Original Article

Comparison of body compositional indices assessed by underwater weighing, bioelectrical impedance and anthropometry in Indonesian adolescent girls

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Objective: to investigate the accuracy of bioelectric impedance analysis and anthropometry to assess percentage body fat (BF %) against underwater weighing (UW). **Design and Methods:** a cross sectional study, 102 girls, aged 11-15, were recruited from two Junior High Schools in Jakarta. **Measurements:** measurements of percentage body fat (BF%) using underwater weighing (UW), bioelectrical impedance analysis (BIA), Tanita BIA, body mass index (BMI) and skinfold equations. **Results:** Correlation between different methods was significant ($p < 0.001$).The mean difference of BF % from BIA, Tanita, BMI and skinfold compared to UW were 1.87±3.14, -3.46±3.28, 1.57±2.90 and -0.360±3.09, respectively. Assessments between UW and other methods were significantly different ($p < 0.0001$) except for skinfolds ($p = 0.3031$). **Conclusion:** The results between UW and other methods was significantly different, except for skinfolds. There was overestimation and underestimation of BF%. The agreement between skinfold measurement and underwater weighing was also influenced by menarche status.

Key Words: body fat, skinfolds, underwater weighing, bioelectrical impedance, anthropometry, Jakarta, Schools, menarche

INTRODUCTION

Most body composition methods are based on the model in which the body consists of two chemically distinct compartments, fat and fat free mass.[1,2]

Many methods are now available to assess of several aspects of body composition. They vary in accuracy and validity, in ease of operation and in cost.

Amongst available methods, anthropometry and bioelectrical impedance, are practical and useful in field studies.[3,4] These techniques are field applicable because they are portable, relatively inexpensive, do not require extensive training for use, are non-invasive and require a minimal amount of time to administer.[5] The methods also have great potential for use by hospitals, sports and fitness institutions and universities.[6]

Hydrodensitometry (underwater weighing) requires much more subject’s cooperation than other methods. It is not widely available and is more expensive,[7] although it remains as one of the non-invasive ‘gold’ standards for assessing body composition.

Bioelectrical impedance method is relatively new.[8,9] Recently a new bioelectrical impedance analysis instrument, TBF 511 (Tanita Corp. Tokyo) was developed. This instrument provides a different approach to estimate fat free mass. It is a leg to leg pressure contact BIA system and it employs two foot pad electrodes with a corresponding digital scale.

The measurement of height and weight (and hence of body mass index) is the easiest technique to use in epidemiological studies when body composition is being assessed. Skinfold measurements share the advantages of subject convenience. However, the measurement of skinfolds is sensitive to inter observer and even intra observer error.[10]

The absolutely accurate assessment of body composition in a living organism is never an easy task. The assessment of body composition in children and youth is a particularly challenging task.[11] Several studies have proposed that bioelectrical impedance and skinfolds measurements are valid techniques for some populations.[12,13]

Studies on direct comparisons between different methods to estimate body composition and a reference method such as underwater weighing (UW) in Southeast Asian population is still needed.

The aim of the current study was to assess human body composition of Indonesian adolescent girls using bioelectrical impedance analysis (BIA), Tanita BIA, skinfold measurement and body mass index equation and compare the validity of each measurement against underwater weighing.

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MATERIALS AND METHODS

Subjects

102 Indonesian adolescent girls, aged 11-15, were recruited from two junior high schools in Jakarta. All subjects were judged healthy during the study period. The subjects and their parents were fully informed about the nature and purpose of the study and all gave their informed consent before participation in this study. Data collection was performed in November 1997 in SEAMEO-TROPMED Laboratory in Jakarta. The study protocol was approved by the Ethical Committee of the Faculty of Medicine, University of Indonesia, Jakarta, Indonesia.

Underwater weighing (UW)

Body density was measured by underwater weighing and corrected for residual lung volume. Underwater weight was measured in a water tank in which a swing chair was suspended from a salter spring scale (model 235, London, UK). The subjects were instructed to exhale maximally, then submerge and remain as motionless as possible for about 5 seconds while underwater weight was recorded to the nearest 0.1 kg.[14] The average of three heaviest underwater weight values among 10 measurement was taken. All measurements were done with the subjects in a fasting state.

