

## PERCENT FAT MASS AND BODY MASS INDEX AS CARDIORESPIRATORY FITNESS PREDICTORS IN YOUNG ADULTS

*(Persentase lemak dan indeks massa tubuh sebagai prediktor kebugaran kardiorespiratorik pada dewasa muda)*

Mira Dewi<sup>1</sup>, Lilik Kustiyah<sup>1\*</sup>, Mury Kuswari<sup>2</sup>

<sup>1</sup>Departemen Gizi Masyarakat, Fakultas Ekologi Manusia (FEMA), Institut Pertanian Bogor, Bogor 16680

<sup>2</sup>Prodi Ilmu Gizi, Fakultas Ilmu-Ilmu Kesehatan, Universitas Esa Unggul, Jakarta 11510

### ABSTRACT

*The present study aimed to analyze the association between body fitness measures, i.e. body mass index (BMI) and percent fat mass (% FM) with cardiorespiratory fitness (CRF) in young adults. Seventy five undergraduate students aged 19-21 years were included in this cross sectional study. Body composition was assessed by tetra polar Bioelectrical Impedance Analysis method, and CRF was determined as  $VO_2$  max level by conducting Balke test and flexibility by sit-and-reach test. Regression tests were performed to assess the associations between the body fitness measures and CRF. The mean (SD) % FM and BMI were 25.6 (8.3) % and 22.4 (4.2)  $kg/m^2$ , respectively. Both BMI and % FM were inversely associated with  $VO_2$  max and flexibility. The associations of % FM with each CRF measure were stronger (% FM- $VO_2$  max:  $R^2=0.45$ ,  $p<0.0001$ ; % FM-flexibility:  $R^2=0.16$ ,  $p<0.0001$ ) than those of BMI (BMI- $VO_2$  max:  $R^2=0.12$ ,  $p=0.002$ ; BMI-flexibility:  $R^2=0.07$ ,  $p<0.0001$ ). Including gender as a variable predictor greatly improved almost all associations. We suggest that %FM is a better predictor for  $VO_2$  max than BMI. Further studies are needed to elucidate the relationships of body fitness measures adjusted for potential confounding factors with CRF measures other than  $VO_2$  max.*

**Keywords:** body mass index, cardiorespiratory fitness, percent fat mass

### ABSTRAK

Penelitian ini bertujuan untuk menentukan hubungan antara persentase lemak tubuh (PLT) dan indeks massa tubuh (IMT) dengan kebugaran kardiorespiratorik (KKR) pada dewasa muda. Penelitian menggunakan desain potong lintang dengan melibatkan 75 orang mahasiswa usia 19-21 tahun. PLT ditentukan dengan metode *tetra polar Bioelectrical Impedance* dan KKR ditentukan dengan  $VO_2$  max berdasarkan uji Balke dan fleksibilitas dengan uji *sit-and-reach*. Hubungan antara PLT dan IMT dengan KKR dianalisis dengan uji regresi. Rata-rata (standar deviasi) dari PLT dan IMT berturut-turut adalah 25,6 (8,3)% dan 22,4 (4,2)  $kg/m^2$ . Baik PLT maupun IMT berbanding terbalik dengan nilai  $VO_2$  max dan fleksibilitas. Korelasi antara PLT dengan kedua komponen KKR lebih kuat (PLT- $VO_2$  max:  $R^2=0,45$   $p<0,0001$ ; PLT-fleksibilitas:  $R^2=0,16$   $p<0,0001$ ) dibanding IMT (IMT- $VO_2$  max:  $R^2=0,12$   $p=0,002$ ; IMT-fleksibilitas:  $R^2=0,07$   $p<0,0001$ ). Memasukkan gender sebagai prediktor variabel memperkuat semua korelasi kecuali antara PLT dan fleksibilitas. Diperlukan studi lebih lanjut untuk mempelajari hubungan antara komposisi tubuh termasuk faktor perancu potensial dengan fleksibilitas dan komponen KKR lainnya.

