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BODY COMPOSITION THROUGH BIOELECTRICAL IMPEDANCE ANALYSIS: DEVELOPMENT OF BODY SCORE PREDICTIVE EQUATION AMONG RURAL SOCIETY

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Abstract

Body composition plays an important role in health and nutrition statuses; however, the fact that technology is integrated in every aspect of life has demanded advances in body composition; one of which is through body score. This study attempts to analyse body composition through Bioelectrical Impedance Analysis (BIA) through relatively new indicators namely body score. As the data collection was conducted amidst the COVID-19, the participants (15 males and 19 females) were verbally consented proving that they all agreed to be a part of this study. Their body height was measured through a wall-hung measure while their body weight was measured using a BIA-based scale, namely Xiaomi Mi Body Scale Composition 2. The results showed that gender has an impact of body score in which males tend to have body weight as the most dominant factors while females prove that there are other important factors such as protein and visceral fat contained in their body. It is implied that the body score system offered by the scale offers a relatively high accuracy of body composition.

Keywords: Bioelectrical impedance analysis, Body composition, Body score predictive equation.

1. Introduction

Body composition is an important indicator of health and nutrition statuses. The composition can be measured using either such invasive and costly methods as dual energy X-ray absorptiometry (DXA), magnetic resonance imaging (MRI), and computer tomography (CT) or a such quick and affordable method as Bioelectrical Impedance Analysis (BIA) [1]. For the last few decades, BIA which relies on body's low voltage alternating conduction has significantly drawn researchers' attention as a method to measure body composition as well as conducting change of the body and other electrical features [2, 3]. Studies investigating the validity and reliability of BIA in comparison with those of DXA as the golden standard of a variety of subjects have been conducted. It has been proven that BIA is both valid and reliable to measure body composition [4-6]. Nowadays, BIA-based instruments with affordable prices are in easily reached; some of which are Xiaomi Body Composition Scale II with high validity and reliability [7]. The scale is able to measure 9 body composition indicators comprising body weight, muscle mass, body mass index (BMI), body fat, water, protein, basal metabolism, visceral fat, bone mass, and body score. It is known that one indicator can be a predictor of comprehensive evaluation of body composition [8].

Studies on body composition using BIA have been widely conducted as it offers ease and accuracy. Therefore, the direction of such studies is no longer on its validity and reliability but is more on data BIA produces regarding predictors of body composition and comparison of body composition between different groups of people. Several studies predicting body composition in terms of water through BIA have been carried out [9]. In the meantime, other studies compared body composition between different groups of people [10]. However, previous studies merely focused on the comparison and did not predict the body composition based on certain indicators and compare it between urban and rural societies. Few of them analyzed predictors of the body composition comprehensively using body score indicators in a certain society; those living in rural areas, for instance.

Prediction of body composition using body score indicators among people in the rural areas is useful in overcoming health issues due to non-ideal body composition. Data of predictive factors of body composition can be used as guidelines of real action particularly regarding dominant factors influencing body score without trial and error. Therefore, this study aimed to analyze predictive factors of body composition through body score indicators and other predictive factors.

2. Methods

As many as 34 people of a rural area in Indonesia voluntarily participated in this study. Initially, each participant was informed about the details of this study, and they conveyed verbal agreement of participation. As the study was conducted amidst the global pandemic of COVID-19, the authors of this study were required to have a permit from the local government, especially regarding such issues as the limited number of participants and strict health protocol implementation (hand washing, mask wearing, and hand sanitizer distribution). The participants consisted of male (n = 15) and female (n = 19) aged between 23 to 59 years old (mean: 36.617 ± 1,50) and heighted between 139 to 173 cm (mean: 155,28±1,31).

All the participants had a one session measurement taking place in the local government temporary facility. They were also required to fill in a questionnaire of demography on the provided chairs arranged to have a 1.5 m distance each. After the questionnaire filling, each of them was called upon to have body height measurement. To avoid crowd, each participant who had been through body height measurement was to have body composition measurement which consists of 7 indicators. All types of the measurement were carried out by a team who had been trained in advance.

Body height measurement was carried out using a wall-hung measure (SH2A, GEA Medical, Jakarta, Indonesia) recorded thoroughly close to 0.5 cm. Prior to the measurement, each of the participants was asked to take a breath and straighten their head. Their body score, body height, body fat, protein, body mass index (BMI), visceral fat, and bone mass were measure using a valid and reliable Body Impedance Analysis namely Xiaomi Mi Body Composition Scale 2, Xiaomi Corporation, Beijing, China. The record of body height measurement was close to 0.01 kg yet that of the other indicators ranged from 0.1 to 1. All the participants were also requested to take off their footwear as their soles of the feet needed to directly touch electrodes of the scale.