Residual lung volume (RV) was measured outside the water tank soon after underwater weight measurement using a closed circuit nitrogen dilution approach modified after Wilmore.[15] The volume of gas trapped in the gastrointestinal tract, sinuses etc., was assumed 100 ml.[16]

Body density (Db) was calculated using the following formula (Buskirk, 1961):

$$Db = Wa/\{[(Wa- Ww)/Dw] - RV - 100\ ml\}$$

where Db = body density ; Wa = weight in air ; Ww = weight in water during maximal exhalation ; RV = residual lung volume. And converted to percentage body fat (BF %) using the formula developed by Weststrate &Deurenberg (1989)[17]:

$$BF\ \% = \{(562 -4.2\ (age-2)/Db) - (525 - 4.7\ (age - 2))\}$$

where age is expressed in years and the density of the FFM assumed to slowly increases with age, from 1.080 kg/l at 7 years[18] to 1.100 kg/l at 18 years[1] in both sexes.

Bioelectrical impedance analysis (BIA)

Measurements were made with a bioelectrical impedance (Multi frequency Human-Im Scan, Dietosystem, Milano, Italy) with the frequency used for this study was 50 kHz. The subject was measured lying comfortably in a supine position on a non conductive surface with legs and arms abducted from the trunk in 30-45 degree angle.[8] To introduce the current into the body, self adhesive electrodes were used after cleaning all skin contact areas with diluted alcohol (70%). The electrodes were attached on the aspect proximal to the metacarpal-phalangeal joint in the middle of the dorsal surfaces of the dominant hand and to the metatarsal-phalangeal joint of ipsilateral foot, respectively. The sensor electrodes were positioned on the middle of the line between radius and ulna of the wrist and the middle line between lateral and medial malleolus at the ankle. The distance between electrodes was 5-6 centimeters. Measurements were performed after the subjects had urinated and were measured in a fasting state, without previous exercise and immediately before the underwater weighing procedure.

To derive percentage body fat, an equation by Houtkooper et al., (1989) was used:

$$BF\ \% = -1.11\ Ht^2/R + 1.04\ Wt + 15.16$$

where B = percentage of body fat; H = height (cm); R = resistance (0); Wt = body mass (kg).[19]

For the percentage of body fat measurement by Tanita (TBF 511, Tanita Corp, Tokyo), a leg-to-leg pressure contact BIA system consisted of two subdivided stainless steel foot pad electrodes mounted on a platform scale, impedance of the lower extremities and body weight are measured simultaneously while the subject stood on the scale. The impedance itself were not displayed, but automatically converted into percentage of body fat.

Anthropometry

Anthropometric measurements included standing height, body weight and skinfold thicknesses. Height was measured to the nearest 0.1 cm using a microtoise (CMS Weighing Equipment Ltd, London). Subject stood on a horizontal surface, chin tucked in, stretched upwards to full extent holding the head in Frankfurt plane. Heels, buttocks and shoulders were in contact with the wall to which the microtoise was attached. Body weight was measured to the nearest 0.1 kg using a SECA electronic weighing scale (model 770 alpha; SECA, Hamburg, Germany). Subject was weighed without shoes and wore a bathing suit. The accuracy of the weighing scale was checked using calibration weights before used. Body mass index (BMI) was calculated for every subject from weight and height. The percentage of body fat was derived by using a formula developed by Deurenberg et al (1991) for adolescents girls.[20]

$$BF\ \% = 1.51 \times BMI -0.70 \times age - 3.6 \times sex + 1.4\ (male =1, female = 0)$$

where age was expressed in years.

Skinfolds of biceps, triceps, subscapullar and suprailliac were measured on the left side of the body in triplicate to the nearest millimetre using a Holtain Calliper(Holtain Ltd, Crymych, Dyfed, Wales, UK). The percentage of body fat was derived using a formula developed by Slaughter et al., 1988[21] for adolescent girls:

$$BF\ \% = 1.33\ (\text{sum tri + subsc}) - 0.013\ (\text{sum tri + subc})^2 - 2.5$$

Statistical analysis

The data were analysed on a Toshiba portable computer with the Statistical Package for Social Science/Window (1993) programme. The difference of means between groups were tested by independent sample T-test, 2 independent samples, one way Anova and K independent samples. Pearson's and Spearman's correlation coefficient were used to test correlation. Agreement between the two methods was shown by plotting the difference in body fat percentage against mean body fat percentage as obtained by two methods (Bland and Altman, 1986).[22]

