Precision of Lunar iDXA Total Body BMD and Composition Measurements on Obese Subjects

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Introduction

Dual-energy X-ray absorptiometry (DXA), the method of choice for measuring bone mineral density, is increasingly accepted as an accurate and convenient method for measuring regional and total body composition. The ongoing worldwide epidemic of obesity has heightened interest in body composition and its association with diseases related to obesity, particularly cardiovascular disease and type-2 diabetes. The ability to monitor change in body composition in an individual depends on the precision error of the measurement. Few studies have reported precision errors in obese subjects.

Methods

This study was approved by the Cedars Sinai Medical Center IRB. We used a Lunar iDXA (GE Healthcare) densitometer to determine total body precision in 29 obese participants (15 females and 14 males) in a weight loss and exercise program. The iDXA system offers a large patient portal (45 cm) and can measure subjects weighing up to 205 kg.

Each subject was measured twice with repositioning between scans at the beginning of the weight-loss program. Subjects were measured with the thick scan mode, as recommended by the iDXA program. Precision was determined using the root-mean squared (RMS) method. Because there were differences in hand position (some flat on the table and some not) between scans, hands were excluded from analysis. There were also some inconsistencies regarding foot positioning for some subjects. Subjects whose supine body width exceeded the dimensions of the scan window were measured using the iDXA MirrorImage™ application (Figure 1), which automatically calculates total body results by doubling the half-body values. Previous studies have shown that this method provides an accurate estimate of total body results [1,2].

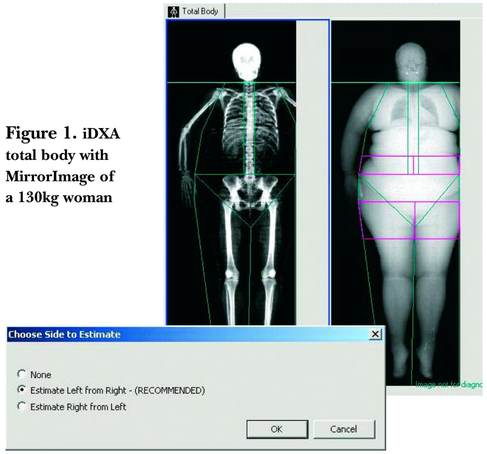


Figure 1. iDXA total body with MirrorImage of a 130kg woman

Results

Average age, height, weight, BMI, and total body %fat for males and females are shown in Table 1. Results show that all subjects were obese according to WHO criteria (BMI > 30 kg/m²) [3]. BMI values ranged from 36.2 to 43.5 in women and 41.6 to 54.4 in men. Total body %fat ranged from 42.9% to 52.6% in women and 37.7% to 49.5% for men. As expected, average bone mineral density (BMD) for these heavy subjects (female, 1.310 g/cm²; male 1.491 g/cm²) was higher than BMD expected for similar-aged adults of average body weight (female, 1.125 g/cm²; male 1.220 g/cm²), confirming the known positive association of BMD with body weight [4,5].

Precision errors (%CV) were surprisingly small, given the size and thickness of these very obese subjects. Precision errors with the iDXA were about 1% for total body BMD and bone mineral content (BMC), 1.2% for total body fat mass, 0.95% for total body lean mass, and 0.8% for total body %fat (Table 2).

Table 1. Subject characteristics: mean (SD)

Gender	n	Age (yr) [range]	Height (cm) [range]	Weight (kg) [range]	BMI [range]	Total %Fat [range]
Female	15	31.8 (7.6) [22.1 – 53.9]	164.8 (4.3) [157.5 – 175.3]	109.9 (9.0) [95.7 – 129.9]	40.5 (3.0) [36.2 – 43.5]	49.3% (3.4%) [42.9 – 53.6]
Male	14	35.1 (7.3) [25.4 – 52.4]	182.8 (6.8) [172.8 – 193.8]	157.3 (19.3) [132.6 – 184.7]	47.0 (4.1) [41.6 – 54.4]	44.0% (4.1%) [37.7 – 49.5]
Combined	29	33.4 (7.5) [22.1 – 53.9]	173.5 (10.6) [157.5 – 193.8]	132.8 (28.2) [95.7 – 184.7]	43.6 (4.8) [36.2 – 54.4]	46.7% (4.6%) [37.7 – 53.6]

Table 2. Mean values and precision error for BMD and body composition

Measurement	Mean	RMS - SD	RMS - %CV
BMD (g/cm2)	1.394	0.015	1.08%
BMC (g)	3347.7	33.59	1.00%
Fat Mass (kg)	59.9	0.73	1.22%
Lean Mass (kg)	66.3	0.63	0.95%
%Fat (Tissue)*	47.9	0.38%	0.78%
% Fat (Region)**	46.7	0.36%	0.78%

* %Fat (Tissue) = fat/(fat + lean); ** %Fat (Region)= fat/(fat +lean + BMC)

Figures 2-6 show the individual precision values for the 29 subjects in the study. The weight (kg) of each subject is indicated. The red line indicates the average precision for the group. The scan images of several subjects indicated movement during the scan, and two subjects displayed an artifact, (unremovable body jewelry.) Positioning inconsistencies resulted in higher than expected variability for one subject. There were no significant correlations between subject weight and precision error for BMD, BMC, fat mass, lean mass or %fat.

