Validity of Body Volume Estimates from Infrared 3-dimensional Scanning and Dual-energy X-ray Absorptiometry as Compared to Air Displacement Plethysmography

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ABSTRACT

Traditional methods of estimating body volume (BV) such as hydrostatic weighing and air-displacement plethysmography (ADP) could theoretically be replaced using BV estimates obtained by dual-energy x-ray absorptiometry (DXA) or infrared 3-dimensional (3D) scanning devices. Multiple 3D scanning technologies have recently become popularized, including scanners that acquire data through pattern deformations caused by the projected light over the 3D object (i.e., structured light [SL] scanners) or by calculating depth from the time it takes reflected photons to reach the scanner's image sensor (i.e. time of flight [ToF] scanners). While these 3D scanning technologies currently predict body composition based primarily on circumference estimates, the BV estimates obtained by this technology could be used to predict body composition if the BV estimates are validated. **PURPOSE:** The purpose of this analysis was to examine the validity of BV estimates obtained from DXA-derived formulas and multiple types of 3D scanners as compared to ADP. **METHODS**: At a single research visit, BV estimates were obtained via ADP, prediction from DXA output, and three infrared 3D scanners in a sample of 102 adults (64 F, 38 M; age: 29.2 ± 13.4 y; BMI: 24.3 ± 3.9 kg/m²; BF%: 24.6 ± 8.3%). The 3D scanners included a SL scanner with a static configuration (SL-S) in which the scanner and participant are stationary during assessments, a SL scanner with a dynamic configuration (SL-D) in which the participant is rotated during the scan, and a ToF scanner with a dynamic configuration. ADP was designated as the criterion method, and BV estimates were compared using one-way ANOVA and post hoc testing with Bonferroni correction. Additional evaluations were conducted using the coefficient of determination (R^2), constant error (CE), total error (TE), and 95% limits of agreement (LOA). **RESULTS**: DXA-derived BV estimates were valid and produced the lowest error of all methods ($p > 0.05$; R^2: 1.00; CE: 0 – 1.4 L; TE: 0.8 – 1.5 L; LOA: 1.0 – 1.8 L). BV_{SL-D} did not differ from BV_{ADP} ($p > 0.05$; R^2: 1.00; CE: -3.9 L; TE: 4.0 L; LOA: 2.5 L), although errors were higher than the DXA-derived equations. The SL-S and ToF scanners did not produce valid estimates, although they differed in the direction and magnitude of errors. The SL-S scanner overestimated BV relative to BV_{ADP} ($p=0.01$; R^2: 0.94; CE: 7.0 L; TE: 8.0 L; LOA: 7.3 L), while the ToF scanner underestimated BV relative to BV_{ADP} ($p < 0.001$; R^2: 0.99; CE: -9.7 L; TE: 9.9 L; LOA: 4.6 L). **CONCLUSION**: The present results add to the growing research indicating that DXA-derived BV may be an acceptable replacement to traditional methods of BV assessment. Although the SL-D 3D scanner exhibited better validity of BV estimates as compared to the other scanners, improvements in the validity of BV estimates obtained from 3D scanners are necessary before this technology can be viewed as a viable alternative to traditional methods of BV assessment.