RESULTS

Table 1 shows some of the physical characteristics of the study population, based on menarche status. In general, the menarche group were older, had higher body weights and body heights, higher BMIs, thicker skinfolds, lower

Table 1. Physical Characteristics of Indonesian adolescent girls

	Menarche - (n=44)	Menarche + (n=58)	Total (n=102)
Age (yrs)	12.3 ± 0.43	12.7 ± 0.69**	12.5 ± 0.62
Body weight(kg)	36.5 ± 6.89	43.2 ± 7.01***	40.3 ± 7.68
Body height(cm)	147 ± 5.9	152 ± 5.9***	149 ± 6.3
BMI(kg/m2)	16.9 ± 2.68	18.8 ± 2.78***	18.0 ± 2.88
Skinfolds:			
biceps(mm)	6.7 ± 3.06	7.5 ± 2.43*	7.2 ± 2.73
triceps(mm)	11.6 ± 3.94	13.6 ± 4.51*	12.7 ± 4.37
subscap(mm)	11.4 ± 4.45	13.5 ± 5.26*	12.6 ± 5.02
supraill(mm)	13.8 ± 4.48	16.3 ± 4.93**	15.2 ± 4.88
∑ skinfolds	43.5 ± 4.24	50.9 ± 4.78***	47.7 ± 4.57
Body density(kg/L)	1.05 ± 0.010	1.04 ± 0.009***	1.04 ± 0.010
Waist circumference(cm)	59.5 ± 6.70	63.2 ± 6.14***	61.6 ± 6.62
Hip circumference(cm)	76.7 ± 8.77	84.5 ± 6.14***	81.2 ± 8.33
Waist:hip ratio	0.78 ± 0.106	0.75 ± 0.038*	0.76 ± 0.077
Trunk:(total skinfods)1	0.58 ± 0.028	0.58 ± 0.087	0.58 ± 0.033

Note: 1. (suprailliac + subscapular) : (biceps + triceps + suprailliac + subscapular); * significantly different ($p < 0.05$), 2 independent sample; ** significantly different ($p < 0.01$), 2 independent sample; *** significantly different($p < 0.001$) , 2 independent sample; ** significantly different ($p < 0.01$), independent sample T test; ***significantly different($p < 0.001$) , independent sample T test

Table 2. Body fat percentage in Indonesian adolescent girls aged 12 derived from underwater weighing divided into groups based on BMI cut off point from NHANES I in The USA

	BMI		
	< 5 percentile < 14.98 (n=7)	5 -84.9 percentile 14.98-22.16 (n=49)	≥85 percentile ≥ 22.17 (n=7)
Body fat (%)	15.9 ± 2.08 (13.4 - 19.6)	21.2 ± 3.49 (13.9 - 29.3)	28.4 ± 1.56 (26.3 - 30.9)
Fat mass (kg)	5.04 ± 0.63 (4.27 - 6.05)	8.54 ± 2.35 (4.80 - 13.3)	15.4 ± 1.43 (13.9 - 17.7)
Fat free mass (kg)	26.7 ± 2.81 (23.6 - 31.3)	31.1 ± 3.38 (25.8 - 37.6)	38.8 ± 2.50 (35.0 - 42.7)

body densities and lower waist-hip ratio than those of non menarche group.

Most of the subjects were aged 12 (61.8 %). Using reference data based on NHANES I in the USA and according to WHO BMI cut-off point, it could be seen in Table 2 that 7 (11.1%) of the subject aged 12 had low BMI-for-age (< 5 percentiles) and 7 (11.1%) of them were at risk of overweight (≥ 85 percentiles).

Table 3 presents a summary of means, standard deviation of body composition as well as p-values of the test between UW against other methods. Comparing to the UW method as a golden standard, only skinfolds gave almost similar results that the difference was not significant; $p = 0.303$, $p = 0.185$ and p=0.124, for BF%, FM and FFM respectively. Except for skinfolds (with the difference of 0.36 ± 0.43 from reference value), there were significant differences between the results of UW and other methods. The difference between BF % estimated from BMI and the reference value was 1.58 ± 2.90. BIA also underestimated body fat with 1.58 ± 3.14 difference from reference value. While Tanita overestimated the BF % with 3.46 ± 3.28 difference from reference value.

