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**Original Article**

# BMD Measurement and Precision: A Comparison of GE Lunar Prodigy and iDXA Densitometers

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## Abstract

This study assessed bone mineral density (BMD) comparability and precision using Lunar Prodigy and iDXA densitometers (GE Healthcare, Madison, WI) in adults. Additionally, the utility of supine forearm measurement with iDXA was investigated.

Lumbar spine and bilateral proximal femur measurements were obtained in routine clinical manner in 345 volunteers, 202 women and 143 men of mean age 52.5 (range: 20.1–91.6) yr. Seated and supine distal forearm scans were obtained in a subset (n = 50). Lumbar spine and proximal femur precision assessments were performed on each instrument following International Society for Clinical Densitometry recommendations in 30 postmenopausal women.

BMD at the L1–L4 spine, total proximal femur, and femoral neck was very highly correlated ($r^2 \geq 0.98$) between densitometers, as was the one-third radius site ($r^2 = 0.96$). Bland-Altman analyses demonstrated no clinically significant bias at all evaluated sites. BMD precision was similar between instruments at the L1–L4 spine, mean total proximal femur, and femoral neck. Finally, one-third radius BMD measurements in the supine vs seated position on the iDXA were highly correlated ($r^2 = 0.96$). In conclusion, there is excellent BMD correlation between iDXA and Prodigy densitometers. Similarly, BMD precision is comparable with these two instruments.

**Key Words:** Bone densitometry; iDXA; osteoporosis; precision; prodigy.

## Introduction

Dual-energy X-ray absorptiometry (DXA) is the current gold standard for the clinical diagnosis of osteoporosis based on measurement of bone mineral density (BMD) *(1)*. As DXA technology continues to evolve, new instruments and technology are introduced, making it necessary to document how these advances compare to prior densitometers *(2)*. GE Healthcare has recently developed the Lunar intelligent DXA (iDXA), a fan-beam densitometer that uses slightly higher amounts of radiation and enhanced detector capabilities, the latter yielding improved spatial resolution *(3,4)*.

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Prior comparison of lumbar spine and proximal femur BMD has demonstrated good agreement between iDXA and Prodigy *(3–6)*. Similar BMD precision for iDXA and Prodigy has been reported in abstract form by the manufacturer *(6)* but not independently validated. As such, this study compared BMD at routine clinical sites, the L1–L4 lumbar spine, proximal femur, and distal forearm, obtained using a Lunar Prodigy and Lunar iDXA densitometer. Additionally, a precision assessment was performed at the lumbar spine and proximal femur with both instruments, and forearm BMD measurement in the supine vs seated position using iDXA was compared.

## Methods

### *Study Participants*

Volunteers (n = 345, 143 men and 202 women) aged 20 yr and older consented to participate in this study, which was approved by the University of Wisconsin Health Sciences

Human Subjects Committee. From this group, 30 women aged 60 yr and older also participated in a precision assessment. A separate subset of 50 volunteers (24 women and 26 men) also had right distal forearm measurements on both instruments. The latter group had forearm scans obtained while sitting and supine on the iDXA. Demographic data for all groups are provided in Table 1. Subjects with surgical hardware or other anatomical abnormalities precluding adequate acquisition for diagnostic interpretation were excluded from this study.

### DXA Acquisition

All participants were scanned on a GE Healthcare Lunar Prodigy and iDXA in routine clinical manner per manufacturer recommendations *(7)*. Lumbar spine (L1−L4) and bilateral proximal femoral scans were obtained in 345 volunteers. Right forearm scans were obtained with subjects sitting in a chair next to each instrument. The right forearm was imaged, rather than the nondominant, as at the time of data collection, supine positioning with iDXA was available only for the right forearm. To potentially enhance patient comfort, increase throughput, and offer technologists an alternative for better forearm positioning, iDXA allows this scan to be performed with a patient lying supine on the table. These iDXA supine forearm measurements were compared with those obtained when sitting. For the Prodigy, Encore software GE Healthcare, Madison, WI) version 9.2 was used for acquisition and 11.4 for analysis; with iDXA, Encore software version 9.3 was used to acquire scans with version 11.0 used for analyses.

