A Comparison of Skinfold Methods and Bioelectrical Impedance Analysis in Predicting Body Fat

Abstract

The present study compared predicted body fat measurements derived from Durnin & Wormersly (1974), & Jackson & Pollock (1978) prediction equations, wit h BIA. Subjects were 12 (females = 5, males = 7) Sport and Exercise Science Students, x age = 21.4 years . Body fat was calculated using the equations of Durnin & Wormersly (1974), and Jackson & Pollock (1978) and using bodystat BIA system. Body fat calculated using the Durnin & Wormersly (1974) equation was compared with BIA using a Paired T-test, as was the body fat calculated using Jackson & Pollock (1978) equation. Significant differences were found in both comparison. P was equal to 0.005 and 0.002 respectively. The study highlights the importance of body fat predictions being used as predictions, and possible errors in data collection.

Introduction

Body composition measurements are now commonly used, by physiologists, nutritionists, coaches, personal trainers and health care professionals, to monitor weight loss programs, exercise regimes, nutritional interventions and to identify health risks, such as having too little body fat and obesity. There are many accurate laboratory based techniques to attain such measurements; for example hydrodensitometry, dual-energy x-ray absorptiometry (DXA), isotope dilution, and air displacement plethysmography. (Wagner & Heyward, 1999). These techniques are often used for research work, but generally are too expensive, time consuming, and impractical for use in field evaluations, gym environments and healthcare settings (Vogel & Friedel, 1992, Swan & McConnell, 1999). A number of field techniques solve the problems, outlined above, and have the added benefits of being portable, are relatively simplistic to use and are noninvasive (Lukasaki, Bolonchuk, Hall & Siders, 1986). They do, however, have limitations of lower accuracy and validity (Vogel & Friedel, 1992). Field methods such as Skinfold (SkF) tests, bioelectrica l impedance analysis (BIA), circumference measures, and near infra-red interactance (NIR), are all doubly indirect, and are based upon regression models devised by comparing measure to criterion measurements (Williams, Going, Milliken, Hall & Lohman, 1994, Swan & McConnell, 1999). The aim of this study was to compare two methods of predicting fat from SkF thickness, the Durnin & Wormersly (D & W) (1974) equation and the Jackson & Pollock (J & W) (1978) equation, with body fat predictions from BIA.

SkF measurements indirectly measure the thickness of the subcutaneous adipose tissue, and must be taken by a trained individual; at the correct sites (Reilly, Maughan & Hardy, 1996). The ∑SkF is then entered into a prediction equation to calculate body density. The body density value may then be used in the Siri (1956) equation to predict body fat; this equation is only for white Caucasians. The prediction equations, used to predict body fat need to be population specific, in terms of gender, race, age, and activity level (Davis & Cole, 1995). SkF has been recommended for use on athletes and sports people, but often cannot be used on the obese (Clarys, Martin, Drinkwater & Marfell-Jones, 1987). This has led to over 100 population specific equations, devised using linear regression models, being formulated (Heyward &

Stolarczyk, 1996). SkF methods are based upon two basic assumptions; that there is a relationship between total body fat and subcutaneous fat, and that SkF can accurately measure subcutaneous fat (Wagner & Heyward, 1999). SkF is susceptible to many sources of error; for example SkF sites need to be exactly located, and only the subcutaneous fat measured. The callipers compress the fatty tissue, therefore if sufficient time isn't given before re-measuring then the data will be inaccurate.

BIA is a method by which a low level electrical current, of a fixed frequency, is introduced to the subject (Wagner & Heyward, 1999). The impedance (Z) of this current is then measured and, through the use of regression equations, displayed as easily understood information such as lean body weight, body fat percentage, and water content (Heyward & Stolarczyk, 1996). This is achieved due to bone and fat being a poor electrical conductor as it is anhydrous, conversely lean tissue is a good conductor as it has a high water and electrolyte content (McArdle, Katch & Katch 2001). The equation assumes that the human body is cylindrical in shape. BIA is very popular as it is quick and easy to perform, and is less obtrusive than the SkF method (Wagner & Heyward, 1999). BIA, like SkF, is open to error. It is very sensitive to hypo and hyper-hydration; hyper-hydration raises the prediction of body fat due to an increase in the impedance measure, the opposite effect is found when the subject is hypo-hydrated. A reduction in skin temperature will also increase the predicted body fat percentage.