In Table 4 the correlation coefficients between body composition estimates from different methods are

Table 3. Percentage of body fat and fat mass derived from different methods (n = 102)

	mean ± SD	Difference	*p* value*
BF %			
UW	21.4 ± 4.71	-	-
BIA	19.6 ± 4.94	1.87 ± 3.14	< 0.0001
Tanita	24.9 ± 5.61	-3.46 ± 3.28	< 0.0001
BMI	19.8 ± 4.37	1.57 ± 2.90	< 0.0001
Skinfolds	21.8 ± 5.12	-0.36 ± 3.01	0.303
FM (kg)			
UW	8.93 ± 3.52	-	-
BIA	8.19 ± 3.65	0.74 ± 1.32	< 0.0001
Tanita	10.4 ± 4.22	-1.44 ± 1.44	< 0.0001
BMI	8.30 ± 3.48	0.63 ± 1.17	< 0.0001
Skinfolds	9.11 ± 3.78	-0.18 ± 1.17	0.185

Note:* 2 related sample ,with UW; † paired sample T test ,with UW; UW- Weststrate & Deurenberg, 1989, BF % = [(562 - 4.2 (age - 2))/Db] - [525 - 4.7 (age-2)]; BIA - Houtkooper et al., 1989, BF % =-1.11 Ht^2/R + 1.04 Wt + 15.16; BMI - Deurenberg et al., 1991, BF% = 1.51 x BMI - 0.70 x age -3.6 x sex + 1.4; Skinfolds, female BF%- Slaugher et al.,1988, BF% = 1.33 (sum tri + subsc) - 0.013 $(\text{sum tri + subsca})^2$- 2.5

Table 4. Correlation between body fat, fat mass and fat free mass of the subjects as assessed by different methods

Methods	Body fat (%)*/°	Fat mass*	Fat free mass°
UW vs BIA	0.782	0.919	0.957
UW vs Tanita	0.798	0.932	0.948
UW vs BMI	0.792	0.933	0.966
UW vs Skinfolds	0.809	0.923	0.966
BIA vs Tanita	0.862	0.943	0.964
BIA vs BMI	0.782	0.925	0.966
BIA vs Skinfolds	0.807	0.922	0.963
BMI vs Tanita	0.916	0.975	0.974
BMI vs Skinfolds	0.859	0.936	0.974
Tanita vs Skinfolds	0.849	0.929	0.961

Note : All methods significantly correlated (*p*<0,001); °Pearson's correlation coefficient; *Spearman's correlation coefficient

Table 5. Comparison of body composition between menarche and non menarche group

Methods	Menarche - (n = 44)	Menarche+ (n = 58)	Difference*
UW			
Fat mass (kg)	7.33±3.14	10.1±3.32	2.81±0.64
Fat free mass (kg)	29.2±4.05	33.1±4.07	3.87±0.81
BIA			
Fat mass (kg)	6.90±3.36	9.16±3.59	2.26±0.70
Fat free mass (kg)	29.6±4.11	34.1±3.88	4.42±0.80
Tanita			
Fat mass (kg)	8.65±3.81	11.7±4.06	3.03±0.78
Fat free mass (kg)	27.9±3.60	31.5±3.71	3.65±0.73
BMI			
Fat mass (kg)	6.96±3.16	9.31±3.38	2.35±0.65
Fat free mass (kg)	29.6±3.96	33.9±3.94	4.33±0.80
Skinfolds			
Fat mass (kg)	7.69±3.36	10.2±3.76	2.49±0.71
Fat free mass (kg)	28.9±3.89	33.0±3.61	4.19±0.75

* expressed in mean difference ± SE

presented. Correlation between each method was statistically significant ($p < 0.001$) with correlation coefficients ranging from 0.782 to 0.916 for BF %, 0.919 to 0.975 for FM and 0.948 to 0.974 for FFM. However, a significant high correlation does not mean that the values obtained by the two methods agree, but only they are related.

Table 5 provides comparison of body composition between menarche and non menarche group. There significant different between the two groups ($p < 0.0001$) for all methods. The difference ranged from 2.26 to 3.03 and from 3.65 to 4.42 for FM and FFM respectively.

