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Original Article

Cross-calibration of a GE iDXA and Prodigy for Total and Regional Body Bone Parameters: The Importance of Using Cross-calibration Equations for Longitudinal Monitoring After a System Upgrade

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Abstract

We aimed to determine if cross-calibration equations could be applied to convert GE Lunar Prodigy total and regional bone measurements to the GE iDXA model to support longitudinal monitoring of subjects. The cross-calibration group comprised 63 adults (age 45.1 [12.8] yr; body mass index: 25.6 [3.7] kg/m^2) and the validation group comprised 25 adults (age 40.5 [11.5] yr; body mass index: 25.7 [3.5] kg/m^2). The parameters reported were total and regional bone mineral density (BMD), bone mineral content, and bone area. There were significant differences between densitometers for all anatomical regions and reported bone parameters ($p < 0.0001$); iDXA reported lower BMD than the Prodigy apart from the ribs. Linear regression indicated good agreement for all measurements. Bland-Altman analyses indicated significant bias for all measurements and that cross-calibration equations were required. The derived cross-calibration equations were effective in reducing differences between predicted and measured results for each parameter and at each region apart from leg BMD, where the difference remained significant (0.013 g/cm^2; $p < 0.05$). Our results indicate that cross-calibration is important to maintain comparability of total body-derived regional bone measurements between the Lunar Prodigy and iDXA.

Key Words: Cross-calibration; iDXA; prodigy; regional total body.

Introduction

Dual-energy X-ray absorptiometry (DXA) densitometers are increasingly being used to perform total body and total body-derived regional measurements of bone in research and in certain fields of clinical practice. The bone parameters bone mineral density (BMD), bone mineral content (BMC), and bone area (BA) can be determined for the total body and regions, head, arms, legs, and trunk. The trunk can be subdivided into 3 regions: spine, pelvis, and ribs.

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The value of total body DXA bone measurements has been widely demonstrated both in sports science and medicine *(1)* and in clinical research *(2)*. Investigations are often longitudinal, for example, in assessing the effects of exercise on bone *(3,4)*, associations with age *(5)*, and to measure regional bone mineral accretion during childhood *(6)*. Such longitudinal investigations can be affected when replacing densitometers or conducting multicenter studies, and appropriate steps should be taken to ensure accurate continuation. As consistent and accurate measurement of DXA-derived BMD over time and during times of equipment upgrade is of high importance during longitudinal monitoring, it is recommended by the International Society of Clinical Densitometry that in vivo cross-calibration is performed *(7)*.

There are a limited number of articles that have investigated the necessity for cross-calibration regionally or for the total body, and of those, only 2 studies (8,9) have used iDXA and Prodigy densitometers; these studies did not report regional bone analysis. Hull et al (8) reported BMC in addition to body composition data concluding that there was high agreement between all DXA systems, however, stating that cross-calibration equations should be used to avoid erroneous results. Krueger et al (9) reported initial investigations into the comparison of total body for all bone parameters stating excellent agreement between the GE Lunar Prodigy and iDXA.

The GE Lunar (GE Healthcare, Madison, WI) range of DXA densitometers are used globally both clinically and for research; the GE Lunar iDXA is the most recent model, advancing on the older Prodigy model. The iDXA uses a higher output X-ray tube than the Prodigy, an identical narrow angle (4.5°) fan beam with 64 high-definition cadmium zinc telluride detectors and a staggered element array. This improves the image resolution by reducing the dead space between the detectors, giving a near radiographic image and improved spatial resolution, pixel sizes iDXA = 2.40 × 3.04 mm compared with Prodigy = 4.80 × 13.0 mm, but with a higher radiation dose (10).

The aim of this study was to determine if cross-calibration was required between 2 fan beam densitometers from the same manufacturer, the GE Lunar iDXA and the GE Lunar Prodigy in the total body, and if so derive calibration equations for total body and 3 regional sites: arms, legs, and pelvis. These sites are commonly monitored for the effect of exercise and weight bearing on bone parameters. The predictive equations were then applied to a validation group of subjects to compare iDXA-measured values with iDXA-predicted values.

Materials and Methods

Subjects

Eighty-eight healthy adults were recruited via an intrauniversity e-mail invitation, and participants were excluded from the study if they had received a DXA scan within the previous 12 mo, were pregnant, or breast feeding. They were subdivided into a cross-calibration group (n = 63) and a validation group (n = 25). Participant descriptive results are provided in Table 1, and in accordance with International Society of Clinical Densitometry recommendations (7), these groups are representative of those normally scanned at the iDXA facility. Ethical approval for the study was provided by the University Ethics Committee, and informed signed consent was attained before scans from all volunteers. All activities performed in this study were in accordance with The Declaration of Helsinki.

The DXA

For all measurements, participants wore light clothing with all metal and plastic artifacts removed. Height was measured on a stadiometer and recorded to the nearest millimeter, and body mass was measured on calibrated electronic scales to the nearest gram (both SECA, Birmingham, UK).

Each participant received 1 total body scan on the iDXA (Carnegie Research Institute, Leeds Metropolitan University, Leeds, UK) and the Prodigy (Bone Unit, University of Leeds) within 24 hours. The participant was positioned centrally on the scanning bed within the transverse scan width of the densitometer, with the legs supported with a velcro strap. On the scanning bed, maximum separation between the arms and trunk was set, and the palm of the hand placed flat on the bed. This ensured that all scan images were within the scan fields of the densitometers and accurate adjustment of the regions of interest could be made.

Scans were analyzed and adjustment of cuts that define individual regions were made using GE EnCore software version 12.5 (Prodigy) and 13.5 (iDXA). The arms and trunk were separated by lines through the glenohumeral joints and the trunk and legs by lines obliquely through the hip joint at 45° to the sagittal plane of the body image. The head was excluded from the trunk region by a transverse line below the mandible. The trunk includes the thorax, abdomen, pelvis, and a portion of the medial thigh. For consistency, manual regional analysis of each scan was performed by the same experienced densitometrist.

Precision and the least significant change (LSC), derived for the iDXA (11) used in this study are provided in Table 2. The LSC is the smallest change in the parameter that can be considered to be a statistically significant and not a change because of the use of different densitometers. LSC is derived from the precision of the parameter and to be confident at the 95% level = $2\sqrt{2}$ precision.

Table 1
Physical Characteristics of the Cross-calibration and Validation Groups

	Cross-calibration, n = 63 (43 female/20 male)		Validation, n = 25 (14 female/11 male)	
Demographics	Mean (SD)	Range	Mean (SD)	Range
Age (yr)	45.1 (12.8)	21.0−63.3	40.5 (11.5)	20.1−59.7
Height (cm)	169.2 (9.6)	151.5−188.0	169.5 (7.9)	154.0−183.0
Weight (kg)	73.2 (13.0)	43.8−109.8	74.0 (11.7)	58.9−101.6
Body mass index (kg/m^2)	25.6 (3.7)	17.0−36.0	25.7 (3.5)	22.1−33.1