JEPonline
Journal of Exercise Physiologyonline

Official Journal of The American

Society of Exercise Physiologists (ASEP)

ISSN 1097-9751
An International Electronic Journal
Volume 5 Number 3 August 2002

Body Composition

EFFECT OF LUNG-VOLUME CORRECTION ON TOTAL BODY VOLUME ASSESSMENT USING DUAL DIGITAL PHOTOGRAPH ANTHROPOMETRY

RICHARD P. MIKAT
Department of Exercise and Sport Science, University of Wisconsin-La Crosse

ABSTRACT

EFFECT OF LUNG-VOLUME CORRECTION ON TOTAL BODY VOLUME ASSESSMENT USING DUAL DIGITAL PHOTOGRAPH ANTHROPOMETRY. **Richard P. Mikat. JEPonline**. 2002;5(3):28-31. Dual digital-photograph anthropometry (DDPA) is a new development of potential value in the assessment of human total body volume (TBV), body composition and circumference measurements. Initial research with this method used lung-volume assessments [functional residual capacity (FRC)] when creating regression formulas for the prediction of TBV. The purpose of this investigation was to assess the benefit of FRC measurement inclusion in TBV regression formulas. Healthy female adults (n=18) (age 22 to 51) were evaluated for TBV by DDPA and hydrodensitometry from a single tester. FRC was measured using an oxygen dilution method. Correlation coefficients between criterion and predicted TBV values (0.99 for DDPA with and without FRC correction) were not significantly different (z=0.00, p=0.50). These results support the exclusion of lung-volume assessments from the DDPA protocol. This will substantially reduce the cost and time of testing while making the evaluations more comfortable and convenient for subjects.

Key Words: Body Composition, Obesity, Percent Body Fat, Hydrodensitometry

INTRODUCTION

Total body volume (TBV) is routinely used for anthropometric assessment, exposure studies, and evaluation of performance relative to body size/shape. Most commonly, TBV is used in conjunction with body mass for the assessment of body composition. Knowledge of body composition is meaningful in the evaluation of human performance, health and physical fitness (1). Further, persons with an excess in body fat have an increased risk for diseases such as coronary artery disease (2), cancer (4, 5), hypertension (4, 5), depression (6), and type II diabetes mellitus (3, 5).

Hydrodensitometry, or underwater weighing, is the gold standard for assessing TBV (7,8). This technique can be complex, time consuming, and expensive (9,10,11). Additionally, many participants find this method of assessment difficult to tolerate and uncomfortable (12,13). For this reason, Dual Digital Photograph

Anthropometry (DDPA) was developed. DDPA uses digital photographs and computer software to estimate body size and shape. It has been shown in previous studies to be both reliable and valid (14,15).

Past studies using DDPA have included measurements of functional residual capacity (FRC). FRC measurements were performed because it was assumed that lung volume correction would improve TBV measurements from DDPA. This assumption, however, was never tested. It was, therefore, the goal of this study to test the hypothesis that lung volume correction significantly improves the ability to predict TBV using DDPA.

METHODS

Subjects

A non-random sample of 18 adult Anglo-American women with a mean age of 37±10.1 years, a mean height of 165±8 cm, and a mean weight of 74.25±13.5 kg volunteered as participants in this study. No participant had obstructive or restrictive lung disease or gross anatomical abnormalities. All participants were instructed regarding personal preparation, test procedures, benefits, and risks prior to data collection. Further, each participant signed a written consent form that had been approved by the institutional review board of the sponsoring university. Further, this study followed the Code of Ethics of the World Medical Association (Helsinki Declaration).

Procedures

Participants arrived at the university Human Performance Research Laboratory after having fasted for a minimum of 6 hours. Each participant relieved her bladder and bowel before being tested. All participants wore form-fitting swimsuits while being tested. Dry body mass (kg) and height (cm) were assessed first using a standard physician's scale.

Residual lung volume (RV) and FRC were assessed prior to DDPA analysis by oxygen dilution (16). The average of two successive measurements of RV and FRC were used as recommended for research and clinical evaluation (16). A constant correction factor of 100 ml was used as the residual gas volume of the GI tract (17).

DDPA was assessed next with a Macintosh PowerBook™ 5300cs personal computer and a Connectix QuickCam™. All participant photographs were taken in a standardized body position (Figure 1).

