
Body mass (*kg*)	58.3 ± 11.2	59.1 ± 11.5	53.6 ± 8.10
Body height (*m*)	1.64 ± 0.07	1.65 ± 0.06	1.56 ± 0.04
BMI (kg/m^2)	21.6 ± 3.6	21.5 ± 3.59	22.0 ± 3.78
ArSE (*movement/ minute*)	29.8 ± 9.1	29.8 ± 9.29	29.7 ± 8.50
AbSE (*movement/ minute*)	32.6 ± 8.70	34.5 ± 7.49	21.2 ± 6.70
Leg Power (*cm*)	53.4 ± 11.5	55.8 ± 10.2	39.2 ± 7.90
Speed (*seconds*)	10.7 ± 1.20	10.4 ± 1.06	12.1 ± 0.99
CRE (*Minute-*	6.51 ± 1.04	6.44 ± 1.05	6.91 ± 0.90

Notes. Value are mean ± SD; Speed (Dash 60 meter); Leg Power (vertical jump); AbSE = Abdominal Strength and Endurance (sit up); ArSE = Arm Strength and Endurance (push up); CRE = Cardiorespiratory Endurance (1000 and 1200 run/walk).

RESULTS AND DISCUSSION

Characteristics of the participant can be seen in table 1. Overall male have more body weight and height than female adolescents. Nevertheless, both male and female have a 'normal' body mass index. The CRE performance of male is better than female. The strength and endurance performance of the arm muscles of male and female adolescents has a relatively equal average. Differences in the average performance and strength of abdominal muscles of male are better than female.

Table 1 shows the relationship between each variable. Body weight has a strong positive correlation with BMI (r = 0.891). Body height correlated relatively small positive with BMI (r = 0.036). The arms muscles strength and endurance were moderately negative correlated with BMI (r = -0.350). The abdominal muscles strength and endurance correlated relatively small negative with BMI (r = -0.094). The leg power has moderately negative correlation with BMI (r = -0.439). The speed has moderately positive correlation with BMI (r = 0.372). The cardiorespiratory endurance has a relatively small positive correlation with body mass index (r = 0.027).

Body height has positively moderate correlation with body weight (r = 0.476). The arms muscles strength and endurance was negatively moderate correlated to body weight and correlated small negative with high body (r = -0.377, r = -0.121). The abdominal muscles strength and endurance was positively little correlated with weight, height, and arm muscles strength and endurance (r = 0.017, r = 0.248, r = 0.032). The CRE correlated negatively small with body weight, body height, Abdominal muscle strength and endurance, and leg power (r = -0.018, r = -0.086, r = 0.032, r = -0.238, r = -0.073). However, the CRE was positively correlated with speed (r = 0.107).

The results of the multiple linear regression analysis performed for all participants to predict BMI based on their arm strength and endurance, abdominal strength and endurance, leg power, speed, and cardiorespiratory endurance are provided in table 3. The results showed that only arm strength and endurance, leg

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power, and speed were significant predictors of BMI. The overall regresion model was significant, F(5, 99) = 7.596, p < 0.001, R2 = 0.277 at p < 0.05. The generalized equation used to predict BMI from arm strength and endurance, leg power, and speed was: Predicted BMI = 0.614 (speed) -0.092 (leg power) -0.079 (arm strength and endurance) obtained from coefficients table with R2 = 0.277 at p ≤ 0.05.

Table 2. The Correlations between BMI and Physical Fitness of Adolescents

	BW	BH	ArSE	AbSE	Leg Power	Speed	CRE
BMI	**0.89**	**0.03**	**-0.3**	**-0.09**	**-0.43**	**0.3**	**0.02**
BW	-	0.47	-0.3	0.01	-0.45	0.4	**-0.01**
BH		-	-0.1	0.24	-0.13	0.1	**-0.08**
ArSE			-	0.03	0.32	-0.2	**0.03**
AbSE				-	0.1	-0.09	**-0.23**
Leg Power					-	-0.3	**-0.07**
Speed						-	**0.10**
CRE							-

Notes. AbSE = Abdominal Strength and Endurance; ArSE = Arm Strength and Endurance; CRE = Cardiorespiratory Endurance.

