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The Path Analysis of Body Mass Index, Physical Exercise, Sleep Quality, and Parental Education on Physical Fitness among Male Adolescences

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ABSTRACT

Background: Rapid physical growth occurs during adolescence period. Physical fitness is a key indicator for general health, which shows individual ability of cardiorespirationand skeletal muscles to adapt to physical activity load. Many factors can influence physical fitness such as Body Mass Index for age (BMI/age), physical exercise, sleep quality and parental education. The purpose of this study was to analyze the relationship of BMI/age, physical exercise, sleep quality and parental education with physical fitness levels among male adolescences.
Subjects and Methods: This cross-sectional study was conducted in three private senior high schools at the Gondokusuman district, Yogyakarta. Study subjects were selected using the fixed exposure sampling technique with inclusion criteria: male adolescence who aged 15-18 years old and had normal or more BMI/age. The dependent variable was physical fitness. The independent variables were BMI/age, physical exercise, sleep quality, and parental education. The data were collected by questionnaire and analysed by path analysis.
Results: Physical exercise (b= 0.32; SE= 0.46; p<0.001) and BMI/age (b= -2.87; SE= 0.27; p= <0.001) were directly related to physical fitness. Indirect relationship was found inparent education and sleep index score with physical fitness through physical exercise. Interestingly, BMI/age had direct and indirect relationship to physical fitness.
Conclusion: BMI/age is a predominant factor that influences physical fitness in male adolescences. Sleep quality and parent education also influence physical fitness, but they had opposite direction. All those factors should be considered as key factors in order to enhance physical fitness in male adolescences.

Keywords: physical exercise, sleep quality, physical fitness, male adolescence

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BACKGROUND

According to the World Health Organization (2017), adolescence is one of the most rapid phases of human development, which is characterized by major biological changes such as increase of body weight and height, and changes in body composition. These adolescent growth and development will be an important determinant for physical health in adulthood period (Balsalobre, *et al.,* 2014). The adolescent's physical health is not only influenced by biological factors but also psychological and social factors (Murti, 2016).

Physical fitness is a very important determinant for general health and physical activity levels in human being (Balsalobre, et al.,2014). In general, the physical fitness is related to ability of cardiorespiration and skeletal muscles to adapt against physical activity load. In this condition, the cardiorespiration has a vital role in providing oxygen to skeletal muscles during physical activities (Sandbakk et al., 2016; Silva and Martins, 2017).

According to (Kolsteren et al., 2014), daily food intake is strongly related to pathogenesis of metabolic, inflammatory and chronic diseases in adolescences. Furthermore, consumption of high dense foods and low physical exercise will increase excessive energy storage in form of fat accumulation, leading to overweight and obesity (Zalilah et al., 2006). For assessment of obesity, body mass index (BMI) is commonly used. Based on (Salmon et al., 2016), BMI/age represents nutritional status for adolescences and is inversely proportional to physical fitness level.

Some studies have documented that physical exercise has many beneficial effects for human health including reduction of cardiovascular diseases, cancer, and diabetes (Powers and Jackson, 2010). Physical exercise which is carried out for 150 minutes/week will reduce 20 - 30% premature mortality and morbidity of many chronic diseases (Herbsleb et al., 2013; Booth et al., 2015; McKinney et al., 2016; Sandbakk et al., 2016). In addition, physical exercise will provide great bioenergetics in skeletal muscles, which is 15-25 times greater than energy use during resting time. Routine physical exercise also significantly increases maximum oxygen consumption (VO2max), which involves pulmonary, cardiovascular and muscle systems (Kwak, 2013). As a results, adapted skeletal muscles will renew muscular contractile tissues and increase muscular mitochondria and vascular system (Booth et al., 2015).

Beside physical exercise, sleep quality is also an important predictor for physical and mental health (Ohayon et al., 2017). Sleep quality will affect food intake, appetite and energy balance through hormonal mechanisms. During night sleep, anabolic hormones are more dominant than catabolic hormones. Some growth hormones will suppress catabolic hormones such as cortisol, which plays an important role in physiological stress condition (Franken et al., 2009). Therefore, poor sleep quality leads to decrease of physical fitness and life quality (Ferranti et al., 2017).

From social factors, high parent education will also improve the physical fitness of adolescences by which adolescences have better level of physical fitness than adolescences who have parent with low education. Higher education is proportional to higher income. Parent with high education will encourage their adolescences to do the desired physical exercise that be able to improve physical fitness (Finger et al., 2014).

Due to changes of information and technology in the world, many adolescences adopt life style in other countries that have negative impacts on physical exercise, sleep quality and nutrition. Additionally, adolescences tend to imitate to their parent lifestyle either positive or negative behaviour, especially consuming daily foods, doing physical exercise and sleeping in the night. So, the purpose of this study was to analyze the relationship of BMI/age, physical exercise, sleep quality and parental education with physical fitness levels among male adolescences.

