

SHORT REPORT

Interdevice Reliability of A-Mode Ultrasound to Measure Body Composition

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Abstract

A-mode ultrasound is a noninvasive, rapid method for measuring subcutaneous fat thickness and estimating body fat percentage (%BF). Validity and reliability of the BodyMetrix BX2000 A-mode ultrasound has been reported; however, this study aimed to compare results from two machines to determine interdevice reliability. Ultrasound measures were repeated with two BX2000 machines at 10 body sites (chest, biceps, triceps, scapula, lower back, hip, waist, thigh, calf, axilla) on 42 males of varying age and leanness (age: 28.6 ± 11.9 y, BMI: 25.4 ± 4.6 kg/m²). The intraclass correlation coefficients ranged from 0.939 to 0.998 with standard errors of measurement from 0.31 to 0.58 mm of fat thickness. The largest mean difference between devices was 0.37 mm at the scapula. The difference between machines in %BF was not significant (0.34%BF; $p=0.09$). The interdevice reliability is similar to the previously reported test-retest reliability with no clinical significance between machines.

Keywords: *subcutaneous adipose tissue, body fat, intermachine variability*

Introduction

Ultrasound as a diagnostic tool to measure subcutaneous fat has recently increased in popularity. This method is fast, cost-effective, portable, and easy to use. A-mode (amplitude modulation) ultrasound provides a graphical

representation of tissue thicknesses in response to reflected sound waves. Each tissue interface elicits a spike in the graph with a large amplitude recorded at the subcutaneous fat-muscle junction. One reads the depth or thickness of the subcutaneous fat layer along the x-axis (Figure 1). For

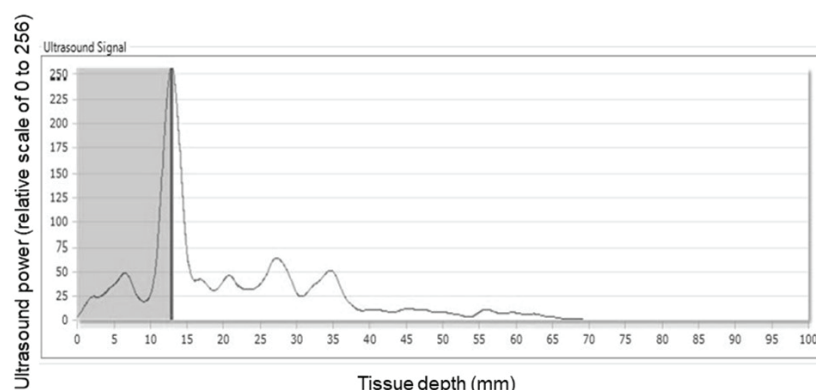


FIGURE 1. Example of A-mode ultrasound with the shaded area indicating the depth of the fat-muscle interface



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a more complete explanation of this technology, see the review by Wagner (2013).

A commercial A-mode ultrasound device commonly used for body composition assessment is the BodyMetrix BX2000 (IntelaMetrix, Inc., Livermore, CA, USA). Fat thickness measurements obtained from this device were validated against cadaver dissections (Wagner, Thompson, Anderson, & Schwartz, 2019) and high-resolution brightness modulation (B-mode) ultrasound (Wagner, Teramoto, Judd, Gordon, McPherson, & Robison, 2020). In addition to validity, test-retest, day-to-day, and interrater reliability of the BX2000 have also been evaluated (Hendrickson, Davison, Schiller, & Willey, 2019; Loenneke et al., 2014; Miclos-Balica et al., 2021; Smith-Ryan, Fultz, Melvin, Wingfield, & Woessner, 2014; Wagner, Cain, & Clark, 2016; Wagner & Teramoto, 2020). Test-retest reliability for the estimate of body fat percentage (%BF) obtained from the BX2000 was reported to be excellent with a ICCs of 0.979 (Miclos-Balica et al., 2021) to 0.996 (Wagner et al., 2016). Similarly, the day-to-day reliability was nearly as good with ICCs ranging from 0.935 to 0.980 (Loenneke et al., 2014; Smith-Ryan et al., 2014). Additionally, the interrater reliability was excellent (ICC=0.972 to 0.987) for both experienced technicians (Miclos-Balica et al., 2021; Wagner et al., 2016) and novice examiners (ICC=0.969 to 0.990) (Wagner & Teramoto, 2020).

Despite excellent ratings for test-retest, day-to-day, and interrater reliability, the interdevice reliability is unknown. Interdevice or intermachine reliability, although rarely evaluated, serves to further demonstrate that a measurement device is acceptable for intersite and multicenter body composition testing. The purpose of this study was to evaluate the interdevice reliability of A-mode ultrasound by comparing site-specific subcutaneous fat thicknesses and %BF estimates from two BodyMetrix BX2000 machines.

Methods

Participants

This study included 42 male participants, ranging from 18 to 57 years of age and varying in body type (16 elite, 18 athletic, and 8 non-athletic). The BodyView Professional software that accompanies the BodyMetrix BX2000 defines these body types as; elite being those with low body fat and good muscle definition, including “six-pack” abdominal muscles; non-athletic being clearly overweight or obese; and the athletic category includes everyone else. Inclusion of the body type classification aids the software in selecting which A-mode peak corresponds to the fat-muscle interface.

The university's Institutional Review Board approved the study (protocol #9696). Upon arrival on testing day, participants signed a written informed consent before participating.