Table 3. Multiple Linear Regression Analysis to Predict BMI and Physical Fitness Variables

Variables	Co-efficient (â)	P-value
ArSE	-0.079	**<0.05**
AbSE	0.002	>0.05
Leg Power	-0.092	**<0.01**
Speed	0.614	**<0.05**
CRE	-0.029	>0.05

Notes. R square = 0.277; adjusted R square = 0.240; P≤0.05.

Table 4 provide the results of the multiple linear regression analysis performed for all participants to predict CRE based on their arm strength and endurance, abdominal strength and endurance, leg power, and speed. The overall regresion model was not significant, F(4, 100) = 2.257, p > 0.05, R2 = 0.082 at p < 0.05. There is only abdominal strength and endurance was

Table 4. Multiple Linear Regression analysis to predict Cardiorespiratory Endurance and Other Physical Fitness Variables

Variables	Co-efficient (â)	P-value
ArSE	0.016	>0.05
AbSE	-0.031	**<0.01**
Leg Power	-0.004	>0.05
Speed	0.088	>0.05

Notes. R square = 0.082; adjusted R square = 0.046; P≤0.05.

significant predictor of CRE. The generalized equation used to predict CRE from abdominal strength and endurance was: Predicted CRE = -0.031 (abdominal strength and endurance) obtained from coefficients table with R2 = 0.082 at p ≤ 0.05.

Based on the results of the correlation significance test as presented in table 3. BMI and CRE have significant correlation with abdominal muscle strength and endurance (tcount = 3.79 > ttable = 1.66, tcount = 2.51 > ttable = 1.66). Similar issues have been identified in Liao study, that the strength and power of lower body explosions have a high correlation with adolescent BMI in Taiwan (Liao et al., 2013). While BMI and CRE did not have significant correlation with arm muscles strength and endurance (tcount = 0.92 < ttable = 1.66, tcount = 0.30 < ttable = 1.66). In Benson study, both strength and cardiorespiratory fitness maintained their protective effect after adjustment for the other physical fitness parameters, emphasizing that these two components of the fitness are independent of each other and not surrogate measures of each other (Benson, Torode, & Fiatarone Singh, 2006). The BMI and CRE did not have a significant correlation (tcount = 0.30 < ttable = 1.66). Muscle fitness and CRE were significantly and negatively correlated with cardiometabolic risk, separate from each other (Buchan et al., 2015) boys performed better than girls in speed, muscular strength, and CRE, but girls performed better than boys in balance and flexibility (De Miguel-Etayo et al., 2014).

Table 5. The Results of Correlation Significance Test

	BMI	CRE
ArSE	3.79	0.30
AbSE	0.92	2.51
Leg Power	4.97	0.71
Speed	4.04	1.12
CRE	0.30	-

n =105, ttable = 1.66

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Findings from Chen, Housner, & Gao (2017) highlighted the importance of maintaining a normal BMI during the primary school years to achieve and maintain better physical fitness. Adolescents with high involvement in physical activity demonstrate BMI and proportional body composition and a better level of cardiorespiratory fitness (Ahmed et al., 2017). Based on the results of this study it was found that BMI and CRE were only correlated with arm muscle strength and endurance. Silva et al., (2017) study findings suggest that body fat is strongly related to cardiovascular risk, but when the outcome is calculated without the central obesity indicator, CRE becomes more related to metabolic risk.

Body weight is a major confounder to performance on the field tests investigated (Pate et al., 1993). Body weight, height, gender, and body mass index are good CRE predictors among school students (Olawale, Mwila, Marie, & Lamina, 2017). Further, Vale et al., (2011) finding suggested that low CRE was a strong predictor of risk values of abdominal obesity in adolescence. The lower level of CRE may be associated with the development of metabolic syndrome in Asian countries (Jae et al., 2014). It is important for us to prepare programs that can provide positive interventions on body mass index, upper body fitness, as well as adolescent respiratory resilience. This condition can be better through school role. Schools have an important role in the development of students (Simbolon & Firdausi, 2017).

CONCLUSSION

BMI is significantly correlated with the three components of physical fitness in adolescents. These components are the arm muscles strength and endurance, leg power, and speed. BMI is not significantly correlated with the other two components of physical fitness, namely abdominal muscle strength and endurance and cardiorespiratory endurance. Overweight and obesity can be prevented through the provision of a program of physical activity that meets the rules of physical fitness. The program should be provided from primary to senior high school and it's a sustainable long-term program at every level of education at school. Hopefully overweight and obesity can be prevented.

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