Figures 1-4 present comparison of UW, BIA, Tanita, BMI and skinfolds. They show the individual differences in all methods. The r^2 value for UW estimated BF % compared with that from BIA was 0.624, with the BIA

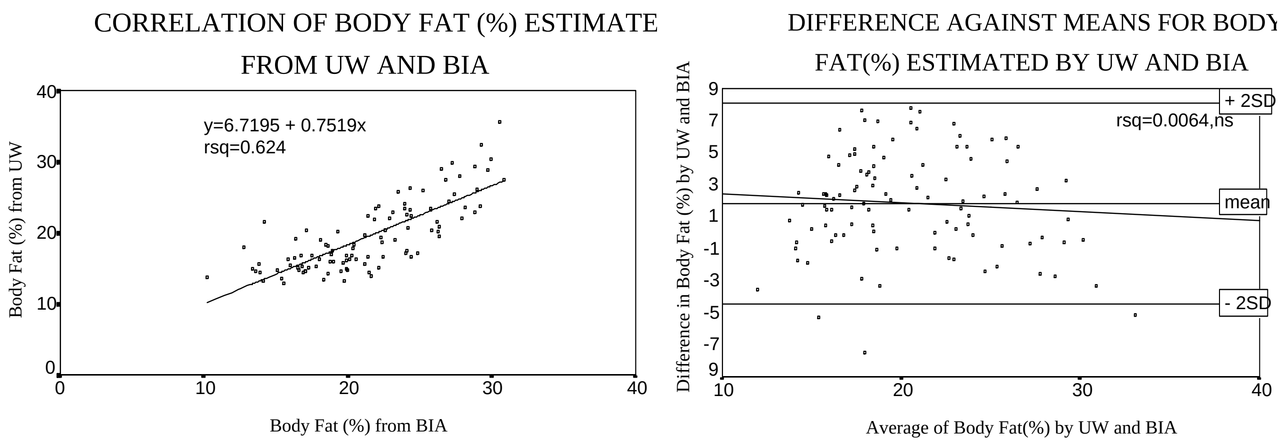

Figure 1. The correlation of BF % estimated from UW and from BIA, and the difference in the two estimates plotted against their mean.

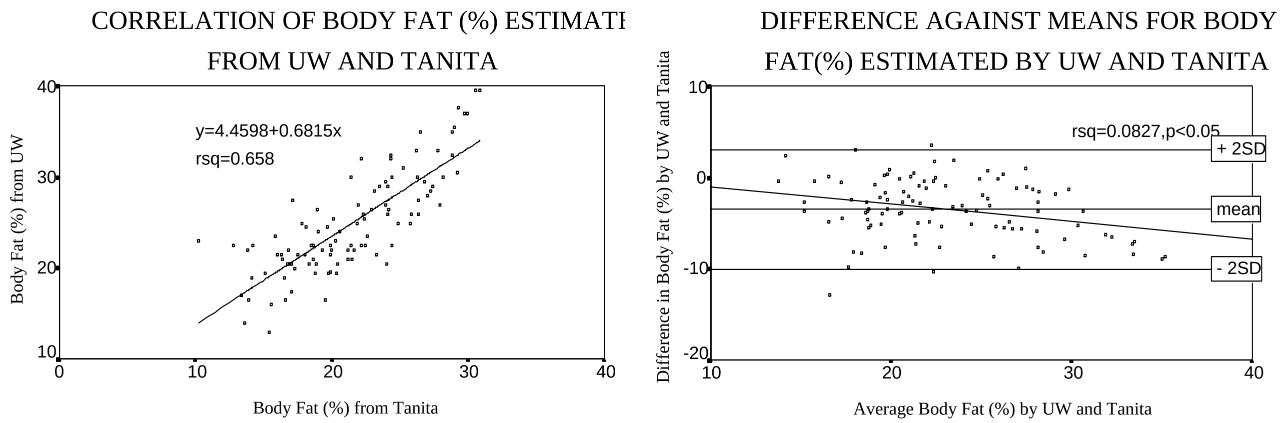

Figure 2. The correlation of BF % estimated from UW and from Tanita BIA, and the difference in the two estimates plotted against their mean.

