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Differentiation of body fat composition between skinfold caliper and bioelectrical impedance analysis methods among professors

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ABSTRACT

Background: Body fat composition which is reflected by body fat percentage (BF%) is one of the important components in disease risk evaluation. Among the methods available to measure BF%, skinfold calipers (SKF) and bioelectrical impedance analysis (BIA) are the most common used. The study is conducted to observe the difference in body fat composition measurement between skinfold caliper and bioelectrical impedance analysis methods among Professors.

Method: This study involved 72 UNPAD Professors (50♂, 22♀) after fitted into criterias. BF% was measured among UNPAD Professors using SKF and BIA. After obtaining agreement by Bland-Altman Plot, the data was analyzed by muliple paired-t test according to gender, physical activity level and BMI categories.

Results: The study showed no significant difference in BF% between SKF and BIA in overall population, between gender and physical activity level ($p>0.05$). For BMI, the only category that showed significant difference in BF% between the 2 methods is obese I group ($p=0.001$, $p>.05$).

Conclusions: There is no significant difference between SKF and BIA methods according to gender, physical activity levels and BMI categories except for obese I group.

Keyword: Bioelectrical impedance analysis, body fat percentage, professors, skinfold caliper

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INTRODUCTION

Body fat composition which is reflected by body fat percentage (BF%) is one of the important components in disease risk evaluation, especially regarding to the influence of excess body fat and its distribution on the onset of non-communicable chronic diseases.[1,2] The body fat content is the most variable component of the body, varying among individuals of the same sex, height and weight, making its accurate measurement difficult.[3,4] A moderately satisfactory estimate of the body fat content can be obtained from the height and weight. However, for more precise evaluation several methods are available which give a reasonably accurate measure of body fat composition, the most commonly and widely used methods due to their ease and feasibility are skinfold caliper (SKF) method and bioelectrical impedance analysis (BIA) method.[5,6]

Skinfold thickness is determined by pinching a fold of skin at the site and its thickness is measured using precision thickness calipers to represent the average thickness of the entire subcutaneous adipose tissue. Data from the sites of measurement will be used to analyzed by using specific formula to show the BF%.[7] While BIA is a portable non-invasive method that introduces a passage of low-level current into the body and measure the impedance to the flow. After identifying the levels of resistance to the electrical current, fat mass and lean body mass can be calculated from the difference in conductivity.[2,4]

BF% can give a significant variation not only across age, sex and ethnic groups but also the occupation of an individual. Different occupations result in different body shapes and body composition because of the various physical activities required for each job. Among the groups that tend to have high BF% is the group that from the academic field with limited physical activity. Regarding to this, the BF% of professors is the main issue of concern because they have many contributions to the society and the university as well. Because of their important role, professors require good health and body fitness to maintain their productivity. One of the factors that determine physical fitness is the BF%. The study is conducted to observe the difference in BF% between skinfold caliper and bioelectrical impedance analysis methods among Professors based on gender, physical activity level, BMI categories.

METHODS

The research was conducted by analytical comparative method using the cross sectional study design to compare the body fat composition of UNPAD professors measured by SKF and BIA method. The research was carried out at the UPT

Kesehatan Universitas Padjadjaran from September to December 2016. The data was secondary data obtained retrospectively from the primary data of the previous research of UNPAD Professors. Before the study proceeded, an ethical clearance letter was obtained from the ethical clearance committee of Faculty of Medicine Universitas Padjadjaran. Samples were collected using consecutive sampling technique. The inclusion criterias included active UNPAD professors that are still teaching including the emeritus professors with complete data needed consisting of sex, body mass index (BMI) and physical activity level. The subjects with very extreme body fat percentage results compared to the others were excluded.

Skinfolds were measured with a Lange SKF caliper by different enumerators at 4 anatomical sites: triceps, suprailiac, abdomen, and thigh. All skinfolds were measured to the nearest 0.5mm on the right side of the body. Each site was measured 3 times with the mean recorded for analysis. Measurements were taken following the recommended standardization procedures from the Anthropometry Standardization Reference Manual.[7] BF% was then calculated by substituting the respective skinfold values into the Jackson and Pollock's generalized body composition '4-sites fomula' according to male and female.[8] The equations were as follow:

BF% (♂) = 0.29288 (sum of four skinfolds) – 0.0005 (sum of four skinfolds)^2 + 0.15845 (age) – 5.76377 (sum of four skinfolds)

BF% (♀) 0.29669 (sum of four skinfolds) – 0.00043 (sum of four skinfolds)^2 + 0.02963 (age) – 1.4072 (sum of four skinfolds)

BIA was performed with subjects in standing position with both feet shoulder-width apart using OMRON BIA analyzer HBF-306. Before the measurement, the data including sex, age, height and weight were inputted manually into the analyzer. Then the grip electrodes were held by both hands of the subjects and a 50kHz electric current passed from one hand to the other. The resistance value was measured. Body fat percentage that estimated by the prediction equations supplied by the manufacturers equation, was digitally displayed and recorded.

