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Body Composition

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TOTAL-BODY PRESSURE MAPPING FOR THE ASSESSMENT OF BODY COMPOSITION

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ABSTRACT

Mikat RP. Total-body Pressure Mapping for the Assessment of Body Composition. *JEPonline* 2007; 10(1):1-6. Several methods of assessing body composition in human beings have questionable reliability and validity. Further, some of them are difficult and/or costly to perform, and may be poorly tolerated by participants. Total-body pressure mapping (PM) is a new method used to assess body composition. This method requires that subjects lie in a supine position on a mattress-sized mat containing a matrix of pressure-sensitive transducers. Data from this mat are used to estimate fat mass (FM), fat-free mass (FFM), and percent body fat. The purpose of this study was to examine the test-retest reliability and validity of PM when compared with criterion values from Dual Energy X-ray Absorbtiometry (DEXA). Twenty seven participants (18 male and 9 female) between the ages of 19 and 24 years were evaluated with PM and DEXA for FM, FFM, and percent body fat. The test-retest intraclass reliability coefficient for PM sensor data was .979. Pearson Product-moment correlation coefficients for FM, FFM, and percent body fat between PM and DEXA were .929, .958, and .872 respectively. The PM method was quick (under 1 second per scan), reliable, valid, easily performed, and well tolerated by all participants. The results of the present study support the need for future research where intricate pressure patterns in a variety of body positions can be tested on multiple populations.

Key Words: Body Density, Obesity, Percent Body Fat, Fat Mass, Fat-free Mass.

INTRODUCTION

Accurate and reliable evaluations of body composition are useful in the assessment of health-related physical fitness. They are also useful in helping individuals track their weight management. An excess in body fat has been shown to increase the risk of developing coronary artery disease, various forms of cancer, hypertension, depression, impaired heat tolerance, hypercholesterolemia, and type II diabetes mellitus (1,2,3,4,5,6). Further, body composition contributes to performance of physical activities and sport (1,7).

Body composition systems can be divided into two primary categories: laboratory and field (8). Common laboratory techniques include Dual-energy X-ray Absorbtiometry (DEXA), underwater weighing (hydrodensitometry), total body water methods, whole-body plethysmography, and radiographic tomography. Of these, DEXA is considered the gold standard (8,9). Common field techniques include anthropometry (by skinfold and/or tape measurements), bioelectrical impedance and near-infrared reactance. Laboratory techniques are typically more valid and reliable than field techniques but are usually time-consuming, costly and may be difficult to administer and tolerate (8,11). Field techniques, while more portable, less expensive and time-consuming, often have questionable accuracy and precision and may also be difficult to administer and tolerate (8).

Total-body pressure mapping (PM) (provisional patent docket 961094.00023 [T05031US]) is a new development that may overcome the inadequacies of existing laboratory and field techniques for assessing body composition. The system requires that subjects lie in a supine position on a mattress-sized mat containing a matrix of pressure sensitive transducers. The mat, along with an analog-to-digital converter and computer, can take instantaneous measurements of pressure at all points of contact between the subject and the surface. These data are used to generate a pressure map. Theoretically, the data from the pressure map can be used to predict measurements of body composition including body density, fat mass, fat-free mass, and percent body fat.

Accurate and precise measurements of body composition are useful and important but current methods of assessment have notable limitations. Therefore, the purpose of this study was to determine the reliability and validity of PM, an alternative to conventional methods of body composition assessment.

METHODS

Subjects

A non-random sample of twenty seven apparently healthy (10) participants (18 male and 9 female) between the ages of 19 and 24 years volunteered as subjects for this study (Table 1). Because the effects of anatomical anomalies were unknown with PM, subjects were limited to volunteers with no gross anatomical abnormalities. All participants received instructions regarding personal preparation,

Table 1. Subject characteristics (mean \pm SD).