SUBJECTS AND METHOD

The protocol of this study has been approved by the Research Ethics Committee, General Hospital Dr. Moewardi Surakarta/ Faculty of Medicine, Universitas Sebelas Maret with number: 517 / IV / HREC / 2018. Before doing this study, all selected subjects signed the informed consent.

1. Study design

This was an analytic observational study with a cross sectional design. The study was conducted from July to August 2018.

2. Population and Sample

The target population of this study was allstudents of senior high schools in Yogyakarta city. Study subjects were selected using the fixed exposure sampling technique with inclusion criteria: male adolescence, 15-18 years old and had normal and more nutritional status. The study subjects were excluded from this study if they had physical disabilities, cardio respiratory diseases and epilepsy, were aerobic athlete and used stimulant drugs or supplements that could increase cardio respiratory activity. Total samples were 225 male adolescences with 75 overweight subjects and 150 normal subjects.

3. Study Variables

Independent variables were BMI/age, physical exercise, sleep quality, and parental education whereas the dependent variable was physical fitness level.

4. Data Collection

This study used primary data that collected using questionnaires for basic characteristics, physical exercise and parent education level. For sleep quality, it used the Pittsburgh Sleep Quality Index (PSQI) questionnaire. The anthropometric data were generated by measurement of body weight with a weight scale (Krisbow, Indonesia) and height with a microtoise (Krisbow, Indonesia). The WHO anthro application was downloaded from https://www.who.int/growthref/tools/en/and was used to determine nutritional status, which was presented as kg/m^2 for age (BMI for age). The protocol of physical fitness measurement were adopted from the Cooper run test 12 minutes (Cooper, 1968).

5. Data analysis

Data analysis in this study used univariate, bivariate, and multivariate analysis. Basic characteristics of study subjects were presented as frequency and percentage, which used univariate analysis. To analyse individual relationship between independent and dependent variables, the Pearson Product Moment test. Multivariate analysis used in this study wasthe path analysis with the Amos program 24 (Arbuckle, 2016). A p value <0.05 was considered as significant relationship.

RESULTS

In this cross-sectional study, we evaluated physical fitness in 225 male adolescences from 3 private senior high schools. Their physical fitness was classified into good and poor categories.

1. Univariate Analysis

Table 1 showed basic characteristics of study subjects in terms of age, BMI/age, physical exercise and parent education. Majority of study subjects aged 17 – 18 years old from which 71.7% among them had good physical fitness.From 150 study subjects, 16 and 17.3% were overweight and obesity respectively and most of them had bad physical fitness. Physical exercise performed by study subjects was proportional to the physical fitness. In contrast, sleep quality was inversely related to the physical fitness. More study subjects with bad sleep quality had better physical fitness. More than half percent of study subjects with good physical fitness came from educated and non-educated parents.

Table 1. Basic Characteristics of Study Subjects

Characteristic	Total (%)	Physical Fitness	
		Good	Bad
		N (%)	N (%)
Age (years old)			
15 – 16	59 (26.2)	34(57.6)	25 (42.4)
17 – 18	166 (73.8)	118 (71.1)	48(28.9)
BMI/age			
Normal (Z score ≥-2.0 s/d ≤1.0)	150 (66.7)	137 (91.3)	13 (8.7)
Over weight(Z score>1.0 to ≤ 2.0	36 (16)	9 (25)	27 (75)
Obesity (Z score> 2.0)	39 (17.3)	6 (15.4)	33 (84.6)
Physical exercise			
Poor	36 (16.0)	11 (30.6)	25 (69.4)
Average	76 (33.8)	45 (59.2)	31 (40.8)
Good	93 (41.3)	76 (81.7)	17 (18.3)
Very Good	20 (8.9)	20 (100)	0 (0)
Sleep Quality			
Poor	209 (92.9)	138 (66)	71 (34)
Good	16 (7.1)	14 (87.5)	2 (12.5)
Parent Education			
Primary school	78 (34.7)	52 (66.7)	26 (33.3)
Secondary school	74 (32.9)	45 (60.8)	29 (39.2)
University	73 (32.4)	55 (75.3)	18 (24.7)

2. Bivariate Analysis

Over all, BMI/age, physical exercise, sleep quality and parent education significantly correlated with physical fitness (Table 2). Negative correlations were observed in BMI/age and sleep quality, but BMI/age had a stronger correlation, than sleep quality. Meanwhile physical exercise and parent education level had positive correlations, which physical exercise was related to physical fitness was stronger than parent education level.

