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The effects of test-retest, technician's skill, and different measurement methods on % body fat prediction

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Abstract. The purpose of this project was to compared the difference in percent body fat (% body fat) measured in two different days in same subject, the difference in % body fat measured from five different testers for the same subjects, and the differences in % body fat measured four different methods. Healthy men (n=7) and women (n=3) aged 25-49 years were participated in this project. Skinfold (SKF), circumference, and bioelectrical impedance analysis (BIA) methods were measured from these subjects, and under water weighing was performed in five of the subjects. Three different statistical analyses were performed to achieve the goals of this project. First, paired t-test was used to compare the differences between the % body fat measured by SKF and circumference that measured in two separate days by same testers. Second, the difference of % body fat by SKF method measured by five different testers for the same subjects was analyzed using one-way ANOVA. Finally, one-way repeated ANOVA was performed to analyze the difference in % body fat measured by four different methods by same testers. There was no significant difference in the differences between the results of % body fat measured by SKF and circumference in two separated days. The difference of % body fat measured by SKF measured by five testers for the same subjects was not statistically significant. The difference among the results of % body fat measured by four different methods also did not significant. These results suggest that SKF, body circumference, and BIA analysis are a stable, valid and reliable body composition measurement method.

Keywords; obesity; body composition measurement technique; body fat;

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1. Introduction

Since obesity or disproportionate fat distribution plays an important role in the development of certain metabolic disorders and can ultimately affect mortality and morbidity, it is important to use reliable and accurate methods to measure body composition [1-2]. There are many ways to measure body composition, but traditionally two-compartment models such as densitometry and hydrometry have been used as reference methods for body composition. Recently, more advanced methods for measuring body fat and body density such as CT, MRI, and DEXA have been proposed. However, these advanced techniques for body composition measurement have problems in economics and complexity of measurement.

On the other hand, anthropometry such as circumference and SKF methods, which have been proven for a long time, have many reliable SKF or circumference prediction equations developed using population-specific or generalized regression model. In addition, there are many studies that have demonstrated that BIA is a useful way to predict body composition [3-4]. However, it was suggested that these three body composition measurement methods have problems related to accuracy due to technician's skill, type of equipment, subjects' factors, prediction equations, and environmental factors [5-10]. Nevertheless, these methods are widely used in the health care field with the advantage of measuring the body composition at a relatively low cost.

Based on this information, this project examined (1) the difference in % body fat measured in two separated days by same tester, (2) the differences in % body fat measured from five different testers about same subjects, and (3) the differences in % body fat measured by four different methods.

2. Methods

A. Subjects

Healthy men (n=7) and women (n=3) aged 25-49 years were participated in this project. SKF, circumference, and BIA measurements were performed to measure body composition. Five of total subjects were measured SKF and circumference measurements twice on two separate days, and under water weighing was performed.

B. Skinfold measurement

Abdomen, chest, calf, midaxillary, subscapular, suprailiac, thigh, and triceps were measured using a skinfold caliper (Harpenden) following the recommendations defined by [11] and [12] from five different testers. The prediction equations for body density (Db) calculation were used according to the choice of different testers, and the equations

used are as follows. 1) Db (chest, abdomen, thigh) = 1.10938 - 0.0008267(sum of 3 sites) + 0.0000016(sum of 3 sites)2 - 0.0002574(age) for men. 2) Db (chest, triceps, subscapular) = 1.1125025 - 0.0013125(sum of 3 sites) + 0.0000055(sum of 3 sites)2 - 0.000244(age) for men. 3) Db (triceps, suprailiac, abdomen, thigh) = 1.096095 – 0.0006952(sum of 4 sites) + 0.0000011(sum of 4 sites)2 - 0.0000714(age) for men.4) Db (chest, midaxillary, triceps, subscapular, abdomen, thigh, suprailiac) = 1.097 - 0.0046971(sum of 7 sites) + 0.00000056(sum of 7 sites)2 - 0.00012828(age) for women. 5) Db (suprailiac, triceps, thigh,) = 1.099421 - 0.009929(sum of 3 sites) + 0.0000023(sum of 3 sites)2 - 0.0001392(age) for women. 6) Db (triceps, suprailiac, abdomen) = 1.089733 – 0.0009245(sum of 3 sites) + 0.0000025(sum of 3 sites)2 - 0.0000979(age) for women. These body density values were then converted to % body fat using Siri's equation, % body fat = (4.95/Db – 4.50) × 100.

C. Circumference measurement

Circumference of waist, abdomen, arm, calf, chest, forearm, iliac, thigh, and hip were measured by an anthropometric tape following [13] from 5 different testers. To convert into % body fat, different body circumferences were used according to young men/women and old men/women. All proceduals were followed 'Appendix I: Evaluation of Body Composition-Girth Method' (website: connection.lww.com/go/mcardle, 2005). Upper arm, abdomen, and forearm were used for young men (18-26 yrs). Abdomen, thigh, and forearm were used for young women (18-26 yrs). Hip, abdomen, and forearm were measured for old men (27-50 yrs). Abdomen, thigh, and calf were used for old women (27-50 yrs). These circumferences were then changed into constant A, constant B, and constant C respectively. % body fat was calculated by following equations. 1) % body fat = constant A + constant B – constant C – 10.2 (for young men). 2) % body fat = constant A + constant B – constant C – 15 (for old men). 3) % body fat = constant A + constant B – constant C – 19.6 (for young and old women).