Procedures

Participants emptied their bladders before testing began. We measured height and weight to the nearest 0.1 cm and 0.1 kg, respectively. Height was measured with a wall-mounted stadiometer (Seca 216, Seca Corp., Ontario, CA), and weight was measured with a digital scale (Seca 869, Seca Corp., Ontario, CA). Participants wore only compression shorts for all measurements. In addition to height

and weight, we entered age and body type, as defined above, into the BodyView Professional software.

Each participant had ten measurement sites (chest, scapula, axilla, triceps, waist, hip, thigh, lower back, biceps, and medial calf) marked with a surgical marker to facilitate accurate placement of the ultrasound transducer head for both devices. Site-point ultrasound measurements were taken with the participant standing, according to the manufacturer's instructions as detailed by Wagner (2013). Participants were measured at all 10 sites with device 1, and then measurements were repeated with device 2. The BodyView Professional software requires multiple measurements at each site to obtain a site-specific fat thickness; thus, 3-5 measurements per site produced an averaged site-specific measurement for each device. The same technician took all measurements with both devices.

Statistical Analyses

Data were analyzed using SPSS version 25.0 (IBM, Inc., Chicago, IL, USA). We calculated means and standard deviations for all variables. The BodyView software uses a proprietary formula to convert the ultrasound fat thicknesses into a %BF estimation using the measurement sites of common skinfold prediction equations. The BodyMetrix conversion of the 7-site Jackson and Pollock (1978) equation was used to estimate %BF. A paired t-test was done to determine if there was a significant difference between the two devices for the estimate of %BF. We assessed interdevice reliability for each of the 10 measurement sites with a single measures intraclass correlation coefficient (ICC) with absolute agreement. Additionally, standard error of measurement (SEM) was calculated [$SEM = SD \times \sqrt{(1-ICC)}$]. The standard deviation used for SEM calculation was the combined standard deviations of the two ultrasound devices. Subsequently, minimal difference (MD) was calculated as $MD = SEM \times 1.96 \times \sqrt{2}$. The ICC, SEM, and MD are the recommended statistics for quantifying reliability (Weir, 2005).

Results

The sample varied in age (28.6 ± 11.9 y), height (182.4 ± 7.6 cm), weight (84.5 ± 16.9 kg), and body mass index (25.4 ± 4.6 kg/m²). During preliminary screening, one participant was determined to be a statistical outlier (>3 SD) for the chest, hip, and axilla measurements. Consequently, this participant was removed from the site-specific analyses for these three sites and the %BF estimation. See Table 1 for interdevice reliability results. The ICCs were excellent for all 10 sites, ranging from 0.939 to 0.998. Additionally, the SEM were small, ranging from 0.31 mm to 0.58 mm, with MD ranging from 0.86 mm to 1.61 mm. Further, mean differences were <0.4 mm at each site and were smaller than the SEM at each site. The difference in %BF between ultrasound 1 and ultrasound 2 was only $0.34 \pm 1.24\%$ BF and not statistically significant; $t(40) = 1.76$, $p = 0.09$.

Discussion

This research represents the first interdevice reliability study of the BodyMetrix BX2000 A-mode ultrasound. The high ICCs and low SEMs at each measurement site indicate excellent agreement between the two machines. Furthermore, the ICCs for interdevice reliability were sim-

Table 1. Interdevice Reliability Results Between Two BodyMetrix BX2000 A-Mode Ultrasound Machines

Measurement site	ICC (95% CI)	SEM (mm)	MD (mm)	Mean difference (mm)
Chest	0.982 (0.927-0.993)	0.40	1.11	0.33
Triceps	0.986 (0.970-0.993)	0.35	0.97	0.20
Biceps	0.939 (0.889-0.966)	0.56	1.55	0.14
Scapula	0.980 (0.936-0.992)	0.47	1.30	0.37
Back	0.998 (0.996-0.999)	0.31	0.86	0.09
Hip	0.991 (0.983-0.995)	0.33	0.91	0.05
Waist	0.998 (0.996-0.999)	0.52	1.44	0.26
Thigh	0.985 (0.971-0.992)	0.35	0.97	0.17
Calf	0.984 (0.970-0.991)	0.34	0.94	0.06
Axilla	0.971 (0.941-0.985)	0.58	1.61	0.30

Legend: ICC - intraclass correlation coefficient; SEM - standard error of measurement; MD - minimal difference

ilar to ICCs reported for intra- and interrater reliability (Hendrickson et al., 2019; Loenneke et al., 2014; Miclos-Balica et al., 2021; Smith-Ryan et al., 2014; Wagner et al., 2016; Wagner & Teramoto, 2020). The mean differences in fat thicknesses between devices at each measurement site were small (<0.4 mm) and less than the SEM, with no statistical or clinically meaningful difference in the estimate of %BF (0.34%). For comparison, Miclos-Balica et al. (2021) recently reported a similar mean difference of 0.50% BF for intertester reliability.

The one statistical outlier in the study happened to be the subject with the largest %BF. In a study of A-mode ultrasound to measure body composition of obese and overweight individuals, Smith-Ryan et al. (2014) reported excellent day-to-day reliability, suggesting that the reliability of the machine was not influenced by high %BF. One limitation of the current study was that only 19% of our sample were in the “non-athlete” BodyMetrix body type classification. More research may be needed on obese individuals to determine if the outlier identified in this study is an aberration or if obese individuals are subject to machine or technician error.

Both devices used were BodyMetrix BX2000 A-mode ultrasound machines. These devices were the same model from the same manufacturer, yet one machine was several years older. Despite the age difference between the devices, the interdevice reliability was excellent, suggesting that results from older devices are still comparable to newer machines.

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There are no acknowledgements.

Conflict of Interest

The authors declare that there is no conflict of interest.

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