All the collected data were input into a provided form and transferred into an Excel. In the meantime, the descriptive statistics (minimum score, maximum score, mean, and deviation standard) of each indicator was also calculated. The data were then visualized plotted through normality plot and measured using multiple linear regression test to find out the general regression equation. In this model, some of the insignificant variables were removed using backward regression analysis method ($p = 0.05$). After this backward method, this study could identify which variables predominantly predict the body score. All of the statistical computations were carried out using SPSS version 26.

3. Results and Discussion

Descriptive statistics and analysis of the mean difference by gender from the values obtained through Bioelectrical Impedance Analysis used in the study are shown in Table 1. Number of participants, mean, standard deviation and standard error were calculated to describe the general picture of participants. Furthermore, an analysis of the mean difference of several factors was carried out to verify the difference in indicators in the sex groups. Based on this analysis, we can observe that not all factors show homogeneity between males and females. Table 1 shows that there is no significant difference in the age variable between the male and female groups so it can be said that age is not a variable that will interfere with the body score prediction analysis. However, it is different from the results of the body score analysis and several predictor variables. Several predictor factors show significant differences between men and women, so it is necessary to analyse the predictions of different body scores between men and women.

Multiple regression analysis in the male and female groups by considering the body score as the dependent variable was carried out to determine the predictive formula and the dominant variable. In each group, all other independent variables were used as predictors.

In the male group, the initial predictive equations involving all independent variables were as follows, Eq. (1):

Body Score = 563.639-2.071 Body Weight -7.312 IMT+3.227 Body Fat-11.806 Protein-4.097 Visceral Fat +12.864 Bone Density (1)

While in females it was as follows, Eq. (2):

Body Score = 3.158-2.113 Body Weight + 0.993 IMT+ 0.888 Body Fat -4.182 Protein -1.620 Visceral Fat +34.918 Bone Density (2)

Table 1. Description of indicators based on gender.

Predictor	Gender	N	Mean	Std. Deviation	Std. Error Mean	p-value
Age	Male	15	37,33	9,21	2,38	0,679
	Female	19	36,05	8,63	1,98	
Body Score	Male	15	68,33	20,96	5,41	0,073
	Female	19	55,42	19,57	4,49	
Weight	Male	15	60,98	7,93	2,05	0,537
	Female	19	63,07	10,83	2,49	
IMT	Male	15	25,07	5,77	1,49	0,197
	Female	19	27,59	5,34	1,22	
Body Fat	Male	15	21,28	7,73	2,00	0,000
	Female	19	39,25	7,85	1,80	
Protein	Male	15	20,47	2,44	0,63	0,000
	Female	19	14,09	2,66	0,61	
Visceral Fat	Male	15	10,40	4,45	1,15	0,028
	Female	19	7,26	3,00	0,69	
Bone Density	Male	15	2,33	0,28	0,07	0,135
	Female	19	2,18	0,30	0,07	

Analysis to obtain the final model that produces a body score prediction equation based on the most dominant predictor is carried out using the Backward Elimination method while a visual description of each variable dominant is presented in the form of an estimation curve.

Table 2 shows that in the male group, the dominant variables as predictors of body score are body weight and BMI. The predictive equations produced are as follows, Eq. (3):

Body Score = 186.275-1.030 Body Weight -2.199 IMT (3)

According to Table 3, the dominant variables in the female group as predictors of body score are body weight, protein, visceral fat and bone density. The resulting predictive equations are as follows, Eq. (4):

Body Score = 82,332-1,414 Weight +1,688 Protein -1,290 Visceral Fat +21,927 Bone Density (4)

Table 2. Final model of body scores dominant predictor for male group.

Model	B	Standardized Coefficients Beta	Sig.
(Constant)	186.275		.000
Body Weight	-1.030	-.389	.029
IMT	-2.199	-.605	.002

Table 3. The final model of the dominant predictor of body score for the female group.

Model	B	Standardized Coefficients Beta	Sig.
(Constant)	82.332		.001
Weight	-1.414	-.647	.021
Protein	1.688	.330	.042
Visceral Fat	-1.290	-.245	.061
Bone Density	21.927	.312	.074

Body weight is the dominant predictive variable in the male and female groups. Research on body weight and composition and the variables that influence it are still very varied and inconsistent. In this study, it can be seen that body weight greatly affects body score, the higher the weight, the lower the body score. This is in line with the research of Shook et al. [1] which stated that body weight is one of the components that affect body composition which in this study was measured by body score. While the research by Skouroliakou et al. [2] one of the factors believed to affect body weight and body composition is nutritional intervention.