D. BIA measurement

Four electrodes applied subject's bared hand, wrist, foot, and ankle, and subjects sustained supine position during BIA measure. Also, subjects stretched their arms and legs alongside.

E. Under water weighing measurement

The subjects sat on a chair attached to a weighing scale. After exhaling, the subjects were submerged, and their hydrostatic weights were measured. The hydrostatic weight was measured 3 times, and the average value was used as a representative value. Residual volume (RV), body density, and % body fat were calculated using following prediction equations; 1) RV = (0.019 × hight(cm)) + (0.0115 × age) - 2.24 for men, 2)

RV = (0.032 × hight(cm)) + (0.009 × age) - 3.90 for men, 3) Db = Wa/{(Wa-Ww) –Dw-(RV+0.1)} where Wa means body weight, Ww means under water weight, and Dw means water density. 4) % body fat = (4.57/Db – 4.142) × 100. The water temperature was maintained between 34℃ and 36℃. The subjects wore only swimming suits during measurement.

F. Statistical analysis

Statistical analysis was used the SPSS statistical data analysis software package. Three statistical analyses were performed to analyze the results of this project; 1) paired t-test was performed to compare the difference between the % body fat from SKF and circumference that measured in two separated days by same tester. 2) the difference of % body fat among different testers about same subjects was analyzed using one-way ANOVA. 3) one-way repeated ANOVA was used to analyze the difference among the different methods by same testers. Statistical significance was set at $P \leq 0.05$, and the data are presented as mean ± SD.

3. Results

G. Baseline characteristics

Subject characteristics of this project are presented in Table 1. Total subjects were ten, and three of them were female.

TABLE I. SUBJECT CHARACTERISTICS

	Age (yrs)	**Weight (kg)**	**Height (cm)**
Subjects (n=10)	30.7 ± 10.29	79.67 ± 15.20	170.33 ± 9.29

H. The comparison of % body fat measured by skinfold and circumference methods between two separate days

The results of % body fat measured by SKF and circumference methods by tester A, B, and C are presented in Table 2. In the results measured by 3 different testers, there were no significant differences between % body fat measured on Day-1 and Day-2 by SKF or circumference methods ($P \leq 0.05$).

TABLE II. % BODY FAT MEASURED BY SKF AND CIRCUMFERENCE METHODS IN SEPARATE DAYS

Tester	**Method**	**No. of subjects**	**% body fat**		**t-value**	**Sig.**
			Day-1	**Day-2**		
A	SKF	4	22.64 ± 7.66	20.36 ± 5.58	1.73	0.18
	Circumference	4	26.32 ± 10.28	29.62 ± 1.78	-0.80	0.48

B	SKF	4	19.43 ± 4.55	19.33 ± 9.26	0.03	0.98
	Circumference	4	24.08 ± 2.09	24.01 ± 5.16	0.042	0.97
C	SKF	4	26.37 ± 7.57	24.42 ± 2.71	0.75	0.51
	Circumference	4	27.47 ± 6.46	25.88 ± 5.35	1.61	0.21

I. The comparison of % body fat measured by skinfold between different testers

Table 3 shows the results of % body fat measured by SKF method by five different testers. There was no significant difference in % body fat among the five different testers ($P \leq 0.05$).

TABLE III. % BODY FAT MEASURED BY SKF FROM 5 DIFFERENT TESTERS

Tester	No. of subjects	% body fat	Sig.
A	5	28.44 ± 8.46	F=0.80 P=0.54
B	5	22.82 ± 7.65	
C	5	20.43 ± 9.04	
D	5	22.47 ± 6.04	
E	5	21.96 ± 6.57	

J. The comparison of % body fat measured by four different body composition measurement methods.

Table 4 shows the results of % body fat measured by four different body composition measurement methods by four different testers. There was no significant difference among the values of % body fat measured by the four different body composition measurement methods ($P \leq 0.05$). Also, same statistical results were found in 4 different testers.

TABLE IV. % BODY FAT MEASURED BY SKF FROM 5 DIFFERENT TESTERS

Tester	Methods	No. of subjects	% body fat	Sig.
A	SKF	4	25.40 ± 6.05	F=1.31 P=0.33
	Circumference		26.67 ±5.85	
	BIA		25.73 ± 5.96	
	UWW		24.30 ± 3.65	
B	SKF	4	19.38 ± 6.62	F=0.12 P=0.94
	Circumference		24.05 ± 3.50	
	BIA		24.73 ± 4.42	
	UWW		26.03 ± 5.87	
C	SKF	4	21.51 ± 6.57	F=1.26 P=0.35
	Circumference		27.97 ± 6.48	
	BIA		28.52 ± 5.83	
	UWW		27.10 ± 4.50	

4. Conclusion

This project examined test-retest effects on % body fat measured by SKF and circumference methods, the effect of different technician's skill on % body fat measured by SKF, and the differences among % body fat data measured by four different body composition measurement methods. In conclusion, there was no significant difference in % body fat measured on 2 separate days from same subjects. In addition, % body fat measured by SKF was not affected by different technicians. Finally, % body fat measured by four different methods showed similar results. The data indicates that as a body composition measurement method, SKF, circumference, and BIA methods are a reliable and reasonable body composition measurement method that is relatively economical and easy to use.

A body composition measurement method, SKF, circumference, and BIA are not only relatively economical and convenient, but also indicates that it is a valid and reliable body composition measurement.

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