Table 2. The Results of Correlation of Independent and Dependent Variables

Independent variable	r	p
BMI/age	-0.67	<0.001
Physical exercise	0.57	<0.001
Sleep quality	-0.30	<0.001
Parent education level	0.14	0.034

3. Multivariate Analysis

As stated in Figure 1, the Amos model of path analysis had 2 endogenous variables and 3 exogenous variables. Physical exercise became an intermediate variable for BMI/age, sleep quality and parent education. Themodel of path analysis fitted to the existing model with CMIN (normed Chi-square) was 1.803,the minimum sample discrepancy function (CMIN/DF)= 0,901. Goodness of Fit Index (GFI)= 0.997; Normed Fit Index (NFI)= 0.994; Comparative Fit Index (CFI)= 1.00; Root Mean Square Error of Approximation (RMSEA) = 0.000; Akaike Information Criterion (AIC)= 27,803 and Bayesian Information Criterion (BIC)= 72,212 with p level= 0.406.

From our model of path analysis, we could then generate indirect and direct correlations (Table 3). It indicated that BMI/age had negative dual effects to physical fitness. Physical exercise directly correlated with physical fitness and mediated sleep quality and parent education level towards physical fitness. All of variables significantly correlated with physical fitness and BMI/age was the strongest factor that affected physical fitness.

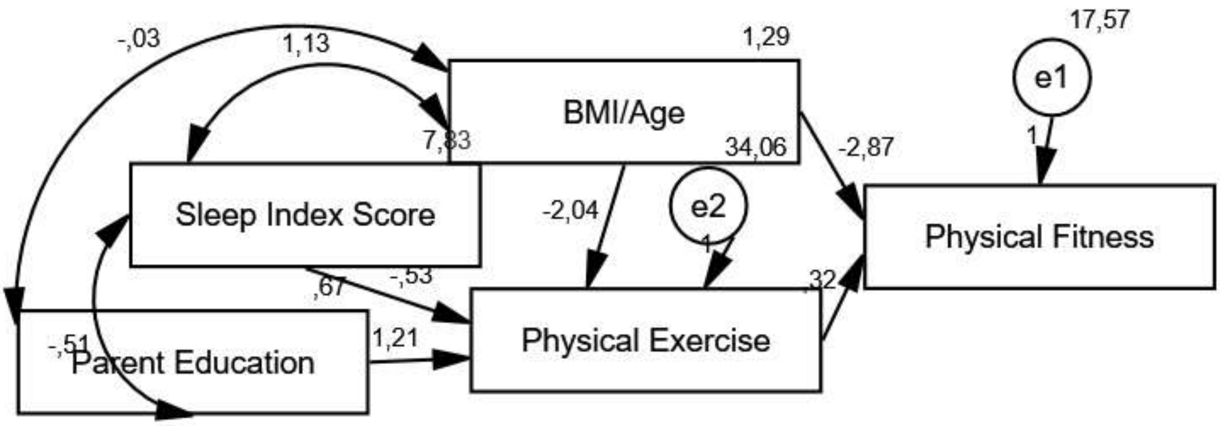

Figure 1. Specified model of Path Analysis between BMI/age, physical exercise, sleep quality, and parental education with physical fitness

Table 3. Path Analysis of BMI/age, Physical Exercise, Sleep Quality, and Parental Education with Physical Fitness

Dependent variable		Independent variable	(b)	SE	p	(β)
Direct effect						
Physical fitness	←	BMI/age	-2.87	0.27	<0.001	-0.52
Physical fitness	←	Physical exercise	0.32	0.46	<0.001	0.35
Indirect effect						
Physical exercise	←	BMI/age	-2.04	0.37	<0.001	-0.34
Physical exercise	←	Parent education	1.21	0.49	0.013	0.15
Physical exercise	←	Sleep index score	-0.53	0.15	<0.001	-0.22
Model Fit						
CMIN= 1.803; p =0.406 (≥0.05)						
GFI= 0.997 (≥0.90)						
NFI= 0.994 (≥0.90)						
CFI= 1.00 (≥0.90)						
RMSEA <0.001 (<0.08)						
*b = unstandardized path coefficient						
*β = Standardized path coefficient						

DISCUSSION

Our study indicates that BMI/age is the strongest direct correlationto physical fitness in adolescents. It is not surprised that 33.3% adolescents in this present study have overweight or obesity and bad physical fitness.In addition, physical exercise is a key point for improvement of physical fitness thatis affected by BMI/age, sleep quality and parent education.