After DDPA, participants were hydrostatically weighed with an analog cadaver scale (Chatillon, New York, NY). Each underwater weight was measured to the nearest gram and with the participant at full expiration. Once the participant's hydrostatic weight was known, density and TBV were calculated. Body density was calculated as follows: $Db = Ma/[((Ma - (Mw\text{-}Tare)) / Dw) - (RV + GI)]$, where *Db* is density of the body, *Ma* is the participant's dry body mass in grams, *Mw* is the participant's underwater weight in grams, *Tare* is the tare weight of the underwater platform in grams, *Dw* is the density of water, *RV* is the participant's residual lung volume in milliliters, and *GI* is the milliliters of trapped gas in the participant's gastrointestinal tract (19). The formula used to calculate TBV was $TBV = (Ma / Db)$ (7).

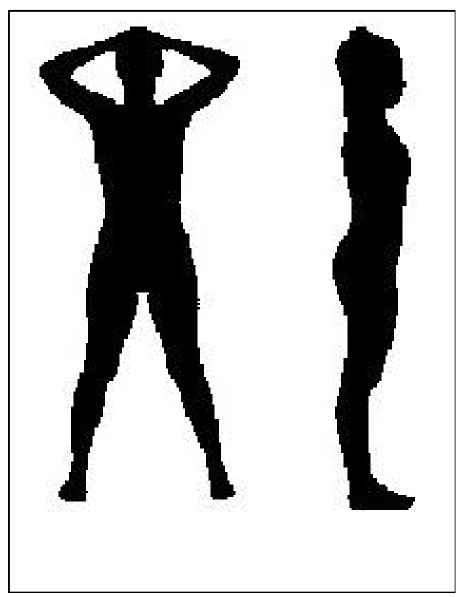

Figure 1. Sample front and side view digital photographs.

Statistical Analyses

A correlation matrix was used to examine the relationship between TBV from DDPA (with and without lung volume correction) and TBV from hydrodensitometry. All analyses were performed with SPSS 10.0. Differences in correlation coefficients were examined by z-scores (18). Alpha was set a 0.05.

RESULTS

Strong correlations existed between TBV from hydrodensitometry and DDPA with lung volume correction (r=0.99) and without lung volume correction (r=0.99) (see Table 1). No significant difference was found between these coefficients when z-scores were examined (z=0.00, p=0.50).

TABLE 1. Correlation Between Criterion and Predicted Methods.

Prediction Method	R	R^2	SEE	TE
DDPA	0.99	0.98	1.57 L	1.66 L
DDPA with FRC Correction	0.99	0.99	1.45 L	1.59 L

Scatter plots showing the relationship between hydrodensitometry and DDPA (with and without lung volume correction) are displayed as Figures 2 and 3. Visual interpretations of these plots confirm the results of z-score examination.

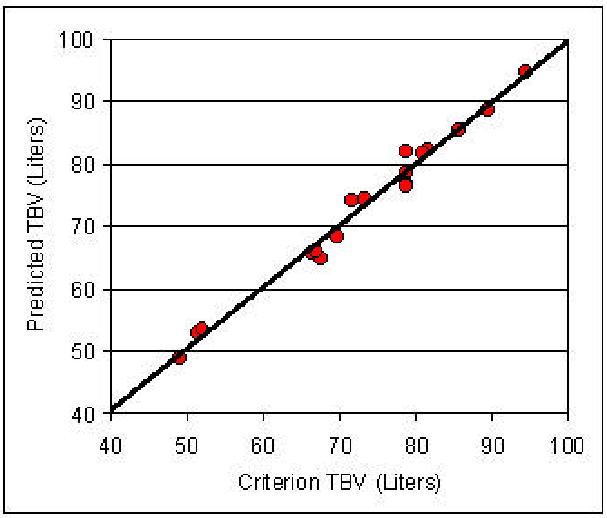

Figure 2. Correlation between TBV from criterion (hydrodensitometry) and predicted (DDPA with lung volume correction) methods.

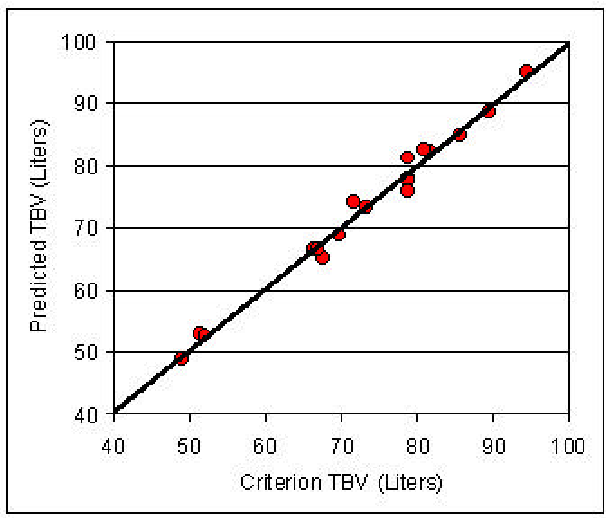

Figure 3. Correlation between TBV from criterion (hydrodensitometry) and predicted (DDPA without lung volume correction) methods.

