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Effect of Energy Intake on Percentage Body Fat as Measured by Bia and Cun-Bae Equation Formula: A Comparative Study of Body Fat Measurement Methods

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ABSTRACT

Introduction: Body composition is becoming important to be taken into account, as it is not only an integral part of individual nutritional assessment but also as a biomarker in acute or chronic diseases. Percentage and distribution of body fat is clinically most interest as it play a significant role in determining cardiovascular risk. Various modern methods have been developed to determine percentage body fat for hospital setting, however, low-cost body composition technology for health surveillance is also required. The aim of this study was to determine the effect of energy intake on percentage body fat and to determine whether the CUN-BAE equation formula has an accuracy comparable to BIA, so that it can used as a low-cost body composition technology for health surveillance.

Material and Method: This crossed sectional study is part of The Jember Body composition Study. This study invited 84 female dental students with an ideal range of Body Mass Index (21.06±0.17) to participate in this study. Calorie intake was calculated using the 24 hour recall method. Assessment of percentage body fat was performed using Bioelectrical Impedance Analyzer (BIA) and CUN-BAE equation formula.

Result: Total energy intake was positively associated with total body fat in female dental students, higher energy intake was associated with higher percentage body fat as determined by CUN-BAE equation (95% CI 16.69, 16.94) as well as by BIA (95% CI 14.11, 15.38). Percentage body fat determine by the CUN-BAE equation method was highly correlated with that determine by the BIA method (95% CI -1.07, 0.33). The average results of FM measurements by the two measurement methods are also same.

Conclusion: Higher energy intake is associated with higher percentage body fat. The CUN-BAE equation method has the same accuracy as the BIA method in calculating percentage fat mass. CUN-BAE equation formula is simple and suitable for low-cost body composition assessment method to assess percentage body fat in a population based study.

KEYWORDS: BIA, Calorie intake, CUN-BAE formula, percentage fat mass

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INTRODUCTION

Fat mass is a balance between energy intake and energy expenditure. In adulthood, increased body fat increases the risk of many diseases, especially degenerative diseases, including obesity, diabetes and heart and blood vessel disease. To our knowledge, no study has simultaneously analyzed the relationship and comparison of calorie intake

with percentage body fat mass (%FM) using low cost body composition measurement such as the CUN-BAE.

It is clear that assessing the body composition is becoming an important part of the management of health and diseases. It has been reported that body composition measurements can detect early protein depletion in cirrhosis patients before other biomarkers suggest such depletion[1]. However, there is no single method of measuring body composition that is recommended for a particular disease. Each method has its advantages and disadvantages. Prevention, treatment, and understanding of disease processes can be improved by better methods for assessing changes in body composition.

Many methods have been developed to measure body composition with the aim of being able to calculate certain body components, not only fat mass and free fat mass. Methods of determining body composition vary in precision but the gold standard is the water displacement technique, the underwater weighing method. However this technique requires a healthy individual to be able to submerse under water. The most recent discovery is the PEA POD tool that allows for accurate body composition assessment of newborns. This technique uses air displacement rather than water displacement[2]. Most modern methods have been developed to determine body fat percentage to meet the needs of large hospitals. This method requires expensive operational costs, heavy equipment and a special place for body composition instruments, so it cannot be used for low-cost body composition technology health surveillance carried out in the field and with a large population[3].

There are several indirect and noninvasive low cost types of body fat measurements, per se the Deurenberg[4] and the Clínica Universidad de Navarra-Body Adiposity Estimator (CUN-BAE)[5] equation which were based on sex, body weight and height, and age or BIA[6] (Bioelectrical Impedance Analyzer) which was developed based on the body resistance against weak electrical currents through the body. As the electrical conductivity is different between various bodily tissues. Assessment of body fat using skinfold technique requires a skilled personal to do the assessments.

The aim of this study was to determine the effect of energy intake on percentage body fat and to determine whether the CUN-BAE equation formula has an accuracy comparable to BIA, so that it can used as a low-cost body composition technology for health surveillance.

METHODS

This analytic observational study with a cross sectional design was conducted in January to March 2021 in hospital dental, Jember University. Total sample in this research is 84 females between 19-20 years were participated in this study. Each participant signed an informed consent.

