# Reference Data for Lunar iDXA for the Assessment of Bone Health in Indian Children and Youth- A Cross-Sectional Study


## ABSTRACT

**Objective:** Dual energy x-ray absorptiometry (DXA) is the commonest bone densitometry technique in children. As no pediatric reference database for Indian children using a narrow fan beam densitometer is available, the aim of the study was to provide sex- and age-specific reference percentile curves for the assessment of bone health using the Lunar iDXA in 1–19-year-old Indian children.

**Methods:** A cross-sectional study was carried out between November 2017 and July 2022 involving 1247 (607 girls) healthy children from Pune, India. The bone mineral content [BMC (g)], bone area [BA ($cm^2$)], and bone mineral density [BMD ($g/cm^2$)] were measured using the GE-Lunar iDXA narrow-angle fan beam scanner. Reference percentile curves were generated for total body BMC (TBBMC), total body BA (TBBA), lumbar spine bone mineral apparent density [BMAD ($g/cm^3$)], and left femoral neck BMAD. Additionally, we provided percentile curves for TBBA relative to height, TBBMC relative to TBBA, lean body mass (LBM) relative to height, and TBBMC relative to LBM.

**Results:** Mean (SD) bone parameters were expressed by age groups for boys and girls separately. The average age-related increase in TBBMD, lumbar spine BMD, and femoral neck BMD was 6.3%, 7.2%, and 4.5%, respectively, across different age groups. The median TBBA and TBBMC for height were higher in boys than girls by 14.7% and 24.9%, respectively. Similarly, the median TBBMC for LBM was 36.8% higher in boys as compared to girls.

**Conclusion:** The study reports reference curves for DXA parameters (narrow fan beam) for Indian children and youth.


***Keywords*:** Bone density, Centile Curves, Dual X-ray Absorptiometry, Normative curves

## INTRODUCTION

The International Society for Clinical Densitometry (ISCD) recommends dual-energy X-ray absorptiometry (DXA) as the preferred method for evaluating bone mineral content (BMC) and areal bone mineral density (BMD) as part of skeletal health assessment for children at increased risk of fractures [1]. Initially, DXA scanners employed a pencil beam of X-rays that scanned the patient in thin parallel lines, producing highly accurate geometric data with prolonged scan times [2]. These were replaced by advanced fan beam systems, which use higher energy photon intensities to generate faster higher-resolution images. Still, magnification depends on how far the bone or tissue is from the X-ray source [3]. To overcome limitations of both pencil and fan beam DXA, the new narrow fan beam bone densitometer has been introduced which scans in a rectilinear raster fashion avoiding magnification and scans the body in a much faster time [4].

Despite advancements in technology, there are still various limitations in interpreting DXA in children. These considerations include effects of a growing skeleton on follow-up assessments and the absence of consensus on which patient demographic and physiological factors should be included in normative databases [5]. The ISCD recommends using an appropriate reference data set which must include a sample of healthy representatives of the general population sufficiently large to capture variability in bone measures that take into consideration sex, age, and ethnicity. It is crucial to define osteoporosis in children, particularly in the absence of vertebral compression fractures, which is indicated by a clinically significant fracture history and bone mineral density (BMD) Z-score of less than -2.0 [1].

The interpretation of DXA results depends upon the reference data used that can significantly affect the standard deviation scores obtained and may lead to misclassification. The use of

different versions of software provided by DXA manufacturers produce significantly varying values for BMD, bone mineral content (BMC), and bone area (BA) in children [6,7].

Currently, there are no pediatric reference databases available for assessment of bone status of Indian children and adolescents using a narrow fan beam densitometer. Therefore, this study aimed to provide sex and age-specific reference percentile curves for the estimation of bone status using the Lunar-iDXA in 1–19-year-old Indian children and youth.

**METHODS**

A cross-sectional, observational study was carried out from November 2017 to July 2022 to measure the BMC, BA and BMD at total body, femur and L1-L4 lumbar spine (LS) in healthy Indian children and youth aged 1 to 19 years.