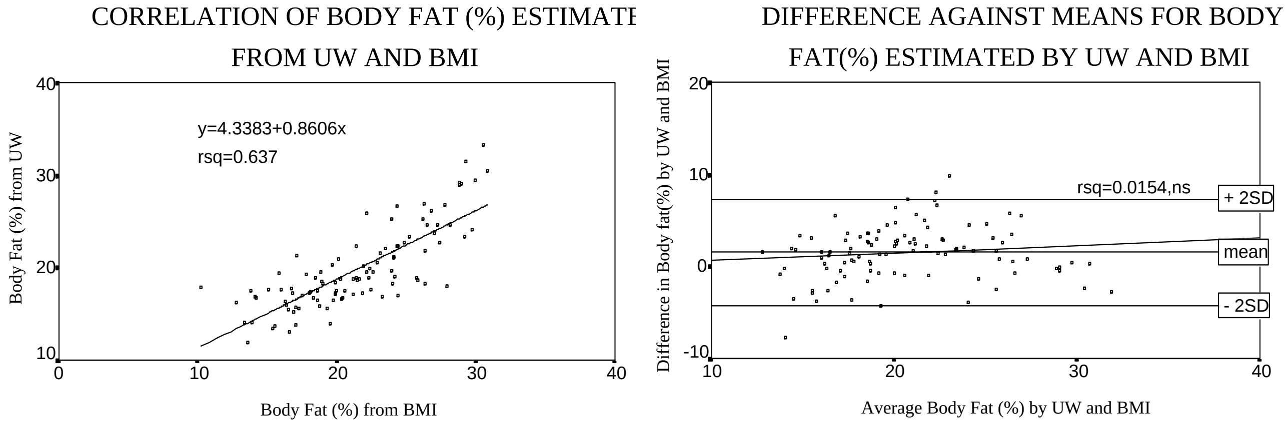

Figure 3. The correlation of BF % estimated from UW and from BMI, and the difference in the two estimates plotted against their mean.

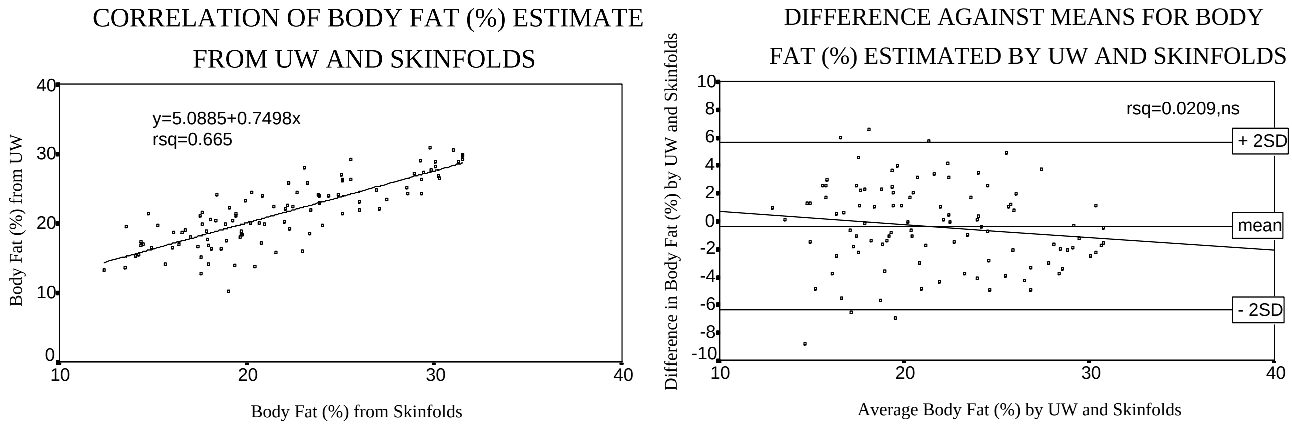

Figure 4. The correlation of BF % estimated from UW and from Skinfolds, and the difference in the two estimates plotted against their mean.

value being a mean of 1.87 ± 6.27 % (mean ± 2SD) less than that of UW (Figure 1). For UW and Tanita the r^2 value was 0.658 and BF % was 3.46 ± 6.56 % higher using Tanita (Figure 2). For UW and BMI the r^2 value was 0.637 and BMI estimated BF % was 1.57 ± 5.79 % less than that using UW (Figure 3). For UW and skinfolds r^2 was 0.665 and skinfold estimated BF % was 0.360 ± 6.02 % less than that of UW (Figure 4).