	<i>Men</i>	<i>Women</i>	<i>Total</i>
Age (Years)	21.61 \pm 1.28	20.89 \pm 0.88	21.37 \pm 1.20
Height (cm)	180 \pm 9	169 \pm 10	167 \pm 11
Mass (kg)	87.00 \pm 18.50	67.25 \pm 13.00	80.50 \pm 19.25

test procedures, benefits, and risks prior to participation. Additionally, each participant signed a written consent form that had been approved by the institutional review board for the protection of human subjects at the University of Wisconsin-La Cross and by the Wisconsin Department of Health and Human Services.

Procedures

Participants arrived at the laboratory after having voided his or her bladder and bowel. Participants were dressed in loose-fitting clothing (typically shorts and t-shirt) with no metal (buttons, zippers, etc.). Further, each subject removed all metal (including jewelry) from his/her body before testing. Body mass was measured to the nearest quarter kilogram and height to the nearest centimeter using a standard physician's scale (Health-o-meter).

After preliminary measurements, subjects received a full-body DEXA scan (Lunar® Prodigy™, Madison, WI) to obtain criterion measurements of body composition. Subjects were asked to lie in a supine position on the DEXA table with their arms at their sides and feet together. Subjects remained motionless for the duration of the scan which in most cases lasted about six minutes. Data collected from DEXA included percent body fat, fat mass, and fat-free mass (Figure 1A).

Following the DEXA scan, each subject was asked to lie in the same supine position on a pressure mat for a PM assessment (Figure 1B) (Force Sensitive Applications (FSA, model #477, Winnipeg, Manitoba, Canada). Its dimensions were 79 by 203 cm and it contained a matrix of 1024 pressure-sensitive piezo-resistive transducers. Prior to testing, the mat was calibrated to a pressure range of 0-100 mm Hg with a variation coefficient of less than 10%. Subjects received two PM assessments so that test-retest reliability could be established. Subjects got off the pad between PM assessments. The number of activated transducers in each increment of 10 mm Hg were recorded were imported to Microsoft® Excel for statistical analyses

Statistical Analyses

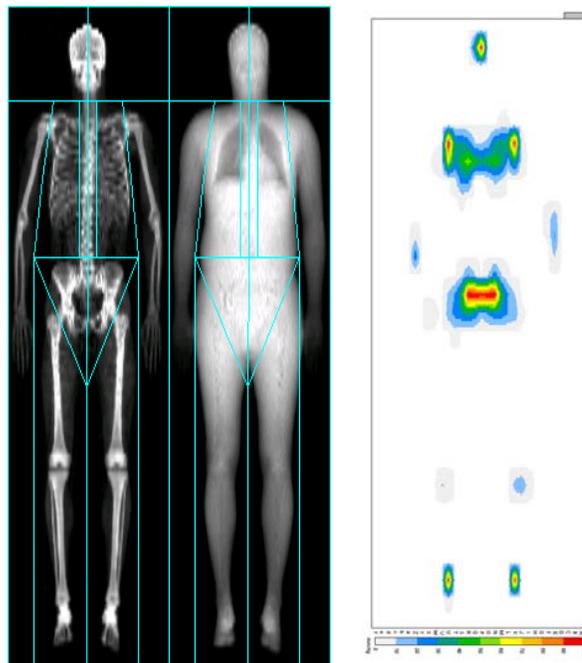
An intraclass reliability coefficient (Cronbach's alpha) was calculated to assess same-day reliability between test and retest values from PM. Following this, stepwise multiple regression analyses were performed to generate regression formulas for predicting body composition from PM. All statistical operations were performed with SPSS 12.0.

RESULTS

The test-retest intraclass alpha reliability coefficient for PM (activated transducer count within each 10 mm Hg increment) was .979. Regression formulas for predicting fat mass were as follows:

$$\text{Equation \#1 (fat mass for men): FM (g) = -12008.0 + (1761.114 * (40-50 mm Hg Range)) + (1477.572 * (70-80 mm Hg Range)) + (668.739 * (100(+) mm Hg Range))$$

$$\text{Equation \#2 (fat mass for women): FM (g) = 5163.577 + (593.901 * (1 to 10 mm Hg Range)) + (-270.813 * (10-20 mm Hg Range))$$



Figures 1A and 1B. Body images from Dual-energy X-ray Absorptiometry (left) and Total-body pressure Mapping (right).