Heads or teachers from creches, playgroups, schools and junior colleges catering to populations of the upper middle and upper socio-economic class from Pune were approached for the study [8]. After obtaining permission, parents were informed about the study and were offered participation. An ethics approval was obtained from the Institutional Ethics Committee. Informed written consent was acquired from parents and participants aged ≥18 years, and assent was obtained from the children, as applicable, before conducting any study procedures. Anthropometric measurements were performed using standard instruments and protocols and Z-scores were computed [8,9].

The BMC (grams), BA ($cm^2$), and BMD ($g/cm^2$) of the total body, LS, and dual femur were measured using the GE-Lunar iDXA narrow-angle Fan Beam DXA scanner (GE Healthcare) with software version enCORE-2010, V18. During LS measurements, the participant was positioned supine, and the natural lumbar lordosis was flattened by raising the knees. For femoral neck measurements, the participant was positioned supine on a scanning table with arms on the abdomen and the whole leg rotated inwards, ensuring that the leg rotated from the

hip and not the knees. Machine stability was assessed using an aluminium spine phantom from the manufacturer, with a coefficient of variation (CV) of 0.5% throughout the study. All scans and analyses were conducted by the same operator trained by the GE-team. The effective radiation dose for the Lunar iDXA is reported as 0.02 μSv for the total body, 0.38 μSv for the spine, and 0.33 μSv for the femur. Using root mean square standard deviation of two repeat measurements for different parameters in 31 children [14 boys, 17 girls, mean (SD) age 11.6(4.0) years] determined the reproducibility of DXA measurements. For body composition, the technique precision was 12.5 g for the total body BMC (0.98% CV), 13.8 $cm^2$ for total body BA (1.13% CV), and 166.8 g for lean body mass (LBM) (0.74% CV). For LS, BMC, technique precision was 0.50 g (2.04% CV), and for LSBA, it was 0.80 $cm^2$ (2.74% CV). For femoral neck BMC, technique precision was 0.126 g (4.2% CV), and for FNBA, it was 0.12 $cm^2$ (3.2% CV) [10].

The BMAD scores, as a volumetric measure of bone density were calculated as: Spine BMAD=BMC/$(area)^{3/2}$ and femoral neck BMAD=BMC/$(area)^2$ [11].

*Statistical analyses:* IBM SPSS for Windows (version 25) was used for data analysis. Data are presented as mean and standard deviation (SD). Independent sample t-test was used to estimate the increment in bone parameters with each year of age and the differences between males and females ($P<0.05$). Pearson's correlation was used to analyse the correlation of age, height and LBM with bone parameters. Sex-specific reference curves displaying $3^{rd}$ , $10^{th}$ , $25^{th}$ , $50^{th}$ , $75^{th}$ , $90^{th}$ and $97^{th}$ percentiles were computed using the GAMLSS model (version 5.4.10) [12]. Percentile curves were plotted using the RefCurv software (https://refcurv.com/). Each variable of interest was summarized by three smooth curves plotted against age representing the median (M), the coefficient of variation (S) and the skewness (L) of the measurement distribution.

**RESULTS**

A total of 1302 children and youth agreed to participate in the study. A paediatrician performed medical examination to evaluate the children's health status. Children with a history of prematurity, pubertal and other endocrine disorders, history of recurrent fractures, history of immobilisation, chronic systemic illnesses and a history of prolonged intake of medications that affect bone health (e.g. steroids) were evaluated and excluded from the study ($n$ = 22). From 1280 children, 25 children were excluded as their height, weight or body mass index (BMI) for the age percentile was less than the 3$^{rd}$ or more than the 97$^{th}$ percentile; records of 8 children were also excluded due to errors in measurement. Finally, data of 1247 children and adolescents (640 boys and 607 girls) were included in the study. The mean (SD) age of the study population was 10.9 (5.1) years. The mean (SD) height-for-age Z-score (HAZ) for boys and girls was -0.1 (1.0) and -0.3 (1.0), weight-for-age Z-score (WAZ) was -0.2 (1.0) and -0.4 (1.0), and body mass index-for-age Z-score (BAZ) was -0.1 (1.1) and -0.3 (1), respectively.