The distribution of the data collected was tested using Kolmogorov-Smirnov normality test (z>0.05). Agreement between methods was compared using Bland-Altman plot and the limits of agreement were estimated as the mean intermethod differences ± 1.96 SD. Multiple paired t-test was done to compare the BF% obtained from the 2 methods according the gender, physical activity level and BMI categories. Statistically significant result was considered when p<0.05.

Table 1 Characteristics of UNPAD Professors

Characteristic	Frequency	%
Age		
45-54	2	2.8
55-64	9	12.5
65-74	32	44.4
75-84	27	37.5
85-94	1	1.4
>94	1	1.4
Gender		
Male	50	69.4
Female	22	30.6
BMI		
Underweight	3	4.2
Normal	11	15.3
Preobese	15	20.8
Obese I	33	45.8
Obese II	10	13.9
Physical Activity Level		
Inactive	33	45.8
Active	39	54.2

Table 2

Characteristics	Mean ± SD
Age (years)	72.9 ± 9.2
BMI (kg/m^2)	26.0 ± 4.4
SK BF (%)	26.56 ± 5.70
BIA BF (%)	26.62 ± 6.65

RESULTS

Table 1 showed the characteristics of UNPAD Professors according to gender, physical activity level and BMI categories while table 2 showed the mean value of each characteristics. From the results, UNPAD Professors were dominated more by male than female. The mean age of the professors was 72.9 ± 9.2 years. 44% of the professors were aged 65-74 years old. The mean value for the BMI was 26.0 ± 4.4 kg/m^2, that falls into the category of Obese I according to the WHO Asian classification of BMI. There were 33 inactive professors (45.8%) who did not meet the recommendations of the WHO GPAQ and 39 active professors (54.2%) who meet the recommendations. For the BF% derived from skinfold caliper and BIA methods, the mean value were similar, 26.56 ± 5.70 % and 26.62 ± 6.65 % respectively (Table 2).

In the Kolmogorov-Smirnov normality test, the p-value obtained for the BF% from SKF and BIA method were both 0.200. It can be concluded that the distribution of the BF% from the methods was normal because p>0,05. As the data is normally distributed, Bland-Altman Plot was used to assess the comparability between the methods. Results suggested great agreement between the two methods by yielding a narrow limits of agreement. Then, paired t-test was used to calculate the p-value to compare the mean BF% obtained from the two methods. Results showed that there was no significant difference between the BF% obtained from both SKF and BIA methods in the population as a whole with the difference 0.06 ± 4.66%, p=0.907(p>0.05).

Multiple paired t-test was then conducted to evaluate the mean difference in the BF% measured by SKF and BIA methods based on gender, physical activity level and BMI categories. Between genders, the p-value for the BF% measured by SKF and BIA methods was 0.338 and 0.999 respectively (p>0.05). It can be concluded that there was no significant difference in the BF% measured by both SKF and BIA methods between male and female groups.

When analyzed by physical activity level, similar results were exhibited in the BF% measured by the two method between active and inactive groups (p>0.05), showing there was no significant difference. For the BMI, the only category that showed significant difference in BF% between the 2 methods is obese I group (p=0.001, p>.05) where SKF measured higher BF% in obese I professors than BIA method while the other categories showed no significant difference.

Table 3 **Results from paired t-test to compare body fat composition between SKF and BIA**

Characteristic	P-value	Mean Difference (%)
Gender		
Male	0.338	-0.09 ± 0.67
Female	0.999	-0.03 ± 8.51
Physical Activity Level		
Inactive	0.987	0.14 ± 4.96
Active	0.855	-0.13 ± 4.45
BMI		
Underweight	0.432	-0.86 ± 1.52
Normal	0.090	-0.70 ± 1.24
Preobese	0.705	0.71 ± 7.09
Obese I	0.001*	-0.80 ± 1.22
Obese II	0.459	2.14 ± 8.74

*P-value is significant, p < 0.05

DISCUSSION

Fifty percent of the UNPAD Professors from the research fall into the obese I and II categories and relatively they have higher BF% measured by both skinfold caliper and BIA methods. In terms of age, there is more than 50% of the professors aged 60 years old and above and they belong to the 'elderly' group according to 'UNDANG-UNDANG REPUBLIK INDONESIA NOMOR 13 TAHUN 1998 TENTANG KESEJAHTERAAN LANJUT USIA', elderly refers to a person who is aged 60 years old and above.[9] From the results, most of the comparisons do not show significant differences between SKF and BIA methods as suggested in the hypothesis. The only significant difference found in the BF% between the 2 methods is the obese I group. The difference can be explained by the gender differences, aging process, difficulty of measuring thick skinfold, hydration status and physical activity before measurement.