Anthropometric and body composition measurements

In this study, height and weight were measured in light clothing, without shoes, to the nearest 1 cm and 0.5 kg, respectively, and BMI was calculated as the ratio of weight in kilograms to the square of height in meters.

CUN-BAE was calculated as $-44.988+(0.503 \times \text{age})+(10.689 \times \text{sex})+(3.172 \times \text{BMI}) - (0.026 \times \text{BMI}^2)+(0.181 \times \text{BMI} \times \text{sex}) - (0.02 \times \text{BMI} \times \text{age}) - (0.005 \times \text{BMI}^2 \times \text{sex})+(0.00021 \times \text{BMI}^2 \times \text{age})$ where male = 0 and female = 1 for sex, and age in years[5].

Bioelectrical Impedance Analysis

The Tania inner Scan BC 541 (Japan) uses multi-frequency bioelectrical impedance analysis to measure TBW by applying an electrical current of 100 μA to the body. The manufacturer's operating instructions and proprietary software calculated %FM, Lean Mass, and visceral fat, total body water, weight, WC, height, age, and gender. Participants were scanned once in the standing position. Participants were instructed to remain stationary for the duration of the scan, which lasted 60 s.

Calorie consumption was determined using the 24 Hour recall method. The procedure was conducted by trained nurse. Food consumption data from the 24 hour recall were converted into energy by the list of Indonesian food ingredient[6].

Statistical analyses

The current study includes 3 sets of analyses of correlations. The first set was the correlation between Energy intake and %FM assessed using the BIA method, second was the correlation between energy intake with %FM assessed by the CUN-BAE equation. Thirdly, The correlation agreement between %FM assessed by BIA and by CUN-BAE equation. The result was analyzed using SPSS 24 application to determine correlation using the Spearman test between total fat mass using CUN-BAE formula and BIA.

Measurements using BIA and CUN-BAE formula were analyzed by independent T-test to determine whether the two measurements were different or not, then the data was correlated using the SPSS 24 application. This study deliberately took female samples, because gender affects fat composition in several studies. This research has been approved by the Director of dental hospital, University of Jember.

We assessed the significance of the difference between 2 correlation coefficients by using the independent T-test. To visually compare the CUN-BAE and BIA data, we used Bland–Altman plots. The plots show the difference between the 2 methods. The limits of agreement between the 2 methods were defined as mean difference ± 1.96 SD. We calculated OR and 95% CI. Statistical analyses were performed using IBM SPSS Statistics for WINDOWS (22.0; IBM Corp., Armonk, NY, USA). Tests of significance were 2-tailed and $P \leq 0.05$ was considered significant.

RESULTS

The general characteristics and results of the anthropometric measurements of volunteers are presented in Table 1. This table shows the mean and SEM of age (19.32±0.06), body weight (51.50±0.57), height (1.56±0.01) and BMI (21.06±0.17) of the 84 females volunteers. The volunteers were in the ideal BMI range and in good health. The Levene's Test results shows that the general characteristics of the BMI of these volunteers are relatively homogeneous.

Table 1. Physical Characteristics of female volunteers in this study

Variable	Mean	SEM
Age (year)	19.32	0.06
Body Weight (kg)	51.50	0.57
Height (m)	1.56	0.01
BMI (kg/m²)	21.06	0.17

