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The Correlation between Body Mass Index, Abdominal Circumference, and Hip Circumference on Cardiorespiratory Endurance using the Rockport Method

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Abstract—Obesity or being overweight is a factor in health that greatly lowers one's confidence. A lot of prevailing causes of death has been linked to obesity. The Body mass index (BMI), abdominal circumference, and hip circumference are anthropometric indicators commonly used to measure fat tissues in the body. An overweight or obese person feels heavy and stiff when exercising. However, regular and precise exercise routines can improve fitness. Cardiorespiratory endurance is a component of fitness. This study aims to determine the relations between body mass index, abdominal circumference and hip circumference, and cardiorespiratory endurance using the Rockport method. Body Mass Index can be obtained from comparing the body weight in kilogram with height in square meter. During the study, the measurement of abdominal circumference and hip circumference was performed using the measurement tape with centimeter accuracy level and the measurement was recorded in standing position. The Physical fitness test was performed by jogging at constant speed for 1600 meters and the time was recorded. The Non parametric Spearman test was used for the data analysis to determine the inter-variable correlation. The Body mass index, abdominal circumference and hip circumference weren't related to cardiorespiratory endurance. However, it is important to maintain a normal BMI.

Keywords—BMI, circumference, cardiorespiratory endurance, rockport

I. INTRODUCTION

This All over the world, over one billion adults are overweight [1]. Overweight and obesity are issues linked with diabetes mellitus 2, cardiovascular diseases, cancer, stroke, and atherosclerosis [2][3][4]. Generally, the Anthropometric measurement is used to determine one's nutritional status to check if one is obese, overweight, normal, or underweight. The Body mass index is an indicator of body fat accumulation [5]. Abdominal circumference and hip circumference are indicators of belly fat which more accurately predict obesity [6]. These anthropometric measurements can be used to measure belly fat which can predict various risks of diseases, including high blood pressure, diabetes mellitus, and coronary heart diseases [2] [6].

The research result on anthropometric measurement to predict various leading causes of death has been reported often. Sebastian reports in his study that abdominal circumference and waist size are linked to an increased risk of cardiovascular diseases and leading causes of death [6]. However, the waist size has greater links to these diseases while body mass index (BMI) isn't linked to cardiovascular diseases. BMI and abdominal circumference can be used to predict obesity, but abdominal circumference has a more profound relation with obesity [7]. The Body mass index as an indicator of accumulation of excessive body fat has no relation to death risks [5] [8]. Indicators of belly fat which includes waist size and waist-hip ratio have significant relation with risks of heart diseases [7]. In terms of cardiovascular diseases, the strongest indicators of body fat are waist-hip ratio, followed by the waist size, then the body mass index [9] [10] [11]. Wang and Hoy in their study stated that abdominal circumference, body mass index, waist size can be indicators of cardiovascular diseases and waist size is a better predictor than other parameters [12].

Various researches have shown that anthropometric measurements can be used to predict various diseases. However, anthropometric measurements predict fitness levels which involve only one variable of fitness component, i.e. cardiorespiratory endurance, has never been examined. This study aims to determine the relationship between body mass index, abdominal circumference and hip circumference, and cardiorespiratory endurance using the Rockport method.

II. METHOD

The research samples comprised of all the attending employees of the department of health, Yogyakarta. Each sample underwent a series of tests which included measurements of body height, body weight, abdominal circumference, hip circumference and a 1600 meter run. All participants were required to finish all measurements and perform warm-ups and stretches especially of their leg muscles before the 1600 meter running test. Participants who couldn't participate in any of the tests were removed from the study.

The weight and height measurements of the body were taken to determine body mass index by comparing body weight in kilogram (kg) with height in square meter (cm) [6]. The abdominal circumference (cm) was measurement during normal expiration phase while the subject was standing. A measurement tape was used to measure the Hip circumference (cm) and the maximum circumference of the buttocks.

The Cardiorespiratory endurance was measured using the Rockport method. Participants much finish the 1600 meter walking/running in a 400 meter athletic course. The amount of times the participants finished the course was recorded. The data time data was confirmed using the VO₂max table to obtain the VO₂max value. The VO₂max value was confirmed using the fitness level table in accordance with gender and the age group. Hence, the fitness level categories were: very poor, poor, moderate, good, and very good. The Non parametric Spearman correlation test was used in the data analysis to determine the relations between body mass index, abdominal circumference, hip circumference, and cardiorespiratory endurance.

III. RESULT

The data shows relationships between the body mass index, abdominal circumference and the hip circumference. The value of p<0.05 show a significant relationship between the variables. The value between the body mass index and the abdominal circumference is p=0.000(p<0.05), which show a significant relationship with the body mass index and the abdominal circumference. Furthermore, the Body mass index and hip circumference had a significant relationship with the value of p=0.000 (p<0.05). The Abdominal circumference and hip circumference had a significant relationship which is shown by the value of p=0.000 (p<0.05).

VO₂max had no relationship with the body mass index, abdominal circumference, and the hip circumference. The Analysis of the Nonparametric spearman correlation data shows relation the three relations, i.e. VO₂max and body mass index, VO₂max and abdominal circumference and VO₂max and hip circumference, has significance values of p>0.05. Hence, there was no significant relationship between VO₂max and body mass index, abdominal circumference, and hip circumference. Data in table 2 shows that the significance values of VO₂max and body mass index is p=0.199, VO₂max and abdominal circumference p=0.853 and VO₂max and hip circumference p=0.720.

The descriptive data of the research variables which include minimal value, maximal value and average, is presented in figure 1. Data of VO₂max by gender and age group is presented in table 1.