**Kata kunci:** indeks massa tubuh, kebugaran kardiorespiratorik, persen lemak tubuh

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\*Korespondensi: Telp: +628121105698, Surel: lilik.kustiyah@gmail.com

## INTRODUCTION

Obesity is considered as a major health problem due to its increasing prevalence and complications such as type 2 diabetes mellitus and cardiovascular diseases. Recent data showed that obesity prevalence among young adults varies between 10-40% (Hossain *et al.* 2007). Excess body fat, particularly visceral fat, as seen in obesity is an important risk of cardiovascular diseases (Lim & Meigs 2013, Neeland *et al.* 2013). It is well recognized that body fat plays an important role in the cardiorespiratory health and is inversely associated with cardiorespiratory fitness (CRF) (Aphamis *et al.* 2014, Gajewska *et al.* 2015, Hsieh *et al.* 2014).

A common indicator for body fat that has been used in studies on the relationship between body fat and CRF is body mass index (BMI), i.e. body weight per height square (Hsieh *et al.* 2014, Hung *et al.* 2014, Mota *et al.* 2009). In comparison to other methods of body composition assessment, BMI is easy to be assessed in most people of all age groups, does not require specific skill, and less costly. There have been studies that showed the significant correlation between BMI and CRF level (Gajewska *et al.* 2015, Hsieh *et al.* 2014, Hung *et al.* 2014). However, as in BMI the fat mass is roughly assessed by body weight, the relationship in certain groups of people may be weakened when BMI is used rather than body fat measures such as fat mass (FM) and % FM. For examples, Pribis *et al.* (2010) studied the relationship among college students and reported that in males, CRF measured as  $VO_2$  max was correlated stronger with % FM than with BMI ( $R^2=0.24$  vs  $0.11$ ). Similarly, Tompuri *et al.* (2014) measured body sizes (weight and height), body composition (FM, % FM and fat free mass (FFM)) and  $VO_2$  max of 38 children and found that FM, but not body size, was significantly correlated with  $VO_2$  max ( $R^2=0.41$ ).

The CRF level and its relationship with body fat vary across age groups and ethnicities (Duncan *et al.* 2009). To date, such relationship has not been extensively studied in Indonesian young adults. Therefore, the present study was aimed to analyze the association between BMI and CRF, and between percent fat mass with CRF in Indonesian young adults.

## METHODS

### Design, place, and time

This was a cross-sectional study. This study was conducted in Bogor Agricultural University, Bogor in 2012.

### Sample size and sampling procedure

Seventy five healthy female and male students (19-21 years old) of the third year in Nutritional Science Program, Faculty of Human Ecology, Bogor Agricultural University were included as subjects. Students were invited to participate by class announcement. Those with history of cardiac and lung diseases and smoking were excluded.

### Data collection and procedure

**Body mass index.** Body weight was measured by a digital scale. Height was measured by a stadiometer in the standing position with the heels, hip, shoulders, and back of the head attached to the wall. BMI is calculated as weight (in kg)/height<sup>2</sup> (in m<sup>2</sup>).

**Percent fat mass.** Body composition (FM, % FM and FFM) was assessed using a tetra polar Bioelectrical Impedance Analyzer (BIA). Compared with magnetic resonance imaging and dual energy X-ray absorptiometry, no systematic biases were found for % FM measured by this method (Bosy-Westphal *et al.* 2008).

**$VO_2$  max.**  $VO_2$  max was determined by Balke test as described earlier (Balke 1963). After 10 minutes of warming up, the subjects were encouraged to run as fast as possible for 15 minutes. The distance achieved was recorded to the nearest 10 meter. The  $VO_2$  max was then calculated using the following formula (Horwill 1991):

$$\%VO_2 \text{ max (ml/kg/min)} = [((\text{distance covered (m)} / 15) - 133) \times 0.172] + 33.3$$

**Flexibility.** Flexibility was determined by sit-and-reach (SR) test developed by Wells and Dillon (1952). This test specifically measures the flexibility of the lower back and hamstring. The subjects sat on the floor with their legs straight ahead. The soles of the feet were attached to the box. The ruler was placed on the floor between the subject's legs. With one hand placed on the other, the subject reached forward. The maximum distance reached was then measured in the nearest cm.

### Data processing and analysis

Bivariate correlations were conducted between all predictors and outcome variables. Multiple regressions including body fat, gender and gender-body fat interaction as factors were conducted individually for each pair of body fat and CRF. Level of significance was set at  $\alpha=0.05$ .

## RESULTS AND DISCUSSION

A total of 75 subjects, 54 females and 21 males, participated in this study. The descriptive characteristics of the subjects are presented in Table 1. There were no significant differences found between females and males in term of their age and BMI. However, significant differences were found between the two genders in all body composition variables and CRF measures (Table 1).