Due to the different assumptions and prediction equations made, by each method of predicting body fat, the hypothesis are:

Ho: There is no significant difference in body fat predicted by the D & W (1974) prediction equation and BIA
Ha: There is a significant difference in body fat predicted by the D & W (1974) prediction equation and BIA

Ho: There is no significant difference in body fat predicted by the J & P (1978) prediction equation and BIA
Ha: There is a significant difference in body fat predicted by the J & P (1978) prediction equation and BIA

Method

Participants

The participants in this study consisted of 11 male and 8 female Sport & Exercise Science Students, N = 19. All subjects did not complete all of the protocols so data was manipulated. After manipulation N = 12, with 7 male subjects and 5 female. x age = 21.4 years.

Measures & Procedures

All measurements were taken in a temperate room. Stature was measured; using a standard stadiometer, to the nearest 1mm. Body mass was assessed, to the nearest 0.5 Kg, with participants wearing minimal clothing.

SkF measurements were taken from the right side of the body, with the subject standing in the anatomical position and with Harpenden skinfold callipers (British Indicators Ltd, Luton, UK). The sites were located as described in Eston & Reilly (2001). The sites measured for the D & W (1974) prediction equation were the bicep, tricep, subscapular and the iliac crest. Those taken for J & P(1978) prediction equation were the pectoral, triceps, subscapular, abdominal, axilla, suprailium and midthigh. A minimum of three measures was taken from each site to gain maximum validity. There was at least 3 minutes between each measurement to allow for compression of the adipose tissue. SkF was measured after 2 seconds of applying the callipers, and measured to the nearest 2mm.

BIA was assessed using the bodystat BIA system. The subjects had electro-conducting gel placed upon the right hand and foot proximal to the metacarpel-phalangeal and the metatarsal-phalangeal joints, electodes were then placed upon this gel. A voltage sensing electrode was then placed at the midpoint between the dital prominences of the radius and ulna of the right wrist, and between the medial and lateral malleoli of the right ankle. During the measurement the subjects were supine with their arms and legs abducted, on a non-conducting surface. The instrument gathered body fat was then recorded.

Data Analysis

Body density was calculated using the D & W(1974) prediction equation, and the Jackson and Pollock (1978) prediction equation.

The D & W(1974) equations uses the ∑4 SkF (bicep,tricep,subscapular and iliac crest). The equation for male and females are shown below:

$$\text{Male} = 1.1610 - (0.0632 \times \log \sum 4 \text{ SkF})$$

$$\text{Female} = 1.1581 - (0.072 \times \log \sum 4 \text{ SkF})$$

The J & P(1978) equations uses the ∑7 SkF (pectoral, triceps, subscapular, abdominal, axilla, suprailium and midthigh). The equation for males and females are shown below:

$$\text{Male} = 1.112 - (0.00043499 \times \sum 7 \text{ SkF}) + [0.00000055 \times (\sum 7)^2] - (0.00028826 \times \text{age})$$

$$\text{Female} = 1.097 - (0.00046971 \times \sum 7 \text{ SkF}) + [0.00000056 \times (\sum 7)^2] - (0.0001288 \times \text{age})$$

The body density data was then manipulated using the Siri equation (1956) to predict body fat. The equation is shown below:

$$\%\text{Fat} = [(4.95/\text{body density}) - 4.5] \times 100$$

A paired T-test was performed between the body fat prediction, by using the D & W (1974) equation, and body fat predicted by BIA. A paired T-test was also performed between the body fat prediction, by using the J & P(1978) equation, and body fat predicted by BIA

Results

Descriptive statistics for prediction of body fat, by skinfold tests and BIA were obtained using mini-tab, and are displayed in Table 1. See Appendix A for full results.

Table 1: Descriptive Statistics for Body fat Prediction Data

	N	x	SD
Durnin & Wormersly	12	20.1	7.22
Jackson & Pollock	12	12.1	6.55
BIA	12	16.8	5.48

The paired T-test between the body fat prediction, by using the D & W(1974) equation, and body fat predicted by BIA showed a T-value = 3.37 and a P-value of 0.005. The paired T-test between the body fat prediction, by using the J & P (1978) equation, and body fat predicted by BIA showed a T-value = -3.98 and a P-value = 0.002. See Appendix B for full analysis.