**Table 1** gives total body (less head) BMC, BA and BMD (referred to as TBBMC, TBBA and TBBMD) data for boys and girls, respectively. The average improvement in TBBMD with age was 6.3%. A maximum increase in TBBMD of 16% was observed in boys at the age of 6+ years, whereas a maximum increase in TBBMD of 14% was observed in girls at the age of 8+ years. Average increase in TBBMC with age was 16.3% in boys and 18.5% in girls. The maximum increase in TBBMC of 46%-47% was observed in both boys and girls at the age of 3+ years.

Age and sex-specific reference percentile curves for TBBMC for age (***Web Figures 1A and 1 B***), TBBA for age (***Web Figures 1C and 1D***) and TBBMD for age (***Web Figures 1E and 1F***) for participants aged 1 to 19+ years were plotted. A steep increase was observed in TBBMC for age, TBBA for age and TBBMD for age till 19.9-years in boys, with a flattening in girls after around 14 years of age. At 19+ years, the median TBBA, TBBMC and TBBMD for age was 20.8%, 32.9% and 15.1% higher in boys than in girls.

**Table 2** describes LS (L1-L4) BMC, BA, BMD and BMAD data for boys and girls, respectively. The average increase in L1-L4 BMD was 7.2%. The highest increase in L1-L4 BMD was observed at 6-years as 13.3% in boys and in girls at 14-years as 14.9%. L1-L4 BMAD was significantly higher in girls as compared to boys at 5+ years, 9+ years, 10+ years and 12+ to 19+ years ($P < 0.05$). LSBMAD for age (***Web Figures 2A and 2B***) showed an increasing trend with an increase in age. In comparison to TBBMC for age and TBBA for age graphs, the increase in LSBMAD curves was less steep.

**Table 3** describes the femoral neck (FN) BMC, BA, BMD and BMAD data for boys and girls, respectively. An average increase in FNBMD of 4.5% was observed. The highest increase in FNBMD was observed in boys, as 9.7% at 6-years and 10.3% at 11-years in girls. FNBMAD was higher in boys as compared to girls at 5+ years and 9+ years while it was significantly higher in girls as compared to boys from age 14+ to 17+ years ($P < 0.05$). FNBMAD for age graphs for boys and girls are illustrated in ***Figures 2C and 2D***. The graph showed a downward trend till the age of 14-years in boys and 10-years in girls after which the graphs became flat.

The iDXA also provides BMC, BA and BMD for other individual body parts like head and spine is described in supplementary table 1 and 2.

## DISCUSSION

Age and sex-specific reference data for TBBMC, TBBA, TBBMD, LSBMD and FNBMD measured by Lunar iDXA narrow-angle fan beam iDXA scanner, for Indian children and youth are described. The numerical value provided by a DXA scan holds little significance without comparison to appropriate healthy controls. Factors such as sex, ethnicity, height, weight, body composition, and physiological maturity influence DXA results and must be taken into account when interpreting scans in children and adolescents [5]. Amongst these factors, about 60% to 80% of the contribution to peak bone mass is thought to be genetically determined. For

example, areal bone mineral density (aBMD) is greater for African Americans compared to Caucasians, while Caucasians have greater aBMD than either Asians or Hispanics [13].

To the best of our knowledge, only the Amalgamated Pediatric Bone Density Study (ALPHABET Study) has provided reference data for size-adjusted bone densitometry measurements in Asian children using iDXA [14]. A comparison of LSBMAD for boys shows values 14% higher in UK Asian data than our cohort at age 5-years. A similar comparison of total body BMD for Asian girls from the ALPHABET study suggests values 10% greater at the age 19-years than present study. Similarly, TBLH BMD of girls of African American, Caucasian, and Hispanic ethnicity from the National Health and Nutrition Examination Survey (NHANES) normative reference dataset was 15%, 10%, and 7% greater than our study at age of 19-years [15]. These data thus underline the importance of an ethnic-specific dataset for Indian children and youth.

A steep increase was observed in total body bone parameters in boys till the age of 19.9 years but it flattened in girls after age of 14-years. This is possibly because of the earlier puberty and bone accrual in girls as compared to boys. Similar results are reported by the Saskatchewan Bone Mineral Accrual Study (BMAS) and also by another Danish study. However, the age of peak TBBMC in these Caucasian studies was 12.5 years in girls and 14.0-14.2 years in boys [16]. Previously, similar trends are reported by the author's group using GE-Lunar DPX Pro Pencil Beam DXA scanner [17].

