Fat mass as the main contributor to the Body Mass Index of obese patients in Banyumas Regency

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Abstract. Body Mass Index (BMI) measurement is the indicator most often used to identify whether a person is obese or not. However, BMI is not always synonymous with body **fat** mass because many other body components that play a role in determining BMI, such as muscle mass and bone mass. This study aims to determine whether the BMI of obese patients can represent body fat mass. This study was a cross-sectional study. A total of 76 obese women aged 18-34 years were taken by consecutive sampling. The examination of height and weight were performed to determine the BMI. Meanwhile, the measurements of fat mass, muscle mass, and bone mass were carried out using a bioelectric impedance analyzer (BIA). Analysis of data used Pearson correlation test and Multiple Linear Regression analysis. The level of significance was at $p<0.05$. The results of the Pearson correlation test showed that there was a significant correlation between fat mass, muscle mass, bone mass, and BMI ($p=0.000$). Multivariate test using Multiple Linear Regression analysis showed that only fat mass has a significant relationship with BMI ($p=0.000$), R square=0.978, and the regression equation BMI = -2.860+0.807 fat mass. The main contributor to the BMI of obese patients in Banyumas was fat mass. For every 1% increase in fat mass, the BMI will increase by 0.807.

Keywords: obesity, body mass index, fat mass, muscle mass, bone mass

1. Introduction

Body composition is the relative proportion of fat mass and fat-free mass in the body. The body composition consists of four main components, namely fat mass, fat-free mass, bone, and water. The two most commonly measured components of body composition are fat mass and fat-free mass [1]. The most practical and effective measurement of body composition is the measurement of body mass index (BMI).

BMI measurement is also an indicator to find out whether a person is obese or not. Obesity can be defined as a condition in which the body is overweight in the form of fat accumulation caused by an imbalance between the calories that enter the body is not balanced with the number of calories released through physical activity so that the remaining calories are stored as body fat [2]. Currently, BMI is used by most health organizations as a measure of adiposity. As a screening tool, BMI is relatively easy to calculate from body weight and height. Low cost, practical, and capable of being carried out in clinical and field conditions [3].

The method of measuring Body Mass Index (BMI) is W/Ht^2. Bodyweight (W) is the body weight in kilograms, while height (Ht) is the height in meters. BMI≥25 kg/m^2 is called overweight and BMI≥30 kg/m^2 is called obese. For the Asia Pacific, criteria for overweight use a BMI ≥23 kg/m^2 and obesity at a BMI ≥25 kg/m^2 [4].

However, BMI is not always synonymous with body fat mass because many other body components that play a role in determining BMI, such as muscle mass and bone mass. Therefore, this study aims to determine the correlation between body composition components and BMI in obese patients, whether the BMI of obese patients could represent body fat mass or other non-fat body mass.

2. Materials and Methods

This study was a cross-sectional study. The subjects were 76 people, collected using a consecutive sampling method. The inclusion criteria for the subjects were women aged 18 - 34 years who were overweight (BMI ≥23 kg/m2). The exclusion criteria were chronic diseases such as diabetes mellitus, hypertension, and heart disease. Each willing participant was given a full explanation and was asked to sign informed consent. The measurement of body weight and height were performed to determine the Body Mass Index (BMI). Meanwhile, measurements of fat mass, muscle mass, and bone mass were carried out using Bioelectric Impedance Analyzer (BIA) from the Tanita®. The measurement was carried out in the Physiology Laboratory, Faculty of Medicine, Jenderal Soedirman University.

The data were analyzed by IBM SPSS Statistics Version 22. The bivariate data analysis used the Pearson correlation test because the scale of the data was numerical and the data met the requirements of the parametric test (all data were normally distributed). The multivariate data analysis used the Multiple Linear Regression test because it connected more than one independent variable (fat mass, muscle mass, bone mass) with one dependent variable (BMI) and the variables scale was numerical. The level of significance was at $p<0.05$. The study had received Ethics Committee Approval from the Medical and Health Research Ethics Committee (MHREC) Faculty of Medicine, Public Health and Nursing, Gadjah Mada University-Dr. Sardjito General Hospital (Ref No: KE/FK/0258/EC/2020).

3. Results

The study found that the mean BMI was 29.45±4.11 kg/m2, the mean fat mass was 40.05±5.04, the mean muscle mass was 40.60±3.40, and the mean bone mass was 2.62±0 33 (Table 1). The Kolmogorov Smirnov test found that all data were normally distributed ($p>0.05$).

Table 1. Characteristics of Subjects

Variable	Mean ± SD	Median	Minimum	Maximum
BMI (kg/m^2)	29,45 ± 4,11	29,05	23,1	44,70
Fat Mass	40,05 ± 5,04	39,80	30,50	58,40
Muscle Mass	40,60 ± 3,40	40,70	33,50	48,10
Bone Mass	2,62 ± 0,33	2,60	1,90	3,30

The bivariate test used the Pearson correlation test because the parametric test requirements were met (data was normally distributed). The Pearson Correlation test was conducted to determine the correlation between fat mass and BMI, the correlation between muscle mass and BMI, and the correlation between bone mass and BMI.

Table 2. The Correlation Fat Mass with BMI

Variable	Mean ± SD	p-*value*	r
Fat mass	40,05 ± 5,04	0,000	0,989
BMI (kg/m^2)	29,45 ± 4,11		

The Pearson correlation test results (Table 2) indicated that there was a significant correlation between fat mass and BMI (p = 0.000). The correlation strength of both was very strong in a positive direction (r = 0.989). This means that the higher the fat mass, the higher the BMI.