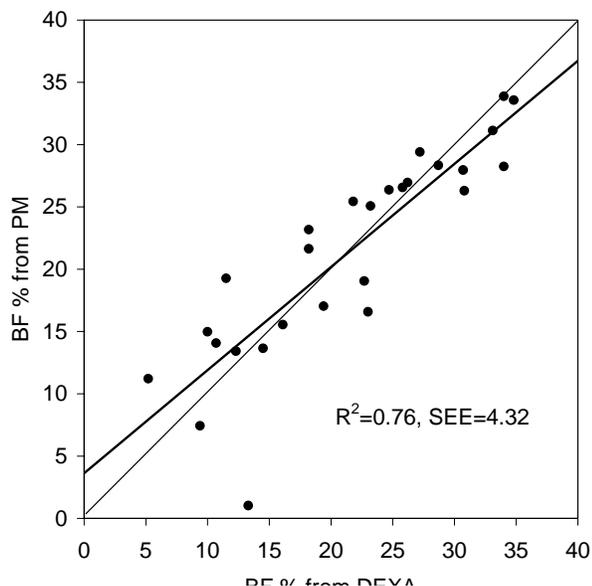


Figure 2. Body fat (BF) percentage comparisons between Dual-energy X-ray Absorbtiometry (DEXA) and Total-body Pressure Mapping (PM).

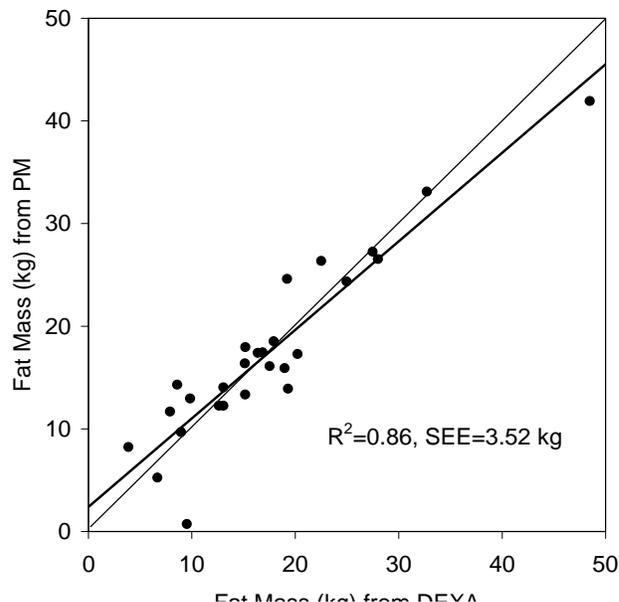


Figure 3. Fat mass (FM) comparisons between Dual-energy X-ray Absorbtiometry (DEXA) and Total-body Pressure Mapping (PM).

Fat-free mass was calculated by subtracting fat mass from total body mass. Percent body fat was calculated from the ratio of fat mass to total body mass. The Pearson Product-moment correlation coefficients between DEXA and PM were .872, .929, and .958 for percent fat, fat mass, and fat-free mass respectively (Figures 2-4). Additional values (split by gender) demonstrating the association between DEXA and PM are presented in Table 2. Bland-Altman residuals are presented in Figure 5. This plot shows no apparent trend in error differences between methods.

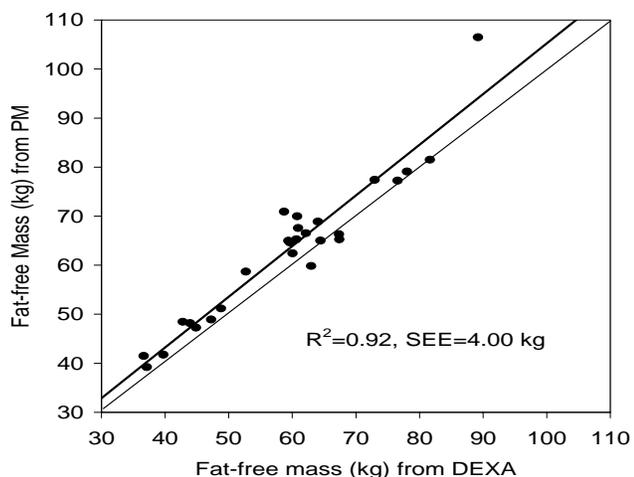


Figure 4. Fat-free mass (FFM) comparisons between Dual-energy X-ray Absorbtiometry (DEXA) and Total-body Pressure Mapping (PM).