Specifically, referring to Figs. 1 and 2, the male group proved that body score is largely determined by body weight. Although in the prediction model it was found that body score was determined by BMI and body weight, but in essence it could be said that weight was the only predictor because weight was also a determinant of BMI. One study in Zagreb Croatia stated that there are limitations of BMI in assessing body composition. The results showed that BMI had no effect on men's health and body composition because although their BMI was high and categorized as obesity, they had large muscle mass and low-fat content [3]. However, this is in contrast to the lengthy scientific comments on BMI put forward by Blackburn and Jacobs [4] and research in America which state that BMI is still a strong predictor of body composition in healthy men [5]. However, Fig. 2 (presented in red vertical line) gives an idea that a man can have a body score 75 then what must be done is only to maintain weight so that it is always at a BMI score 22 by means of regular exercise and nutritional intervention [2]. Meanwhile, in the female group, there was no special pattern of correlation between body weight, BMI, and body score.

In the female group, Figs. 4 and 5 (presented red box) illustrate that the protein content is low, but the visceral fat content is high. This is related to consumption patterns that are low in protein but high in fat and carbohydrates. In the context of the Sundanese people (as the participants are all from Sundanese ethnicity), the appropriate diet is a diet that tends to be high in carbohydrates [6, 7]. Excess carbohydrates will be stored in the form of liver and muscle glycogen. If the deposit capacity in the liver and muscles is fully filled, carbohydrates will be converted into fat deposits [8]. Research in Thailand shows a positive relationship between fasting sugar levels and visceral fat. The higher the fasting sugar level, the higher the visceral fat. Fasting sugar levels are an important indicator of a person's long term high carbohydrate diet [11]. Research on the consumption pattern of the Babakan Madang community, the same location as this study, shows that the consumption pattern of the community is still not good. As many as 32% of the population has a consumption pattern that does not vary and is monotonous. In addition, 76% of housewives have a low level of knowledge about consumption patterns [12]. Lack of knowledge about consumption patterns tends to cause

invariance which results in a long-term high-carbohydrate diet, resulting in the accumulation of visceral fat in the body.

Bone density shows different things from other predictors which tend to be in agreement with commonly known theories. It is shown in Fig. 6 that the curve of body composition in terms of bone density in female group is decreasing, as that in terms of body weight is (see Fig. 3). In general, the higher the bone density gets, the better the quality of a person's body composition tends to be [13]. This study shows that the higher the bone density, the lower the body score, as well as a tendency to have a negative relationship between body weight and bone density and weight and height. The female subjects in this study tended to have small bone mass, short stature but body weight. In research in America, it is known that the cause of high body weight and low bone mass in women is caused because women have entered menopause. During menopause, there are problems with the metabolism of bone-building substances in women due to hormonal changes [14]. However, in this study the menopausal status of female participants was not studied. Therefore, in the next study regarding bone mass in women, the variable of menopausal status should be a variable that is taken into account.

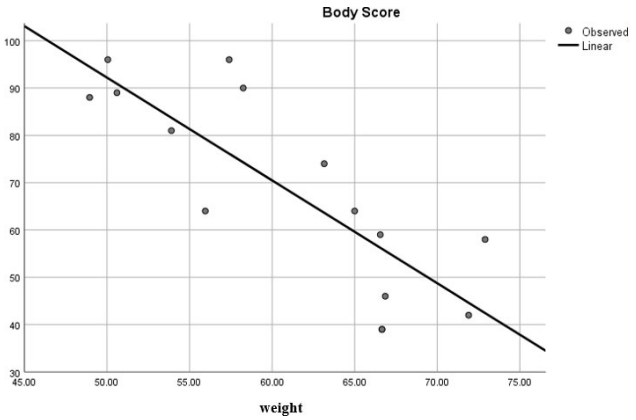

Fig. 1. Body score estimation curve based on the weight of the male group.

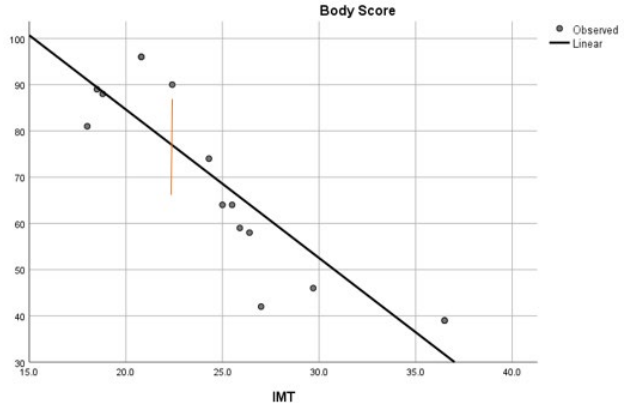

Fig. 2. Body score estimation curve based on IMT of the male group.

