

Viraj De Silva¹
Chamath Ekanayake¹
Shalika Jayasinghe¹
Minoli Fernando¹
Nadeera Kodithuwakku¹
Isuru Weerasena¹
Dammika Karunaratne¹
Mohammad Mushraf¹
Chamil Jayawardena¹
Anuja Mallawarachchi²
Sharmila Rajaratne¹

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¹*Department of Physiology, Faculty of Medicine,
University of Peradeniya, Sri Lanka*

²*Department of Physical Education, University of Peradeniya, Sri Lanka*

RELATIONSHIP AMONG THE DIFFERENT BODY FAT MEASURING METHODS

INTRODUCTION

There is growing evidence that clearly links body composition with health risks and the development of certain diseases. Detection of excess body fat percentage, in early stages may help to prevent associated complications. An autopsy is the only direct method of measuring body composition; all other methods rely on indirect measurement techniques. Most of these methods are based on the assumption that the body consists of two compartments; the body fat, which includes the entire content of chemical fat or lipids in the body, and fat-free mass, which includes all the rest of the body apart from fat. In this study, three body fat measurement methods, hydrodensitometry, skin fold technique and girth method are compared.

Hydrodensitometry, referred to as a gold standard (Heymsfield 2005), is a technique that has been validated through repeated scientific studies and against which other clinical and field method results are evaluated. Estimation of body composition through hydrodensitometry is based on the Archimedes' principle, by which the density of an object is calculated by dividing the object's weight in air by its loss of weight in water. Underwater weighing although considered a relatively precise method for assessment of body fat, is a complex technique and difficult to be widely applied. Fat beneath the skin typically represents most of the skin fold measurement and it is assumed that a direct relationship exists between total body

fat and subcutaneous fat, which is applied in girth technique (Hoeger and Hoeger, 2006). As the skin fold and girth techniques are easy to administer and relatively inexpensive, they are widely used in the field and clinical settings to estimate body fat percentages.

The objective of this study was to compare body fat percentages obtained by Hydrostatic weighing, the skin fold thickness and girth methods.

METHODOLOGY

All measurements were taken from 60 healthy males between the ages of 18 to 60 years. The skin fold measurement was taken from the chest, abdomen and thigh on the right side of the body with a Harpenden skinfold caliper. Sum of the skin fold thickness is used in mathematical regression equations, developed to calculate body fat percentage (Jackson and Pollock, 1978). For the girth technique, the waist and the wrist circumferences were measured with a measuring tape and the difference was used to calculate the BF% (Penrouse 1985).

After obtaining informed written consent from the subjects, underwater weights were obtained in the university swimming pool using an especially designed measuring device (Fig.1) which allows the subject to sit on a chair and be completely submerged underwater. Ten readings were obtained from each subject using a Salter balance and the fat percentage was calculated from the density (Hoeger and Hoeger, 2006). The paired T test was performed using SPSS (version 16) to find whether there are significant changes in the values.

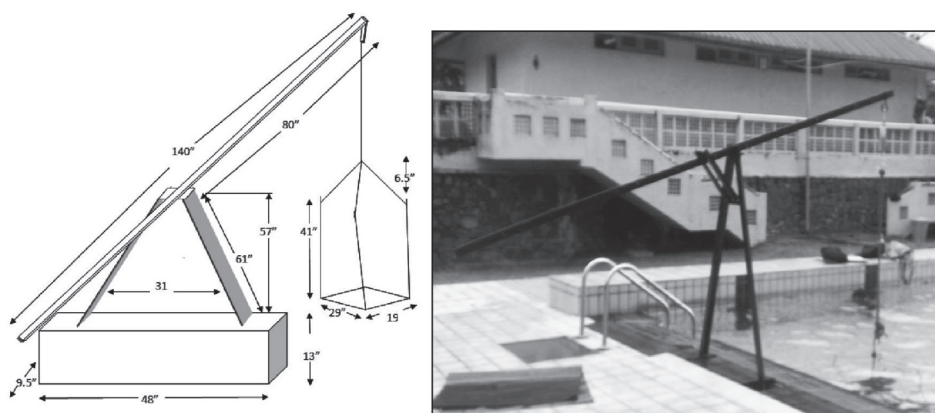


Fig. 1. Measuring device designed to measure underwater weight of subjects (left) and the measuring device fixed to the swimming pool (right)

RESULTS

We have considered 60 men aged between 18 and 59 (mean age of 34.55), mean height 168.81cm and mean weight 66.475 kg. Mean BMI of the subjects was 23.327.

Mean of the body fat percentages obtained from the hydro densitometer (the gold standard method) is 19.48, while the means of BF% obtained from skin fold thickness and girth were 22.58 and 21.24 respectively (Table 1).

Table 1. Mean and standard deviation of each method

Method	Mean	Standard Deviation
Hydrostatic weighing	19.48	5.71
Skin Fold Thickness	22.58	7.77
Girth Method	21.24	8.42

Paired T test

Mean body fat percentage measured by the gold standard was significantly different from the means of the other two methods. But when we compared skin fold and girth there were no significant differences between the results obtained using each method (Table 2).

i. Pair 1 = Hydrostatic Weighing Vs Skin fold measurement:

The difference of means is – 3.105 which indicates that mean value of the body fat percentage obtained from skin fold measurement is higher than the mean value of the body fat percentage obtained from Hydrostatic Weighing.

The P value of this pair is 0.003, which is much lower than 0.05. Therefore, the mean difference in these two methods is significant and it is not due to chance.

ii. Pair 2 = Hydrostatic Weighing Vs Girth measurement:

The difference of means is – 1.602 which indicates that mean value of the body fat percentage obtained from girth measurement is higher than the mean value of the body fat percentage obtained from Hydrostatic Weighing. But the difference is much lesser than in pair 1.