The Bland and Altman plots show that the limit of agreement (mean difference ± 2 SD), for the comparisons of BF % estimates from the methods, were large. Even in the case of UW and skinfolds the range of limits of agreement is from -6.38 to 5.66 BF %, while for UW and Tanita this range is -4.40 to 8.14 even widest range among the methods.

In Table 6, the subjects were divided into menarche and non menarche group, comparing body composition results between UW and other methods. The differences were higher in menarche group than the non menarche. In the non menarche group the p value for differences between BIA and BMI against UW were still significant ($p < 0.05$).

DISCUSSION

The prediction equations used in the present study were developed in Caucasian population with hydrodensitometry (underwater weighing) as the reference method. Given the equation to estimate BF % itself was developed from Caucasian population, it may contain error to the method itself. Siri estimated the maximal error of a two- compartment model (FM and FFM), to be about 4 % of body weight. Errors in estimating BF % are also contributed to by ethnicity.[1]

Using three compartment model in Indonesian young adults, Küpper et al. demonstrated that predictive methods that widely used (UW, deuterium oxide dilution, skinfold thickness, BIA and BMI) underestimated body fat. Therefore the development of population specific prediction formulas is necessary.[23]

The present study shows that only the mean of skinfold method which used Slaughter et al (1988) prediction equation was not different from that of UW, although they were highly correlated between the five methods. However, for UW and skinfolds, these correlation masked a considerable lack of agreement. Only the mean difference of UW and skinfold approximately zero value (mean difference = -0.360).

Lohman and colleagues, (1991)[24] reported that skinfolds are one of the most practical approaches to assess of body composition in the 20-50 year age group. Skinfolds are considered to be practical methods in predicting body fatness in children and adolescents.[25]

Available cross-validation study of the Slaughter skinfold equations showed that once, the Slaughter skinfold

Table 6. Comparison of body composition results between under water weighing and other methods in menarche and non menarche group

	Menarche -		Menarche +	
	mean	*p* value	mean	*p* value
Body fat (%)*				
UW	19.4 ± 4.56	-	23.0 ± 4.25	-
BIA	18.2 ± 4.77	0.0258	20.6 ± 4.88	< 0.0001
Tanita	22.9 ± 5.25	< 0.001	26.4 ± 5.43	< 0.0001
BMI	18.4 ± 4.14	0.0117	21.0 ± 4.23	< 0.0001
Skinfolds	20.3 ± 4.93	0.105	22.9 ± 5.03	0.880
Fat mass(kg)*				
UW	7.33 ± 3.14	-	10.1 ± 3.32	-
BIA	6.90 ± 3.36	0.0282	9.16 ± 3.59	< 0.0001
Tanita	8.65 ± 3.81	< 0.001	11.7 ± 4.06	< 0.0001
BMI	6.96 ± 3.16	0.0178	9.31 ± 3.38	< 0.0001
Skinfolds	7.69 ± 3.36	0.0863	10.2 ± 3.76	0.819

* *p* values refer to differences from the under water weight (UW) method

equations with triceps and subscapular skinfolds as independent variables, were perhaps the best predictive formula to estimate BF % and FFM in children and adolescents.[25]

In this study results from skinfold had stronger correlation with BMI than UW. In a study done by Eaton et al, (1993)[5] skinfolds were more correlated with UW than BMI, and these finding supported by Jackson and Pollock (1995).[26] This could be explainable by different ethnic, age group and predictive equations.

Zillikens and Conway (1990)[27] have investigated the accuracy of generalized skinfold equations in black subjects and compared the fat pattern of black and white adults. D_2O dilution was used as the reference methods. They demonstrated differences in fat pattern and fat distribution between black and white adults, with black adults showing more upper body fat deposition marked by lower values of suprailiac: subscapular ratio of skinfold thickness compared with white adults. This findings, once again, supported the view that a prediction equation should be developed for Indonesian population which has different fat pattern.[28]

This current study revealed that BF % derived from BMI are underestimated from the one from UW. Despite its lack of inter-method agreement, the BF % derived from BMI was considered the second best after skinfolds, since the mean difference also more or less approached zero (mean difference =1.572) with the smallest standard deviation (2 SD = 5.790).