The precision assessments were performed in routine clinical manner according to International Society for Clinical Densitometry (ISCD) recommendations *(1)*. Specifically, a cohort of 30 women aged 60 and older (described in Table 1) had lumbar spine and proximal femur scans obtained twice on both instruments; they stood up from the table between each set of scans. All precision scans were obtained at the same study visit and were performed by the same ISCD-certified technologist (MC).

### Statistical Analyses

Bone mineral content, area, and BMD from Prodigy and iDXA were compared using Deming regression assuming equal error variance and Bland-Altman analyses (Analyse-it, Leeds, UK). Two-tailed paired *t*-tests of mean differences were calculated with Minitab (State College, PA). The precision (percent coefficient of variation and least significant change with 95% confidence interval; 2-sided testing) was calculated using the ISCD precision calculator (www.iscd.org). Comparison of precision by instrument was determined by calculating each sample variance; group difference was then determined using the *F*-test (Microsoft Excel, Redmond, WA).

## Results

### Bone Mineral Density

There was excellent agreement of BMD measurements at the lumbar spine and proximal femur between the two densitometers. Specifically, at all measured sites, BMD was highly correlated, $r^2 \geq 0.98$. Additionally, the BMD mean bias was $\leq$0.007 g/cm$^2$ at all skeletal sites (Fig. 1 and Table 2). Statistically significant mean differences were observed at the lumbar spine ($p < 0.05$) and femoral neck ($p < 0.001$). Of note, although statistically significant, these differences are likely of no clinical consequence as the numerically greatest mean BMD difference (observed at the femoral neck) was only 0.007 g/cm$^2$. Similar to the spine and proximal femur comparisons, one-third radius BMD correlation between densitometers was very good, with an $r^2 = 0.96$. Mean one-third radius BMD bias was −0.021 g/cm$^2$. Finally, in this study, one-third radius BMD obtained supine or sitting demonstrated good correlation, $r^2 = 0.96$ with a mean bias of 0.007 g/cm$^2$ (Fig. 2, Table 1). Finally, the possibility that BMD comparability might differ between males and females was explored by performing ordinary linear regression with dummy variables for male slope and intercept differences. There were statistically significant differences in intercept and slope only at the left total femur. The estimated male BMD difference was small, from +0.009 to −0.013 g/cm$^2$ through the entire range.

### Precision

No clinically relevant differences in BMD precision were observed at the L1−L4 spine or proximal femur sites (Table 3).

**Table 1**
Subject Demographics

| | Main study sample (n = 345) | Precision cohort (n = 30) | Radius cohort (n = 50) |
|---|---|---|---|
| Age (yr) | 52.6 ± 18.5 (20.1−91.6) | 69.6 ± 4.9 (61.8−78.9) | 51.7 ± 17.0 (22.5−87.5) |
| Body mass index (kg/m$^2$) | 26.5 ± 5.5 (17.4−48.8) | 26.1 ± 4.6 (18.1−33.4) | 26.1 ± 5.7 (18.7−41.8) |
| L1−L4 BMD (g/cm$^2$) | 1.201 ± 0.195 (0.658−2.066) | 1.116 ± 0.130 (0.816−1.388) | 1.171 ± 0.167 (0.722−1.564) |
| Left total femur BMD (g/cm$^2$) | 1.012 ± 0.175 (0.592−1.603) | 0.856 ± 0.103 (0.658−1.128) | 0.977 ± 0.158 (0.619−1.322) |
| Left femoral neck BMD (g/cm$^2$) | 0.970 ± 0.182 (0.588−1.631) | 0.818 ± 0.103 (0.610−1.012) | 0.936 ± 0.179 (0.588−1.381) |
| One-third radius BMD (g/cm$^2$) | N/A | N/A | 0.903 ± 0.127 (0.538−1.170) |

Data reported as mean ± standard deviation and (range); proximal femur = total femur and femoral neck.
*Note:* iDXA BMD data reported.
*Abbr:* BMD, bone mineral density; N/A, not applicable.