DISCUSSION

The results of the present study were similar to those found in other examinations of the DDPA protocol (14,15). When laboratory conditions are well controlled and subjects adhere to the required protocol, DDPA closely predicts variables such as TBV. Lung volume correction had been used in all previous studies with DDPA. The results of this study demonstrate that lung-volume correction does not significantly improve the validity of DDPA for the prediction of TBV.

CONCLUSION

Lung-volume measurements (such as RV and FRC) are time-consuming, difficult to perform and tolerate, and expensive. The results of this investigation suggest that TBV can be accurately predicted by DDPA without lung-volume correction. Recommendations for future studies include the comparison of body composition by criterion and DDPA methods without FRC correction, and the examination of other populations. It is further recommended that future studies with DDPA use DEXA as a criterion method for body composition analysis.

Address for Correspondence: Richard P. Mikat, Ph.D., 129 Mitchell Hall, Department of Exercise and Sport Science, University of Wisconsin - La Crosse, La Crosse, WI 54601; Phone: (608) 785-8182; Fax: (608) 785-8172; E-Mail: mikat.rich@uwlax.edu

REFERENCES

1. Cureton KJ, Sparling PB, Evan BW, Johnson SM, Kong UD, Purvis JW. Effect of experimental alterations in excess weight on aerobic capacity and distance running performance. ***Med Sci Sports Exerc*** 1978; 10:194-9.
2. Hubert HB, Feinlab M, McNamara PM, Castelli WP. Obesity as an independent risk factor for cardiovascular disease: A 26 year follow-up of the participants in the Framingham heart study. ***Circ*** 1983; 67:968-77.
3. Kuczmarski RJ, Flegal KM, Campbell SM, Johnson CL. Increasing prevalence of overweight among U.S. adults: The National Health and Nutrition Examination Surveys, 1960 to 1991. ***JAMA*** 1994; 272:205-11.
4. Lew E, Garfinkel L. Variations in mortality by weight among 75,000 men and women. ***J Chron Disord*** 1979; 32:563.
5. Nann GV. The influence of obesity on health, I and II. ***N Engl J Med*** 1974; 291:178-85, 226-32.
6. Tucker LA. Mental health and physical fitness. ***J Hum Mov Stud*** 1987; 13:267-73.
7. Katch FI, Hortobagyi T, Denahan T. Reliability and validity of a new method for the measurement of total body volume. ***Res Q Exerc Sport*** 1989; 60:286-91.
8. Freedson P, Sady S, Katch VL, Reynolds HM, Campaigne B. Total body volume in females: Validation of a theoretical model. ***Hum Biol*** 1979; 51:499-505.
9. Jackson AS, Pollock ML. Factor analysis and multi-variate scaling of anthropometric variables for the assessment of body composition. ***Med Sci Sports Exerc*** 1976; 8:196-203.
10. Katch FI, McArdle WD. Prediction of body density from simple anthropometric measurements in college-age men and women. ***Hum Biol*** 1973; 45:293-303.
11. Sady S, Freedson P, Katch VL, Reynolds HM. Anthropometric model of total body volume for males of different sizes. ***Hum Biol*** 1978; 50:529-40.
12. Dempster P, Aitkens S. A new air displacement method for the determination of human body composition. ***Med Sci Sports Exerc*** 1994; 27:503-9.
13. Jackson AS, Pollock ML. Generalized equations for predicting body density of men. ***Br J Nutr*** 1978; 40:497-504.
14. Mikat RP. Chest, waist, and hip circumference estimations from stereo photographic digital topography. ***J Sports Med Phys Fit*** 2000; 40:58-62.
15. Mikat RP, Eisenman PA, Ellis GD, Johnson SC, Sands WA, Schultz B. Body composition and total body volume from stereo photographic digital topography. ***Clin Exerc Physiol*** 2000; 2:193-8.
16. Wilmore JH. A simplified method for the determination of residual lung volumes. ***J Appl Physiol*** 1969; 27:96-100.
17. Katch FI, Katch VL. Measurement and prediction errors in body composition assessment and the search for the perfect prediction equation. ***Res Q Exerc Sport*** 1980; 51:249-60.
18. Steel RD, Torrie JH, Dickey TA. ***Principles and practice of statistics: A biomedical approach*** New York: McGraw Hill, 1997: 297-9.