Bivariate correlations derived from the Pearson procedure are given in Table 2. Both % FM and BMI were negatively correlated with all CRF measures, and the correlations were stronger for % FM than BMI ( $R^2=0.45$  vs  $0.12$  for  $VO_2$  max and  $0.16$  vs  $0.07$  for flexibility).

Multiple regressions including gender and its interaction with the corresponding body fat variable as factors were conducted to determine if the significant correlations remain when gender is taken into account. Interaction terms between body fat measures and gender in all models were found not significant and therefore were dropped from the model and the regression were conducted with the reduced model. Gender was found not significant in % FM and flexibility association model and so this factor was dropped from this model.

The associations between  $VO_2$  max and body fat measures that seem to be stronger for % FM than BMI became more equal when gender was taken into account. As much as 58% and

57% of the total variability in  $VO_2$  max was explained by the % FM-gender and BMI-gender models, respectively. On the other hand, models that included body fat measures (% FM and BMI) explained only small proportion of variability in flexibility (Table 3).

The present study sought to evaluate the relationships between two body fat measures, i.e. BMI and % FM and CRF. The negative correlations between body fat measures and CRF parameters as found in this study were as expected and similar to other reports (Aphamis *et al.* 2014, Gajewska *et al.* 2015, Moliner-Urdiales *et al.* 2011, Neeland *et al.* 2013, Tompuri *et al.* 2014, Wang *et al.* 2011, Wu *et al.* 2015, Koley 2006), showing consistency of the inverse relationship between the two variables.

In obese individuals, the oxygen consumption per body mass unit is significantly reduced due to the excessive fat which influence the heart function. Fat accumulation in muscle results in failure of the muscles to use oxygen effectively, and thereby reduces the  $VO_2$  max level (Chatterjee *et al.* 2005). It is important to point out that only less than 10% of our subjects were obese and thus, our study suggested that the unfavorable effect of body fat mass on  $VO_2$  max is apparent even within BMI category of less than obese. BMI does not accurately measure the body fat and therefore the finding should be confirmed with the more sophisticated method to measure body fat such as 2, 3 or 4 compartments model.

Table 1. Descriptive characteristics of subjects

Characteristics	Females (n=54)	Males (n=21)
Age (year)	19.94 ± 0.53	20.00 ± 0.63
% Fat mass	28.8 ± 5.62	17.28 ± 8.37**
Fat mass (kg)	16.30 ± 6.68	11.23 ± 7.76**
Fat free mass (kg)	38.43 ± 4.80	49.40 ± 4.25**
Body mass index (kg/m <sup>2</sup> )	22.63 ± 4.21	21.72 ± 4.29
$VO_2$ max (ml/kg/min)	30.30 ± 2.67	37.36 ± 4.44**
Flexibility (cm)	9.1 ± 5.86	12.6 ± 6.83*

\*significant at  $\alpha = 0.05$ ; \*\*significant at  $\alpha = 0.01$

Table 2. Bivariate correlations between % fat mass, body mass index, and cardiorespiratory fitness measures

Cardiorespiratory fitness	Body fat	Correlation coefficient	R <sup>2</sup>	p-value
$VO_2$ max	% Fat mass	-0.671	0.45	<0.0001
	Body mass index	-0.345	0.12	0.002
Flexibility	% Fat mass	-0.397	0.16	<0.0001
	Body mass index	-0.258	0.07	0.025

Table 3. Associations between cardiorespiratory fitness and body fat measures

Dependent	Independents	$\beta$	p-value	R <sup>2</sup>
VO <sub>2</sub> max	% Fat mass	-0.209	0.0002	0.58
	Gender	4.66	<0.0001	
	Intercept	36.306	<0.0001	
VO <sub>2</sub> max	Body mass index	-0.301	0.0006	0.57
	Gender	6.792	<0.0001	
	Intercept	37.114	<0.0001	
Flexibility	% Fat mass	-0.302	0.0002	0.16
	Intercept	17.927	<0.0001	
	Body mass index	-0.369	0.023	
Flexibility	Gender	3.015	0.047	0.13
	Intercept	36.306	<0.0001	

Our study showed that in comparison to BMI, % FM had stronger correlation with VO<sub>2</sub> max (R<sup>2</sup>=0.45 vs 0.12). However, the correlations were greatly improved, especially for BMI, and about equal when gender factor was included in the models (R<sup>2</sup>=0.58 for % FM and 0.57 for BMI). This suggests the importance of taking this factor into account when studying such relationship. According to our model, within the same BMI or % FM, males would have higher VO<sub>2</sub> max than females by 6.79 and 4.66 units, respectively.