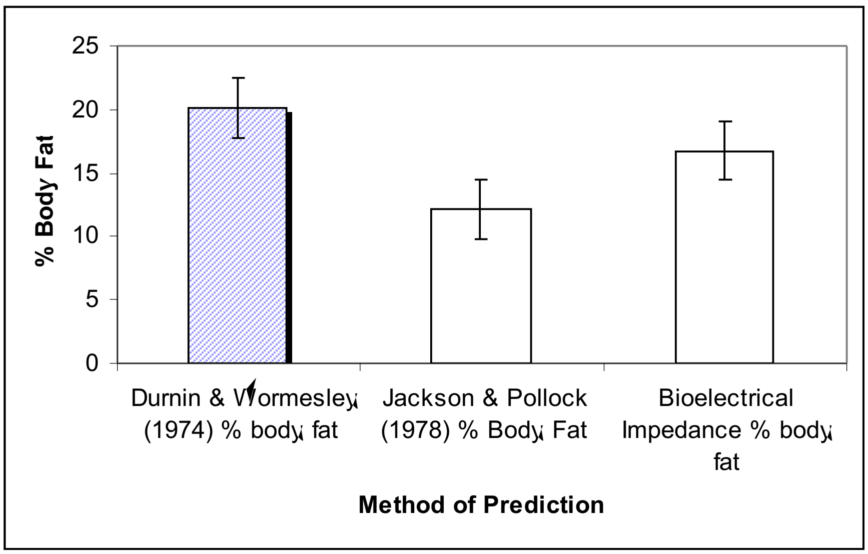

Fig 1: A Graph to Show x Scores of Three Methods of Body Fat Prediction, and the Standard Error of the Mean

Discussion

The paired T-test between the body fat prediction, by using the D & W (1974) equation, and body fat predicted by BIA showed a significant difference, that is, the D & W prediction equation over-estimates body fat when compared to BIA. The alternate (Ha) hypothesis may be accepted, and the null (Ho) rejected, due to P<0.005. This indicates that there is a >99% probability that the difference was due to systematic occurrences as opposed to error..

The paired T-test between the body fat prediction, by using the J & P (1978) equation, and body fat predicted by BIA showed a significant difference. The J & W prediction equation under-estimates body fat when compared to BIA. The alternate (Ha) hypothesis may be accepted, and the null (Ho) rejected, due to P<0.002. This indicates that there is a >99% probability that the difference was due to systematic occurrences as opposed to error.

The mean values showed that the D & W (1974) equation overestimates body fat, as predicted by BIA, by 3.3% body fat, they also show that the J & W (1978) equation underestimates body fat as predicted by BIA, by 4.7% body fat. Comparison of the mean scores of the D & W (1974) equation, and the J & W (1978) equation shows that there difference of 8% body fat.

The results are surprising and have important possible practical implications. Assuming that data was valid and there were no major errors, they show the importance of body fat predictions, by doubly indirect methods, being treated as predictions and not measurements. If body fat was calculated, before and after an intervention, by two different methods, then the effectiveness of the intervention wouldn't be shown. This may have drastic psychological effects if change in body fat was a major goal; for example if an athlete had attempted to reduce body fat, to an ideal weight, before an event and it was measured at the start of the training schedule using the J & P equation. Then after three months of training, bodyfat was measured using the D & W equation then it may appear that the athlete had maintained or even put on body fat and that the training hadn't worked. This may decrease motivation and negatively influence performance.

However, there are several errors that may have occurred during the data collection. According to Reilly et al, before BIA is taken subjects shouldn't have urinated in the previous 30 minutes, consumed food or drink in the previous 4 hours, exercised in the previous 12 hours or consumed alcohol in the previous 48 hours. Subjects were not informed of the protocol or restrictions until 30 minutes before the tests commenced. Therefore it is unlikely many, if any, of the subjects complied with these restrictions. SkF measurements were taken by different experimenters for each subject. All of the experimenters were very inexperienced and for many it was the first time taking measurements. These two factors leave the SkF measurements very open to error, especially considering that to achieve consistency in measurements an individual needs to have assessed approximately 50 people with varying body fat (McArdle, Katch & Katch, 2001).

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