The LSBMD for age graph was steeper as compared to LSBMAD for age graph for both sexes in the present study. Thus, computing BMAD at the LS is crucial as it is less affected by changes in height and age. A study demonstrated that spine BMAD had the strongest and most consistent association with upper limb fracture risk in children [18]. Spine BMAD reference ranges partially reduced the confounding influence of shorter stature on bone density [19].

A downward trend in femoral neck bone accrual was seen till the age of 14-years in boys and 10-years in girls after which the graphs became flatter in this study. This is possibly due to earlier acquisition of peak bone mass at the femoral neck as compared to other sites, as reported in young women [20]. In young men, the increase in bone density at spine occurred over the same time period as the hip, but the stable period after accrual is longer in the spine than in the hip, where it decreases shortly after a stable level is reached [20].

The gender differences in pre-pubertal subjects are inconsistently reported earlier [21,22]. A higher TBBMC was seen in pre-pubertal males compared with females due to relatively more lean and less fat mass [21, 22]. The gender differences in bone mineralization in pre-pubertal children were attributed to physical activity and exposure to sunlight [23]. Moreover, racial differences in BMD are also influenced by lifestyle factors, including diet [24].

Large sample size, use of narrow-angle fan beam DXA scanner and inclusion of participants younger than five years of age and beyond 18 years are perceived strengths of this study as data on bone density parameters in these age groups is limited. One of the limitations of this study was lack of data on confounders such as dietary calcium intake, vitamin D status of participants and physical activity. This limited explanation for the gender difference seen in this study. Data from a single centre, lower numbers under 3 years of age, unavailability of data on pubertal staging, and lack of cross-calibration with other scanners were also other limitations.

In conclusion, reference curves for DXA parameters for Indian children using a modern narrow-angle fan beam scanner are presented.

**What this study adds?**

- Normative data to assess bone health of Indian children and youth using the narrow fan-beam densitometer (iDXA) are presented.
- Bone accrual occurred earlier in girls as compared to boys with earlier acquisition of peak bone mass at the femoral neck as compared to other sites.

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Web Figure Legends:

Web Figure 1A and B: TBBMC for age in Boys & Girls

Web Figure 1C and 1D: TBBA for age in boys and girls

Web Figure 1E and 1F: TBBMD for age in boys and girls

Web Figure 2A and 2B: Lumbar Spine BMAD for age

Web Figure 2C and 2D: Femoral neck BMAD for age

**Table 1. Total body less head bone parameters in boys and girls**

| *Age (y)* | *Boys* | | | | *Girls* | | | |
|---|---|---|---|---|---|---|---|---|
| | *n* | *TBBMC (g)* | *TBBA ($cm^2$)* | *TBBMD ($g/cm^2$)* | *n* | *TBLHBMC (g)* | *TBLHBA ($cm^2$)* | *TBLHBMD ($g/cm^2$)* |
| 1 | 19 | 139 (25) | 412 (50) | 0.336 (0.033) | 19 | 132 (30) | 390 (53) | 0.337 (0.037) |
| 2 | 20 | 203 (36)[a] | 539 (63)[a] | 0.374 (0.035)[a] | 22 | 195 (37)[a] | 529 (56)[a] | 0.365 (0.039)[a] |
| 3 | 28 | 277 (51)[a,b] | 639 (76)[a] | 0.433 (0.039)[a,b] | 22 | 236 (44)[a] | 606 (57)[a] | 0.386 (0.041) |
| 4 | 25 | 319 (57)[a] | 695 (72)[a] | 0.456 (0.044)[a,b] | 32 | 295 (47)[a] | 681 (67)[a] | 0.432 (0.038)[a] |
| 5 | 35 | 347 (58) | 747 (72)[a] | 0.462 (0.039) | 30 | 364 (65)[a] | 764 (73)[a] | 0.474 (0.053)[a] |
| 6 | 33 | 461 (78)[a] | 856 (67)[a] | 0.536 (0.055)[a,b] | 32 | 427 (77)[a] | 835 (80)[a] | 0.509 (0.052)[a] |
| 7 | 34 | 552 (91)[a,b] | 956 (91)[a,b] | 0.576 (0.053)[a,b] | 32 | 477 (74)[a] | 901 (86)[a] | 0.528 (0.046) |
| 8 | 36 | 678 (144)[a] | 1072 (134)[a] | 0.629 (0.072)[a] | 37 | 623 (116)[a] | 1027 (112)[a] | 0.603 (0.061)[a] |
| 9 | 63 | 767 (129)[a] | 1145 (109)[a] | 0.667 (0.066)[a] | 46 | 726 (121)[a] | 1115 (102)[a] | 0.648 (0.066)[a] |
| 10 | 57 | 843 (147)[a] | 1216 (117)[a] | 0.690 (0.071) | 43 | 833 (197)[a] | 1208 (141)[a] | 0.683 (0.089)[a] |
| 11 | 31 | 1016 (253)[a] | 1341 (201)[a] | 0.748 (0.094)[a] | 27 | 1022 (245)[a] | 1365 (160)[a] | 0.74 (0.105)[a] |
| 12 | 33 | 1111 (200) | 1448 (149)[a] | 0.764 (0.079) | 30 | 1096 (214) | 1384 (130) | 0.79 (0.116) |
| 13 | 34 | 1245 (272)[a] | 1524 (176) | 0.809 (0.100)[a] | 31 | 1204 (214) | 1464 (109)[a] | 0.819 (0.108) |
| 14 | 30 | 1432 (264)[a,b] | 1684 (172)[a,b] | 0.845 (0.088) | 34 | 1251 (192) | 1500 (115) | 0.831 (0.081) |
| 15 | 30 | 1547 (301)[b] | 1750 (157)[b] | 0.878 (0.115) | 34 | 1350 (190)[a] | 1517 (108) | 0.889 (0.087)[a] |
| 16 | 30 | 1684 (231)[a,b] | 1806 (134)[b] | 0.930 (0.0790)[a,b] | 36 | 1349 (174) | 1527 (111) | 0.883 (0.08) |
| 17 | 32 | 1871 (281)[a,b] | 1909 (125)[a,b] | 0.978 (0.115)[b] | 31 | 1324 (131) | 1491 (111) | 0.889 (0.07) |
| 18 | 32 | 1941 (258)[b] | 1910 (142)[b] | 1.016 (0.106)[a,b] | 29 | 1389 (181) | 1544 (117) | 0.898 (0.077) |
| 19 | 30 | 1964 (320)[b] | 1882 (176)[b] | 1.040 (0.091)[b] | 33 | 1407 (240) | 1532 (140) | 0.915 (0.093) |

*Data presented as mean(SD), [a]P <0.05 in comparison to the preceding age group, [b]P<0.05 in comparison to girls;*

*TBBA Total body bone area, TBBMC Total body bone mineral content, TBBMD Total body bone mineral density*