Table 3. The Correlation Muscle Mass with BMI

Variable	Mean ± SD	p-*value*	r
Muscle mass	40,60 ± 3,40	0,000	0,452
BMI (kg/m^2)	29,45 ± 4,11		

The results of the Pearson correlation test (Table 3) showed that there was a significant correlation between muscle mass and BMI (p = 0.000). The correlation strength of both was moderate in a positive direction (r = 0.452). This means that the higher the muscle mass, the higher the BMI.

Table 4. The Correlation Bone Mass with BMI

Variable	Mean ± SD	p-*value*	r
Bone Mass	2,62 ± 0,33	0,000	0,437
BMI (kg/m^2)	29,45 ± 4,11		

The results of the Pearson correlation test (Table 4) showed that there was a significant correlation between bone mass and BMI (p = 0.000). The correlation strength of both was moderate in a positive direction (r = 0.437). This means that the higher the muscle mass, the higher the BMI.

Table 5. Multiple Regression Linear Analysis

Variable	Coefficient	Beta	p	Anova	R square
Constanta	-3,596				
Fat mass	0,804	0,986	0,000	p=0,000	0,978
Muscle mass	0,408	0,040	0,842		
Bone mass	-0,421	-0,340	0,865		

The multivariate analysis (Table 5) showed that muscle mass and bone mass not significantly affect BMI (p>0.05), although bivariately had a significant effect on BMI. Therefore, the variables of muscle mass and bone mass were gradually excluded from the multivariate analysis process as shown in Table 6.

Table 6. Multivariate Analysis of Fat Mass by BMI

Variable	Coefficient	Beta	p	Anova	R square
Constanta	-2,860		0,000		
Fat mass	0,807	0,989	0,000	p=0,000	0,978

Table 6 showed that Anova p-*value* = 0,000, meaning that the overall regression line equation was significant. Fat mass had p = 0.000 ($p<0.05$), which means that fat mass had a significant effect on BMI. The magnitude can be seen from the R square value of 0.978, meaning that the fat mass variable can explain the BMI variable by 97.8%. The regression equation can also be drawn up:

$$\text{BMI} = -2{,}860 + 0{,}807 \text{ Fat mass}$$

This equation means that for every 1% increase in fat mass, the BMI will increase by 0.807.

4. Discussion

BMI was first reported by Quetelet in the nineteenth century. The measurements used are weight and height. The Quetelet index is the weight divided by the height squared, now known as BMI. BMI is accepted by most health organizations as a measure of body fat and as a screening tool for diagnosing excess body fat. Modern imaging methods, however, show that BMI has limited predictive value for estimating fat mass and fat-free mass. Therefore, the use of BMI as a measure of body composition in clinical practice and field applications remains a constraint [3].

There is variability in the correlation between BMI and fat mass. Several factors are suspected to be the cause. First, there is the influence of age. The fat mass at the same BMI will be greater in older people than in young people[5]. This is because of the decrease in muscle mass and other lean mass that is characteristic of older people as they age. Second, the influence of race on body fat mass. For the same BMI and the same age, the fat mass of non-Hispanic blacks is smaller than that of Mexican-Americans[5]. The third factor affecting the correlation between BMI and fat mass is the level of physical activity. High levels of exercise, especially weight training, increase muscle mass. By increasing the proportion of muscle mass, it will reduce the proportion of fat mass. Thus, at the same BMI, active people have a lower fat mass than sedentary people [3]. Furthermore, gender differences also influenced the correlation between BMI and fat mass (FM). Women have a higher fat mass per unit of BMI than men (6–9).

In obese patients, BMI also does not only represent the amount of fat mass in the body. Obesity also increases organ mass in the body due to metabolic changes. This increase in organ mass will also increase BMI(1,10,11). Therefore, this study aims to determine the correlation between body composition components and BMI in obese patients, whether the BMI of obese patients could represent body fat mass or did it represent other non-fat body mass. Based on the bivariate analysis, it turns out that almost all body components affected BMI. Fat mass, muscle mass, and bone mass had moderate to very strong correlations with BMI (Tables 2, 3, and 4). However, the multivariate analysis showed that muscle mass and bone mass did not have a significant effect on BMI (Table 5). BMI is influenced by fat mass up to 97.8%. This study proved that in obese female patients in Banyumas, the main contributor to BMI was fat mass. BMI can represent the percent body fat of obese patients in the Banyumas Regency.

It is very important to be able to improve the BMI of obese patients in Banyumas because it turns out that high BMI represents high body fat. Accumulation of fat in obesity is the basis of the pathogenesis of chronic diseases such as metabolic syndrome. The accumulation of fatty acids in the adipocyte tissue of obese patients causes hypertrophy and hyperplasia of adipocyte cells. Hypertrophic adipocyte cells will secrete proinflammatory such as Nuclear Factor kappa β (NFk β) and macrophage infiltration in adipose tissue. Macrophages then stimulate adipokine secretion, including pro-inflammatory mediators such as Tumor Necroting Factor α (TNF α), Interleukin 1β (IL 1β), and Interleukin 6 (IL 6). Furthermore, adipokine secretion disorders will cause an increase in food intake and a decrease in energy expenditure by the hypothalamus, thereby reducing insulin sensitivity in the skeletal muscle and liver (12–15). Inflammation and oxidative stress in obesity are the mechanisms underlying the metabolic syndrome as a complication of obesity. Metabolic syndrome plays a major role in morbidity and mortality.

5. Conclusion

There was a correlation between fat mass, muscle mass, and bone mass with the BMI of obese patients in the Banyumas Regency. The main contributor to the BMI of obese patients in Banyumas was fat mass, with a very strong correlation. For every 1% increase in fat mass, the BMI will increase by 0.807.

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