Theoretically, BMI is negatively associated with physical fitness level. Adolescences with overweight/obesity have high fat accumulation, which will lower daily activities including physical exercise and physiological functions of the body systems such as cardio respiration, metabolic endocrine, haematology and psychoneurology (Ortega et al., 2013). Other studies reveal that adolescences with overweight will decrease the cardiovascular structure and function, which result in decrease of cardiac output and stroke volume, increase of total blood volume, hearth rate and vascular systemic resistance and stimulate the sympathetic nervous system (Lavie et al., 2014; Castro et al., 2017). Overweight or obesity also decreases endurance, flexibility, coordination and explosive power of skeletal muscles (Abdelkarim et al., 2017). Our findings are in agreement with a previous study performed by Abdelkarim, et al., (2017) but their study involved children as study subjects. The Abdelkarim's study also used the Spearman test to analyse their data to correlate between BMI, physical fitness, coordination, speed ability, flexibility, and endurance. Therefore, our finding straight forward addresses the correlation between BMI and physical fitness. The disadvantage of our study, however, does not measure muscle flexibility, coordination and explosive power.

In the present study, overweight indirectly influences physical fitness through exercise. This is consistent with the result of study from Wiklund (2016) that increased body weight is negatively associated with energy expenditure during daily activities. Adolescents with overweight tend to have sedentary life, which result in reduction of energy expenditure. Each 10% weight gain will increase more 370 - 530 Kcal daily energy expenditure, compared with normal weight (Wiklund, 2016). From our study, we have several limitations. Firstly, our study doesnot collect data of adolescences and their parent daily activities so that we do not know how much energy they spend for daily activities. We also have no data of other factors that influence adolescences activities such as self-efficacy, willingness, intentions and environment. Therefore, further study should add health promotion in order to improve their physical fitness.

There are 2 reasons why adolescences with obesity have low physical fitness. Firstly, Fu et al. (2016) stated that each joint in adults with overweight and obesity have a higher mechanical workload (0.36 j/ kg), compared to mechanical workload in normal adults (0.27j / kg). In the last step of walking (push off),adults with normal weight use together ankle joints and muscles, but adults with obesityjust use mechanical workload of the ankle because of fat accumulation (Fu et al., 2016). Secondly, the knee flexion is also decreased by 15% in adults with overweight and obesity, leading to increase of joint and muscles movement surrounding the knee. However, a study related to mechanical load in adolescences with obesity has not been established.

A direct relationship is observed between physical exerciseand physical fitness. Adolescences who routinely carry out aerobic exercise have good level of physical fitness. According to Kwak (2013), routine physical exercise can increase VO2Max, pulmonary capacity, cardiovascular and muscle works. The physical exercise will also enhance metabolism through glucose and fat mobilisation. During the aerobic exercise, type I and type IIa muscle fibres need 36 ATP for muscle contraction. These muscle fibreshave high aerobic resistance and more ATPases (Kwak, 2013; Booth et al., 2015).

Another finding in our present study indicates that poor sleep quality reduces indirectly physical fitness level. In the normal condition, sleep is regulated by a circadian rhythm to maintain a sleep pattern for 24 hours. If sleep quality is poor, the circadian rhythm will be disrupted, which leads to reduction of melatonin hormone secreted by the pineal gland and anabolic hormones such as growth hormone, testosterone and Insulin-like Growth Factor 1 (IGF-1). On the other hand, catabolic hormones such as cortisol and myostatin will increase. The IGF-1 mediated signalling is a central element in stimulation of muscle protein synthesis, characterization of muscle growth and related to adaptive process of skeletal muscles. This hormone promotes activation of phosphatidylinositol 3-kinase and Akt, which induce muscular hypertrophy. In contrast to anabolic hormones, increased cortisol levels can modulate muscle protein metabolism like enhancement of muscle atrophy and muscle protein catabolism and decrease of muscle protein synthesis through anubiquitin–protea some pathway (de Mello et al., 2011).

Data of sleep quality in our study supports Chen et al., (2017) study that sleep quality affects muscle strength among Chinese university students. Chen's study showed that sleep quality is association with grip strength in male ($p<0.001$) and female students ($p= 0.001$). However, they used high number of study subjects (10,125), who aged 16 – 30 years old and males (6,251) approximately doubled than females (3,874). Chen et al. (2017) used logistic regression analysis rather than path analysis.

The last factor that influences physical fitness is parental education. Well-educated parents will have positive behaviours such as doing regular physical activity and having high level of knowledge.They finally share their habits to children, especially through social media/electronics. For example, parents who have good lifestyle like performing routine aerobic exercise and eating healthy foods will provide a good behaviour for their children in future to prevent obesity. Our study is in accordance with a study conducted by Finger et al., (2014). They state that parent education is related to physical fitness levels (OR= 1.6; 95% CI= 1.2-2.1).Our result study is different from Finger's study in terms of size and type of collected data. They used 2,677 adolescences and classified parent education in to categorical data. To generate relationship between parent education and physical fitness, they used a multiple logistic regression test.

In conclusion, BMI/age has the strongest relationship to physical fitness in male adolescences. Sleep quality can reduce physical fitness through reduction of physical exercise. Meanwhile, parent education can increase physical fitness through physical exercise as well. Therefore, all those factors should be considered in order to enhance physical fitness in adolescences especially with obesity.

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