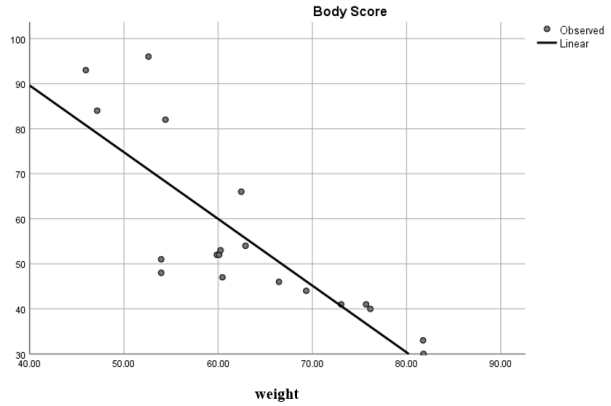

Fig. 3. Body score estimation curve based on the weight of the women's group.

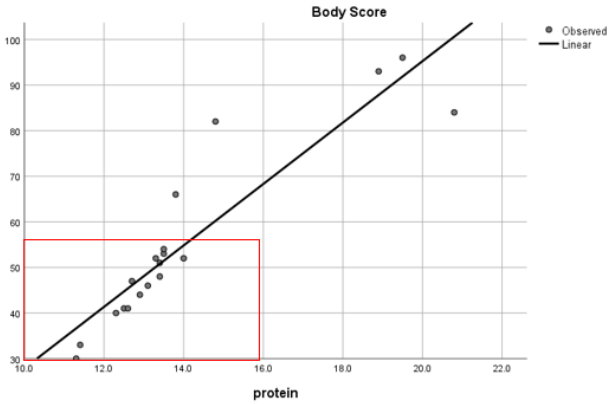

Fig. 4. Body score estimation curve based on protein levels in the female group.

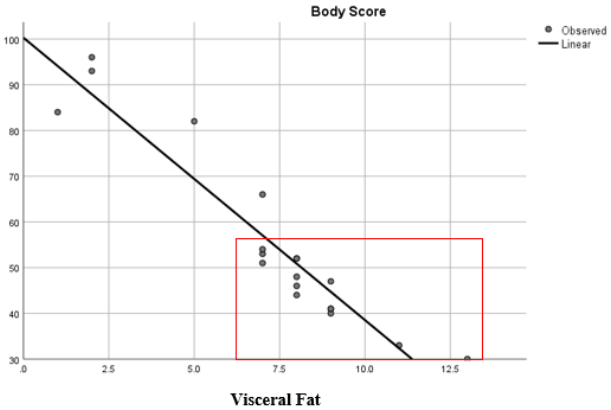

Fig. 5. Body score estimation curve based on visceral fat in the female group.

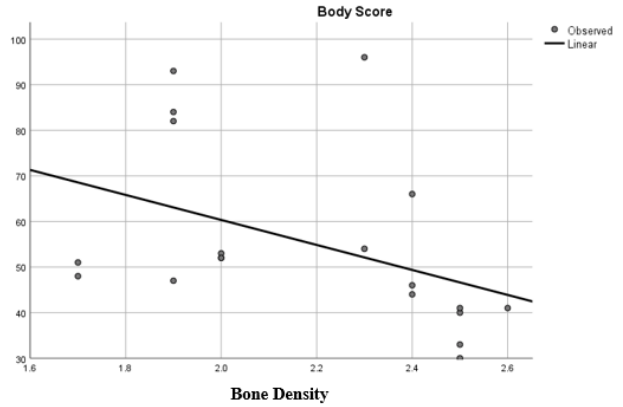

Fig. 6. Body score estimation curve based on bone density of the female group.

4. Conclusion

This study shows that body score as an indicator of body quality is influenced by gender. For men, it can be said that weight is the only dominant predictor, while for women, apart from weight, there are other predictors, namely protein content, visceral fat, and bone density. In addition, BIA can be used as a body composition measurement tool; however, particularly for bone mass variable in women, it requires additional information related to menopausal status. It is strongly suggested that future research put more focus on either the improvement of digital scale implementing BIA through body score or more gender-based additional predictors of body composition.

Declaration of Interests Statement

The authors declare no conflict of interest.

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