The P value is 0.021, which is lower than 0.05. Therefore, the mean difference in these two methods is significant and it is not due to chance.

iii. Pair 3 = Skin fold measurement Vs Girth measurement:

The difference of means is 1.636 which indicates that mean value of the body fat percentage obtained from skin fold measurement is higher than the mean value of the body fat percentage obtained from girth. But the difference is much higher compared to pairs 1 and 2.

The P value is 0.164, which is higher than 0.05. Therefore, the mean difference in these two methods is not significant.

Table 2. Paired T test results

Pair		Paired Differences			
		Mean difference	95% Confidence Interval of the Difference		Sig. (2-tailed)
			Lower	Upper	P value
1	Hydrostatic Weighing vs. Skin fold	-3.10	-5.107	-1.103	0.003
2	Hydrostatic Weighing vs. Girth	-1.76	-2.955	-0.248	0.021
3	Skin fold vs. Girth	1.34	-0.689	3.960	0.164

DISCUSSION

As shown in paired T test analysis, there were significant differences in BF% values between hydrostatic weighing vs. skin fold, and hydrostatic weighing vs. girth method. This means that both methods used in the clinical set up (i.e. skin fold or girth) would not give a reliable value of a person's BF% compared to the actual/gold standard value. Thus it appears that we cannot predict a person's BF% by looking at a value obtained either from skin fold or girth method. The most likely reason being, both skin fold and girth methods measure only the subcutaneous fat and not also the visceral fat.

But when carefully looking at the mean values of each method, it is obvious that mean values obtained from both skin fold and girth methods were higher compared to the hydrostatic method. So, it is questionable as to why this happened despite the fact that skin fold and girth methods were accessing only the subcutaneous fat and those two methods were expected to give lower values compared to the hydrostatic weighing.

The fact that skin fold method is not a reliable method was established by another study while comparing it with Dual Energy X ray Absorptiometry (DEXA),

mentioning that accuracy of most of the skin fold-thickness equations for assessment of BF% in adolescents was poor at the individual level (Rodríguez 2005). But, in another study which compared DEXA, skin fold and Bio impedance (BIA), there was a systematic tendency for DEXA values to be higher than those derived from skin fold-thickness measurements and BIA (Gutin 1996). Although in our study we were not comparing DEXA and BIA, we could not identify a systematic tendency in the results, either to be higher or lower compared to the skin fold measurements.

When considering the skin fold and girth techniques, there were no a significant difference in our study. This means according to our study there is not much difference either using skin fold or girth to assess body fat percentages. A study published in Journal of postgraduate medicine mentioned that the difference in body fat percentage content calculated by both methods was found to be significant in young men but not for middle aged men (Hegde 1996). The controversy between this study and ours may be due to the wide age range in our study.

Strengths and drawbacks

As a student group we were able to construct an instrument in order to get the underwater weight of the subjects. This was a supplementary objective of our study and to our knowledge none of the other university departments in Sri Lanka has such a measuring device, or do underwater weighing to measure body fat percentage. We hope there would be more studies in this area using this measuring device.

We would like to mention a few drawbacks when we were conducting the study using the hydrostatic weighing. All the subjects ideally should have been fasting for around 8 hrs prior to taking the readings, however due to practical difficulties this was not practiced. Secondly, the subjects' residual volume was obtained using a predicting equation and thus could have decreased the accuracy of this method. Also, while the underwater weight was being obtained, the subjects were informed to completely exhale all the air before submerging, but we were unable to confirm if this was truly so, and that could have altered the readings, too. Finally, since we have used the University swimming pool as our study area and not a controlled tank, the water was not an ideal set up and it might have affected the readings as well.

When measuring body fat using the skin fold method the major drawback is that one may also include muscle tissue together with the subcutaneous fat, and thus may obtain a false high value. To minimize that error, one specific member of the group was trained to take the measurements, and the measurement was done thrice.

Suggestions for further study

It is important to find out an association between the gold standard and the skin fold. For example it would be beneficial both in clinical and field set up if we could postulate a formula to obtain the actual BF% by measuring skin fold.

CONCLUSION

From our study it is clear that accuracy of skin fold or girth measurement as body fat measuring methods are poor. But when compared with girth measurements, the skin fold method for measuring body fat percentage appears to be more reliable.

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ABSTRACT

Objective

This study compares three body composition assessment techniques, namely, skin fold, girth, and hydrostatic weighing.

Methods

All measurements were taken from 60 healthy males between the ages of 18 to 60 years. Underwater weight was measured in a swimming pool and the body fat percentage (BF %) was calculated from the density. Skinfold thickness was measured at three places on the body: chest, abdomen and thigh with a Harpenden caliper, and BF% was calculated. For the girth technique, the waist and the wrist circumferences were measured with a measuring tape and the difference was used to calculate the BF%. Differences in values obtained were compared by the paired T test.

Results

Means of BF% obtained from each method are 19.48 in hydrostatic weighing, 22.58 in skin fold and 21.24 in girth. Significant differences were observed in BF% values between hydrostatic weighing versus skin fold ($p=0.003$ and mean difference = -3.10), and hydrostatic weighing versus girth measurement ($p=0.021$ and mean difference = -1.76).

Conclusion

The paired T test analysis shows that compared to hydrostatic weighing method, the other two methods are not reliable to measure an individual's BF%.

Key words: *body composition, skin fold, girth, hydrostatic weighing*