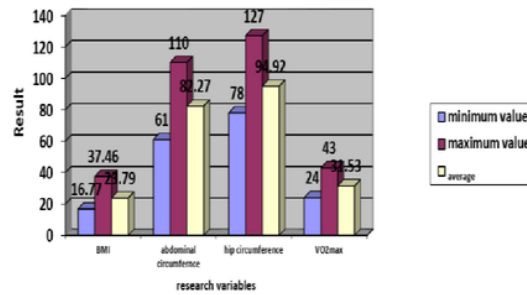


Fig. 1. Minimal value, average and maximal values of research variables

TABLE I. VO₂MAX BY GENDER AND AGE GROUP

Gender	Age (year)	categories					n
		very poor	poor	mode rate	good	very good	
Male	20-29	17	2	0	0	0	19
	30-39	13	4	2	1	0	20
	40-49	17	6	3	0	0	26
	50-59	11	5	2	2	0	20
n		58	17	7	3	0	85
Female	20-29	0	9	5	0	0	14
	30-39	0	4	15	3	0	22
	40-49	0	0	9	4	0	13
	50-59	0	0	2	20	1	23
n		0	13	31	27	1	72

TABLE II. RESULT OF NON PARAMETRIC SPEARMAN CORRELATION TEST DATA ANALYSIS

variable	variable			
	BMI	Abdominal Circumference	Hip Circumference	VO ₂ max
BMI	-	0.000	0.000	0.199
Abdominal Circumference	0.000	-	0.000	0.853
Hip Circumference	0.000	0.000	-	0.720
VO ₂ max	0.199	0.853	0.720	-

IV. DISCUSSION

Obesity is a condition where body mass with fat is greater than the body mass without fat. Many methods exist to determine body fat, including the Anthropometric method which is easy and cost-efficient. One of the commonly used anthropometric methods is the Body mass index (BMI), abdominal/waist circumference and hip circumference. The American Heart Association recommends using BMI and abdominal/waist circumference to measure body fat (obesity). BMI is measured by calculating the body height and weight. This calculation leads to a misinterpretation when one has body height dominated by muscle mass, like an athlete for example. Meanwhile, the abdominal and hip circumference produces more accurate results in assessing the body fat distribution. Compared to women, men have more dominant muscle mass, and men's abdominal circumference is related to physical fitness rather than BMI. In women, physical fitness is related to BMI [13].

The Rockport method is a safe method for elderly people to measure physical fitness and it doesn't require prior health examination. The method was selected in this study because it's inexpensive and quite accurate. The present research on the 157 male and female subjects showed that 72.6% of the subjects had normal abdominal circumference and only 27.4% had an exceeding abdominal circumference. Meanwhile, the BMI measurement showed that most subjects (56.1%) had normal BMI and only 31.8% was overweight and 3.2% was obese. The Fitness level measurement by VO₂max showed that most subjects (36.9%) had very poor and poor (23.6%) fitness level.

Adam states that in men, excess body fat is stored in the belly, while in women it is stored in the buttocks and *gluteofemoral* fat deposits [14]. Belly fat deposit describes central fat deposit which is closely related to diabetes mellitus, hypertension, heart and vascular diseases, and other metabolic diseases. Therefore, body distribution shouldn't be only assessed using BMI, but also, with abdominal circumference and hip circumference.

The present study showed a correlation between BMI, abdominal circumference and hip circumference ($p < 0.05$), however, there was no correlation between the fitness level (VO₂max) and BMI, abdominal circumference and hip circumference. It implies that an excessive BMI increases the risk of diseases and an increased central fat distribution can be found by measuring the abdominal circumference. The research result was in line with a previous research in Finland on a 25-74 years old age group which determined obesity using BMI, abdominal circumference and abdominal circumference to hip circumference ratio, showing that normal weight reduces risk of cardiovascular diseases [15].

On the other hand, BMI, abdominal circumference and hip circumference couldn't be used to predict one's fitness level. The result was different from the study of Gonzalez-Suarez *et al* on a group of overweight and obese preadolescents, which showed that excessive BMI and abdominal circumference lowers some fitness variables, e.g. the sit-and-reach test, 1-minute sit-ups, standing broad jump, and 20-m shuttle run [16]. Generally, there are several components of fitness, including cardiorespiratory endurance, muscle strength and endurance, body composition and flexibility [17].

This was the main factor that differentiated it from the study of Gonzalez-Suarez *et al*. which uses a group of preadolescents and fitness test which focused on muscle strength and endurance. Meanwhile, the present study was performed on a working age group with a fitness test which prioritized cardiorespiratory endurance measurement.

Another study who performed cross-sectional research on 403 healthy men and women aged 50±88 years old, showed that BMI and abdominal circumference are related with a much stronger VO₂max in women rather than men [13]. Moreover, men have stronger correlation between abdominal circumference and physical fitness than BMI, while in healthy women; BMI has a stronger relation with physical fitness than abdominal circumference. This

occurred because fat deposit in men is mainly focused on the abdomen, while in women, the fat deposit focuses mainly in the buttocks and the *gluteofemoral* area [14]. The present study had different result from Dagan *et al*. because the study had no data on sports activity, smoking habit, daily nutritional patten and caloric intake of the subjects, which might affect result the research.

V. CONCLUSION

The present study showed that (1) there were relations between the body mass index, abdominal circumference and hip circumference. The Body mass index had relations with abdominal circumference and hip circumference. The Abdominal circumference had a relationship with the Hip circumference. (2) VO₂max had no relationship with the body mass index, abdominal circumference and hip circumference. (3) There should be examination of other physical fitness components to find the relations between body mass index, abdominal circumference and hip circumference, and cardiorespiratory endurance (VO₂max) in the present study.

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