The differential effect of genders on body fat measures and VO<sub>2</sub> max relationship were shown in some studies. In a similar age group with this study, Pribis *et al.* (2010) reported stronger correlations between BMI and VO<sub>2</sub> max, and also between % FM and VO<sub>2</sub> max in women than in men (R<sup>2</sup>=0.17 vs 0.11 and 0.24 vs 0.17, respectively). Similarly, Dagan *et al.* (2013) showed that in adult men and women aged 50 ± 8 years, the correlations between BMI and VO<sub>2</sub> max were found stronger in women than men (R<sup>2</sup>=0.26 vs 0.08). In both studies, the multiple regression models were run separately for males and females therefore a model including gender as a dichotomous variable was not completed. We found that the interactions between BMI and % FM, and gender were not significant which means that the amount of unit decrease in VO<sub>2</sub> max per one unit increase of both BMI or % FM was not affected by type of gender. Adding gender factor results in great improvement of the correlations between BMI and VO<sub>2</sub> max but not as great for correlations between % FM and VO<sub>2</sub> max; this fact suggests that % FM is a better proxy for VO<sub>2</sub> max rather than BMI.

Other factors have been shown to affect CRF such as physical activity (PA) level (Gu-

tin *et al.* 2005, Myers *et al.* 2015) and smoking status (Kendzor *et al.* 2015). We controlled the smoking status by excluding those who smoked, however, we did not include PA and this is one of the study weaknesses.

Flexibility of muscle was another measure of CRF included in the present study. Our study suggest that flexibility was inversely correlated with both % FM and BMI, and the correlation was stronger with % FM (R<sup>2</sup>=0.16, p<0.0001 vs R<sup>2</sup>=0.07, p=0.025, respectively). Gender was found to be a significant factor for flexibility in the model with BMI, but not in that with % FM. BMI and gender explained 13% of variability in flexibility. Within the same BMI, males have 3 cm higher flexibility than the females.

There are only few studies on the relationship between body fat measures and flexibility, and the results seem to be vary across groups. Saghand and Gholami (2013) conducted a study in 450 female students aged 19-25 years and found a positive weak correlation between flexibility as assessed by SAR test and BMI, but not with % FM. In a study involving 102 female volley players around 15 years of age, Nikolaidis (2013) reported a weak positive correlation between flexibility by SAR and BMI (r =0.22, p<0.05). In elderly (>60 years of age), Silva *et al.* (2013) also showed a weak positive correlation between flexibility and BMI (R<sup>2</sup>=0.03, p<0.05) in males but not in females. In this study, flexibility was measured by a method designed for elderly people, i.e. 'pick up a pen'. Similar to our study, Miyatake *et al.* (2004) showed that the flexibility tends to be lower in women with overweight BMI and abdominal obesity, although the association did not reach significance level. The present study and others suggest that the relationship of both

body fat measures with flexibility was weaker than with  $\text{VO}_2$  max. Yet, this has not been clearly elucidated and warrants further investigation.

Our study is among few studies that provide information on the comparison between different body fat measures on CRF measures. This knowledge is particularly important when considering and interpreting different variables of body composition in studies on CRF. In addition, our study also used two different CRF measures and thereby contribute to the knowledge of how they responded to different body fat measures. However, our study has some limitations. First, the sample was relatively small and not randomized. Second, the range of BMI and % FM of our subjects, although normally distributed, were relatively narrow and may not be representative to the age population. Third, we did not include other possible source of variability such as PA in the models. Considering these limitations, the inference has to be taken carefully.

### CONCLUSION

In conclusion, our study showed that % FM and BMI were inversely correlated with CRF, and gender was found to strengthen the correlation, especially with BMI. Body fat has greater effect on  $\text{VO}_2$  max than on flexibility. In healthy young adults such as our group, both % FM and BMI can be used as predictors of CRF especially for  $\text{VO}_2$  max. We suggested that %FM is a better predictor for  $\text{VO}_2$  max than BMI. Further studies are needed to elucidate the relationships of body fatness measures and potential confounding factors with CRF measures other than  $\text{VO}_2$  max.

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