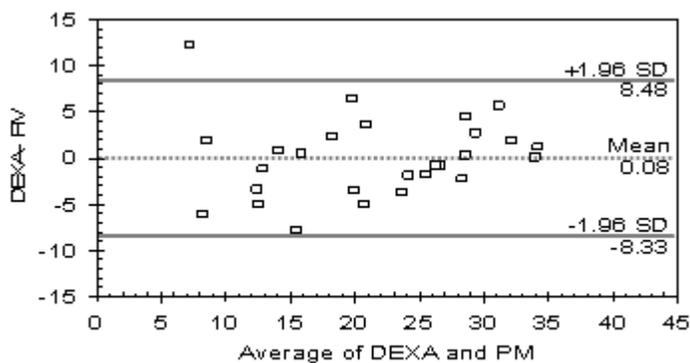


Figure 5. Bland-Altman plot of body fat percentage differences between Dual-energy X-ray Absorbtiometry (DEXA) and Total-body Pressure Mapping (PM).

Table 2. Body composition correlations between Dual-energy X-ray Absorbtiometry and Total-Body Pressure Mapping.

	<i>r</i>	<i>r</i> ²	Adj. <i>r</i> ²	SEE
FM	.929	.862	.857	3.52 kg
FM ♂	.919	.845	.812	4.59 kg
FM ♀	.973	.947	.929	1.60 kg
FFM	.958	.917	.914	4.00 kg
FFM ♂	.927	.859	.850	4.14 kg
FFM ♀	.983	.967	.962	1.48 kg
% BF	.872	.761	.752	4.32 %

DISCUSSION

The reliability of PM appeared to be excellent and sufficient for laboratory and field assessments of body composition (8). Because lung volumes were not controlled-for in the present study, it is believed that reliability will improve in future studies that do provide this form of control.

The results from the present study suggested fairly good to ideal correlations between data from PM and DEXA. Further, a monograph by Lohman (11) indicated that Standard Error of Estimate (SEE) values of 4 to 4.5% body fat were regarded as “fair” to “fairly good” relative to other laboratory and field methods. Typical SEE values of 3.4 to 4.8% are common with skinfold and bioelectrical impedance analyses of body composition (20). Air displacement plethysmography (BOD POD) typically has an SEE of about 1.8% (12,13).

Clinical Implications

The PM method for assessing body composition was found to be reliable and therefore a potential method for tracking changes in participants. The validity of PM was acceptable but not as high as some existing laboratory and field techniques (11). The PM method was quick (data collection took less than 1 second per subject), inexpensive (about 1/3 the cost of a Bod Pod system), easy to perform, and extremely well tolerated by participants. Further, PM data is collected electronically and is, therefore, not likely to be significantly effected by intertester or intratester error.

Future Research

The investigator speculates that some of the variance in this study was from subject breathing during data collection. During a one-breath cycle there were major fluctuations in upper-body data. It is recommended that future studies average the data from a one-breath cycle or use a standard lung volume (such as Functional Residual Capacity) to correct for breathing error. Standardizing breathing would likely improve both reliability and validity. Data from this study also suggest that separating the body into segments or zones and varying the bin size ranges may produce more valid results. Finally, it is recommended that future studies use larger sample sizes, cross-validation techniques, and examine data from subjects of other ages and ethnicities.

CONCLUSIONS

The PM method was quick (under 1 second per scan), easily performed and easily tolerated by participants. Also, it appeared to be highly reliable and valid when compared to DEXA. The results of this study support the need for future research.

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