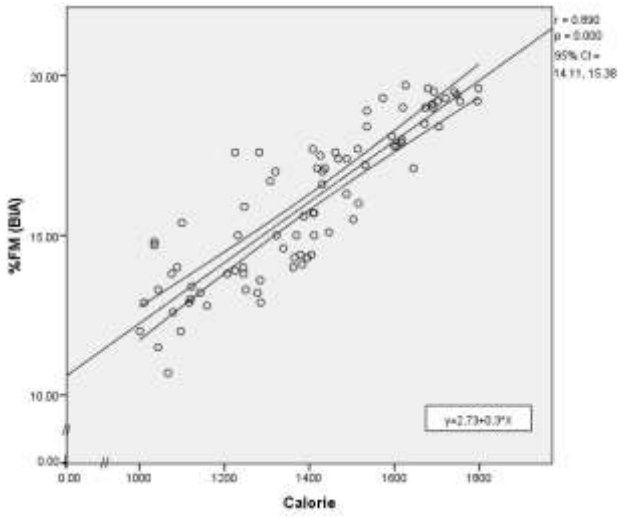

Figure 1. Plot of the relationship between %FM using BIA formula and calorie

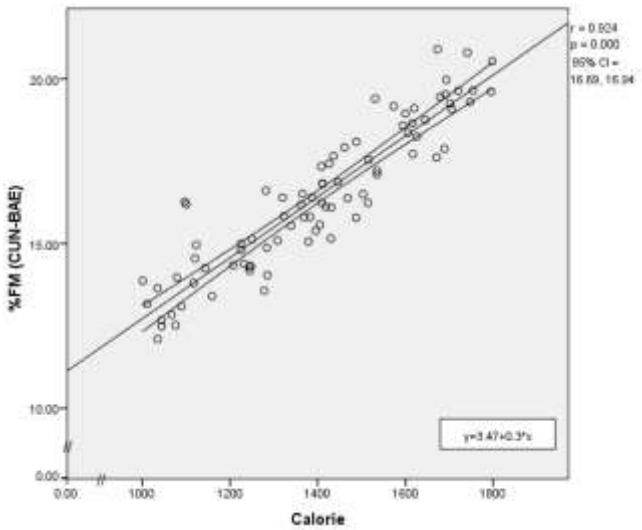

Figure 2. Scatter plot of the relationship between %FM using CUN-BAE formula and calorie intake

Figures 1 and 2 show the correlation between calories consumed and %FM as measured using the CUN-BAE equation method (Figure 1) and the correlation between calorie consumption and %FM as measured by the BIA method. Figure 1 shows a high correlation (r=0.89, 95% CI 14.11, 15.38) between energy consumption and %FM as measured by the CUN-BAE equation and in Figure 2 also shows a very high correlation (r=0.924; p=0.000; 95% CI 16.69, 16.94) between energy consumption and %FM as measured by the BIA method, 95% CI In both figures it shows that the majority point is around the regression line.

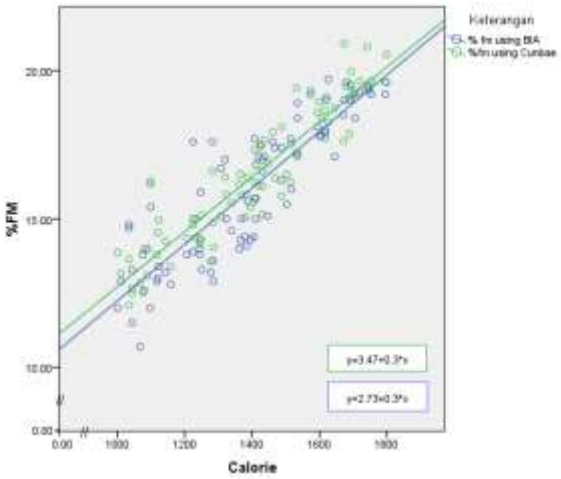

Figure 3. Scatter plot of the relationship between %FM measured prediction fat mass and calorie

Figure 3 is a comparison of the correlation between %FM calculations as measured by the CUN-BAE and BIA formulas. The %FM linear regression using the CUN-BAE formula is located higher than the %FM linear regression using BIA. This means that the CUN-BAE method overestimates the BIA calculation.

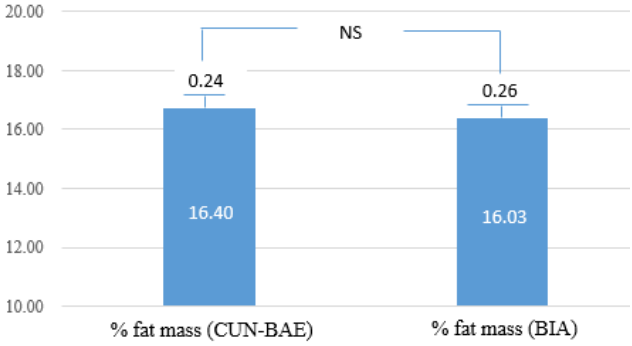

Figure 4. Graph of the average %FM as assessed BIA and CUN-BAE formula

Figure 4 shows the average %FM using BIA (16.03±0.26) and the average %FM using CUN-BAE (16.40±0.24). From the results of the T test, it was found that the average results of %FM measurements between the two methods were not significantly different, meaning that the two methods produced the same %FM calculations.