Figure 2. Total body BMC precision for 29 subjects (average precision indicated by red line)

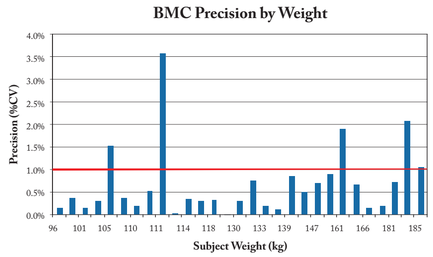


Figure 3. Total body BMD precision for 29 subjects (average precision indicated by red line)

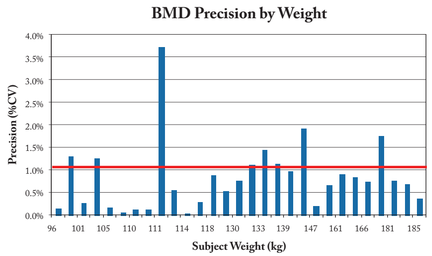


Figure 4. Total body fat mass precision for 29 subjects (average precision indicated by red line)

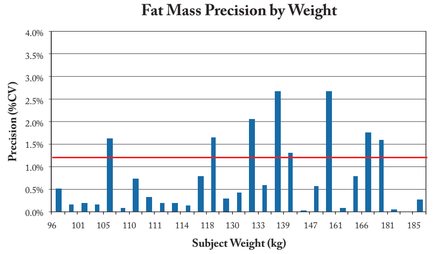


Figure 5. Total body lean mass precision for 29 subjects (average precision indicated by red line)

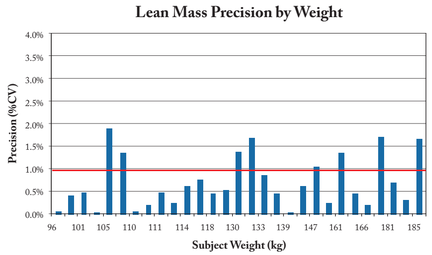
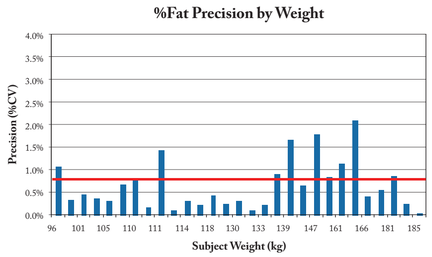


Figure 6. Total body %fat precision for 29 subjects (average precision indicated by red line)



Discussion

Previously, improved total body precision with the iDXA compared to the Lunar Prodigy (GE Healthcare) has been demonstrated in average subjects (mean BMI 25) [6, 7]. This is one of the first studies to evaluate iDXA total body precision in highly obese subjects (mean BMI 44). We found precision errors with the iDXA were small, despite several challenges that occur when scanning very obese subjects. One challenge occurs when the subject's supine body width is too large to fit within the scan window of the densitometer. Previous studies have shown there is nearly perfect symmetry in total body values between the right and left halves of the body [1,2]. Therefore, if subjects are positioned so that at least one half of the body lies within the scan window, the iDXA MirrorImage software finds the body's central axis and accurately calculates results for the total body.

Another potential challenge in measuring obese subjects involves patient thickness. Precision error typically increases with subject thickness due to decreased x-ray penetration and image quality, a challenge that is addressed by increased resolution of the detector and higher x-ray flux with the iDXA [7,8]. Within this obese group, there were no significant correlations between subject weight and precision error for BMD, BMC, fat mass, lean mass or %fat. Finally, there were some inconsistencies in scanning procedure regarding patient positioning that may have led to a small degradation of precision results. Despite these challenges, precision was remarkably good, about 1% for total body BMD, BMC, and lean mass, 0.8% for total body %fat, and 1.2% for total body fat mass.

Conclusion

Lower precision error improves confidence in clinical decision-making and minimizes the time necessary to detect a significant change in an individual. We conclude that iDXA precision was excellent, despite the known challenges of scanning very obese subjects. With the increasing incidence of obesity in society, the higher table weight limit and wider patient portal on the iDXA system combined with excellent precision make this system a valuable tool in the measurement of body composition in larger individuals.

References:

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