In this study, our findings supported those reported by Webber and colleagues (1994)[7] that mean estimate body fat from BMI was markedly different from that obtained from skinfolds. This is understandable considering skinfolds presents subcutaneous adipose tissue while BMI represents visceral as well as subcutaneous fat. The BMI level and subcutaneous fat distribution could be different between age group, ethnicity and sexes.

With respect to estimates of fat mass from BIA, the constancy and water content of the fat-free mass can be questioned.[29] The density of fat-free mass was reported to vary between ethnic groups, and this means that the water content of the fat-free mass also varies.[28] In general, it is agreed that the fat-free mass is taken as 73.2 %. Changes in water and electrolyte content of the body influence BIA measurements and may lead to errors in BF % estimation. Furthermore, the diurnal changes in fluid balance are likely to occur in tropical countries, which, in turn negatively affect the validity of BF % assessments using BIA under field condition in tropical countries.[30] BIA also may under estimate total body fat in the presence of increasing intra-abdominal fat since the greatest proportion of body resistance is accounted for the limbs with a much smaller fraction in the trunk.[31] These explanation contributed to underestimating of BF % from BIA compared with that from UW.

Tanita was a relatively new tool to measure BF %. It was a leg-to-leg BIA system based on pressure contact foot-pad electrodes. A study by Baumgartner et al (1989),[32] found a high correlations among the tetrapolar arm-to-leg lead placemant and selected impedance measurements of the arms, trunk and legs, suggesting that the measurement of a single extremity's impedance may reasonably predict arm-to-leg impedance and body composition.

In this study, BF % from Tanita was overestimated that of UW. The prediction equation used in this machine was not displayed nor mention in the manual, but a study found that the mean of BF % from the BIA machine was significantly lower than that was obtained by BIA equation.[3] However due to the lack of data on Tanita validation study, a further research is recommended.

Until now no systematic body composition studies in Indonesian adolescent have been performed to check the applicability the commonly used prediction for determining body composition by anthropometry or BIA and eventually, develop a population specific prediction formulas.

This study showed that agreement between methods influenced by menarche status. It is supported by Katchadourain, (1977)[33] that the female sex hormones promote the deposition of proportionately more fat than muscle tissue in girls.

In conclusion, BF% values obtained from BMI, BIA and Tanita BIA showed marked differences, although the correlation coefficient is significantly high. BF % from skinfold measurement was not significantly different from UW. The difference between skinfold and UW were also influenced by menarche status. A further research taking menarche status into consideration with a larger sample of adolescent girls is recommended.

The use of triceps and subscapular Slaughter skinfold prediction equation for adolescents in Indonesia is recommended since at this time the equation is considered to be the best anthropometric method to estimate BF % while waiting the development of population specific prediction formulas for Indonesian people.

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Original Article

Comparison of body compositional indices assessed by underwater weighing, bioelectrical impedance and anthropometry in Indonesian adolescent girls

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比較由水中秤重法、生物電阻、人體測量評估之印尼青少女女孩之體組成指標

目的：與水中秤重法(UW)對照，研究生物電阻分析(BIA)和人體測量學評估體脂百分比(BF%)的正確性。**設計與方法：**一個橫斷性研究，召募 102 位 11-15 歲來自兩所位於雅加達的中學的女孩。**測量法：**體脂百分比(BF%)的測量法用水中秤重法(UW)、生物電阻分析、Tanita BIA、身體質量指數(BMI)和皮脂厚度公式。**結果：**不同方法間有顯著的相關(p < 0.001)。BIA、Tanita、BMI 和皮脂厚度測得的 BF%與 UW 比較平均差異分別為 1.87±3.14、-3.46±3.28、1.57±2.90 和-0.360±3.09。UW 與其他方法估計的差異，除了皮脂厚度(p = 0.3031)外，其餘均有顯著差異。**結論：**UW 與其他方法的結果，除了皮脂厚度外均達到顯著差異，那是對 BF%的高估和低估；皮脂厚度測量法和水中秤重法之間的一致也受到初經狀況影響。

關鍵字：體脂肪、皮脂厚度、水中秤重法、生物電阻、人體測量學、雅加達、學校、初經。