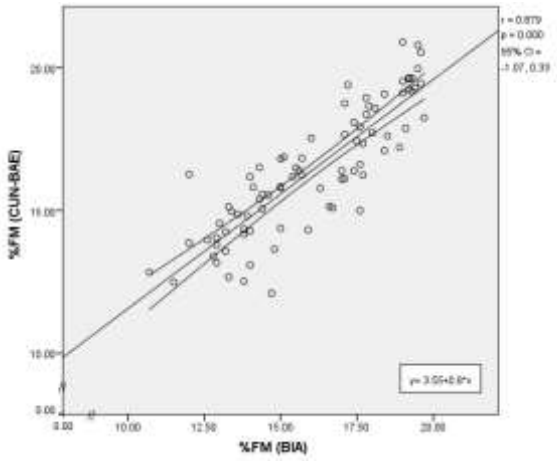

Figure 5. Scatter plot of the relation between %FM using BIA formula and CUN-BAE formula

Figure 5 shows the high correlation between the calculation of %FM using the CUN-BAE equation and the BIA method (r=0.879; p<0.05; 95% CI=-1.07, 0.33). As expected the majority point is around the equation line. This correlation supports the calculation results of the average %FM as shown in table 1.

DISCUSSION

Energy balance affects a person's weight. High energy consumption but not balanced with high energy use will result in weight gain.Weight gain can be caused by an increase in the number of free fat components or fat mass[7]. But a positive energy balance will be stored mainly in the form of body fat although the underlying mechanism is still debating. Maybe because fats and carbohydrates are composed of the same chemical elements. This leads to a situation where individuals with the same BMI will have different %FM[8]. The lack of consistency in reporting research results may be due to the different research methods and tools used in the study. It may also be due to a combination of residual confounding factors and measurement errors inherent in self-reported food intake. In this study, both methods of measuring body composition were able to detect a relationship between energy consumption and an increase in %FM[9].

Both the BIA and CUN-BAE methods are indirect methods of measuring body composition. The indirect method provides an estimate or body composition index based on the results of the direct method. The indirect method relies on the assumption of biological interrelationships between components and body tissues measured directly in normal individuals.

So the indirect method tends to have a larger prediction error than the direct method. In comparing these different body composition methods especially BIA and CUN-BAE, both accuracy and precision are important. Accuracy, however, can be rather difficult to compare for several reasons. First, there is no ground truth available. Second, these two methods may not measure the same thing, so even if two methods correlate strongly, there may be a significant bias if they measure different physical entities.

Several studies have reported that BIA is a good method for measuring %FM in healthy individuals with normal body fat distribution[10]. However, several studies have reported that BIA is not good for measuring body composition in obese patients because BIA tends to result in lower %FM calculations[11]. However, other studies have reported that BIA was suitable to be used in various range of BMI [12] As in this study, the results of the %FM BIA calculationare lower than the CUN-BAE method. Javier (2011) in his body composition study on chronic illness also found that the CUN-BAE equation produced a higher value of %FM compare to that assessed by BIA method in both male and female subjects[13].

The BIA method is strongly influenced by the hydration status of the individual, because the working principle of this method is to conduct weak electric currents. Intra and extracellular fluid balance plays an important role in this BIA method. Measurement of BIA depends on several factors such as, for example, age, gender, ethnicity, and the presence of medical conditions[14]. However, this study showed that average of %FM by BIA and %FM by CUN-BAE formula doesn't reach significance level.

CONCLUSION

Higher energy intake is associated with higher percentage body fat. CUN-BAE formula and BIA were able to detect a relationship between energy consumption and an increase in %FM. The CUN-BAE equation method has the same accuracy as the BIA method in calculating percentage fat mass. CUN-BAE equation formula is simple and suitable for low-cost body composition assessment method to assess percentage body fat and therefor, suitable as low cost body composition assessment method to be used in a population based study.

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