From the data, UNPAD Professors are dominated by male. The fat distribution between male and female is different and this may contributes to the difference in the BF% measured by SKF and BIA. Male tend to have lower fat storage than female. Female professors mostly are in post-menopausal stage where there is an increase in total body fat mass due to the decreased estrogen level as estrogen plays an important role in regulating body fat distribution in women.[10]

Besides, aging process is another possible factor that responsible to the difference in the results. Aging is associated with its inherent changes in body composition may induce errors in estimations in BF%. Fat-free mass (FFM) progressively decreases, whereas fat mass increases along with aging. Maximal fat mass is usually reached at 60–70 years old. Aging is also related with a redistribution of both body fat and FFM with a greater relative increase in intraabdominal fat than in subcutaneous or total body fat.[11] Therefore, the BF% obtained from SKF might not be the precise value of the body fat content of professors because the use of the SKF depends on the assumption that the subcutaneous fat constitutes a constant proportion of the total body fat.[12]

Plus, a tendency was found for the skinfold compressibility to decrease with age due to the decrease in the water content of the tissues present in the skinfold.[13] The difference in the results maybe also be the result of the fact that females have less compressible SKF than males and compression of the fat layer during the use of calipers.[6,14] Almost half of the professors are obese and it makes the precise measurement of their skinfolds difficult because of the difficult handling of the thick skinfolds. It is a challenge for the enumerators to truly measure the skinfold that consists of a double thickness of skin and underlying adipose tissue leaving the underlying muscle undisturbed. The enumerators may struggle to grasp the true amount of skinfold as the calipers may not enough to hold the thick skinfold in obese professors and it relies highly on the techniques of the enumerators.

When SKF is performed correctly, the results can be compared with hydrostatic weighing which is the gold standard method of body composition. However, when skinfold assessment is not executed properly, the potential error is inflated, making the resulting data and findings misleading and not applicable. Varying skinfold site by as little as 1 cm produces significantly different results when experienced practitioners measure the same participant. The skill level of the skinfold technician can have a large impact on reliability and accuracy. In the research, the measurement of BF% are conducted by different enumerators for the total 72 professors. Inter-observer variations and errors may occur because of the different handling of the calipers. The enumerators are trained but not well-trained, they receive training for the measurement event only. Therefore the skills possessed by them may not be proper enough to produce accurate measurement. Beisdes that, there are several critical techniques regarding caliper use must be mastered to generate reproducible skinfold values including the proper caliper alignment and placement on the fold, measurement duration (1- to 2-s placement), and the rotation of sites measured during the assessment. It also possible for the measurement error to occur due to error in landmarking the skinfold site.[1,3]

These 2 methods are based on the assumption that the body can be considered to consist of two compartments of relatively constant composition but which are distinctly different; these compartments are: the body fat, which includes the entire content of chemical fat or lipids in the body, and the fat-free mass (FFM), which includes all the rest of the body apart from fat.[15] But realistically the body is not always made up by constant composition of both fat mass and FFM due to many influencing factors. One of them is the hydration status as BIA measures mostly the FFM. Significant alteration in body hydration and fluid distribution will affect impedance measurement.[4]

The variability of the BIA method may also be explained in part by factors related to gender differences in body composition and its influence on the principles of the method. BIA primarily measures total body water and assuming a stable hydration of fat-free mass at 73% then the body fat value is then determined. Hence, with the increase in BMI, there was a larger error of BIA because BIA produces a larger error for measuring adiposity as a result of dependence on two previous measures (body water and fat-free mass).[15] Factors such as physical activity level and consumption of food and beverages before measurements may change the measured impedance.[4] In addition, the error might be strengthened by variations in the posture of the individual during the exam of BIA, and the contact and location of the electrode. The variations may lead to inconsistent resistance and reactance values, impairing the accurate measurement.[2]

The limitations of the research is both the hydration status and physical activity level before measurements are not assessed where these two factors might affect to the measurement of BF% by BIA. Because the data used are secondary data so it is hard to assess the confounding factors that can affect the BF% measurement by SKF and BIA methods. In conclusion, since there is no significant difference in the BF% of UNPAD Professors measured by the two methods except those in obese I group, therefore, the choice of which method to use in the application in the daily practice depends on the researches after taking into account of the advantages and disadvantages of the two methods to measure the BF% of the professors.

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