**Table 2. Lumbar spine bone health parameters in boys and girls**

| *Age (y)* | *Boys* | | | | | *Girls* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *n* | *L1 – L4 BMC (g)* | *L1 – L4 BA ($cm^2$)* | *L1 – L4 BMD ($g/cm^2$)* | *L1 – L4 BMAD ($g/cm^3$)* | *n* | *L1 – L4 BMC (g)* | *L1 – L4 BA ($cm^2$)* | *L1 – L4 BMD ($g/cm^2$)* | *L1 – L4 BMAD ($g/cm^3$)* |
| 5 | 37 | 11.2 (1.7) | 21.5 (1.9) | 0.519 (0.054)[b] | 0.22 (0.02)[b] | 30 | 11.8 (1.8) | 21.1 (1.9) | 0.579 (0.125) | 0.24 (0.03) |
| 6 | 34 | 13.5 (2.1)[a] | 23.0 (1.7)[a,b] | 0.588 (0.066)[a] | 0.24 (0.03)[a] | 32 | 12.9 (2.3)[a] | 21.8 (2.3) | 0.586 (0.067) | 0.25 (0.03) |
| 7 | 34 | 15.6 (3.1)[a,b] | 25.9 (3.2)[a,b] | 0.606 (0.095) | 0.24 (0.04) | 32 | 14.2 (2.4)[a] | 23.3 (2.5)[a] | 0.608 (0.072) | 0.25 (0.03) |
| 8 | 36 | 18.4 (4.3)[a] | 28.0 (3.3)[a,b] | 0.652 (0.088)[a] | 0.25 (0.03) | 37 | 17.4 (3.5)[a] | 26.1 (3.2)[a] | 0.664 (0.084)[a] | 0.26 (0.03) |
| 9 | 63 | 20.5 (3.1)[a] | 30.0 (3.0)[a,b] | 0.681 (0.071) | 0.25 (0.03)[b] | 46 | 19.9 (3.7)[a] | 28.1 (2.6)[a] | 0.703 (0.090)[a] | 0.26 (0.03) |
| 10 | 57 | 22.0 (4.3)[a] | 31.8 (3.9)[a] | 0.687 (0.072)[b] | 0.24 (0.02)[b] | 43 | 22.6 (6.5)[a] | 30.6 (4.1)[a] | 0.727 (0.118) | 0.26 (0.03) |
| 11 | 31 | 26.6 (6.7)[a] | 34.7 (5.4)[a] | 0.759 (0.091)[a] | 0.26 (0.03)[a] | 27 | 29.1 (8.5)[a] | 35.4 (5.2)[a] | 0.835 (0.188)[a] | 0.27 (0.04) |
| 12 | 33 | 28.0 (7.6)[b] | 36.2 (4.8) | 0.764 (0.114)[b] | 0.25 (0.03)[b] | 30 | 32.8 (9.9) | 37.7 (5.2) | 0.852 (0.159) | 0.27 (0.04) |
| 13 | 34 | 30.3 (7.7)[b] | 38.7 (5.5)[a] | 0.774 (0.107)[b] | 0.25 (0.03)[b] | 31 | 36.3 (8.2) | 38.4 (4.2) | 0.938 (0.129)[a] | 0.30 (0.03)[a] |
| 14 | 30 | 37.3 (9.1)[a] | 42.6 (5.8)[a,b] | 0.864 (0.114)[a,b] | 0.26 (0.03)[a,b] | 35 | 38.0 (8.2) | 39.4 (4.2) | 0.956 (0.116) | 0.30 (0.03) |
| 15 | 30 | 43.5 (9.8)[a] | 46.2 (5.4)[a,b] | 0.933 (0.127)[a,b] | 0.27 (0.03)[b] | 34 | 42.5 (8.3)[a] | 41.4 (4.4) | 1.019 (0.116)[a] | 0.32 (0.03) |
| 16 | 30 | 47.4 (7.9)[b] | 47.7 (4.7)[b] | 0.992 (0.108) | 0.29 (0.03)[b] | 37 | 43.1 (6.7) | 41.4 (4.1) | 1.039 (0.090) | 0.32 (0.03) |
| 17 | 33 | 54.0 (8.7)[ab] | 51.2 (4.0)[a,b] | 1.050 (0.113)[a] | 0.29 (0.03)[b] | 33 | 44.0 (7.0) | 41.6 (3.2) | 1.056 (0.113) | 0.33 (0.03) |
| 18 | 32 | 54.8 (8.3)[b] | 50.2 (5.3)[b] | 1.074 (0.138) | 0.31 (0.03)[b] | 30 | 47.0 (6.5) | 43.0 (3.8) | 1.092 (0.096) | 0.33 (0.03) |
| 19 | 31 | 57.0 (11.1)[b] | 51.8 (5.6)[b] | 1.093 (0.132) | 0.30 (0.03)[b] | 34 | 46.4 (7.4) | 42.0 (3.7) | 1.102 (0.119) | 0.34 (0.04) |

*Data presented as mean (SD), [a]P<0.05 in comparison to preceding age group, [b]P<0.05 in comparison to girls;*

*BA Bone area, BMC Bone mineral content, BMAD Bone mineral apparent density, BMD Bone mineral density*

**Table 3 Femoral neck bone parameters in boys and girls**

| *Age (y)* | *Boys* | | | | | *Girls* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *n* | *FNBMC (g)* | *FNBA ($cm^2$)* | *FNBMD ($g/cm^2$)* | *FNBMAD ($g/cm^3$)* | *n* | *FNBMC (g)* | *FNBA ($cm^2$)* | *FNBMD ($g/cm^2$)* | *FNBMAD ($g/cm^3$)* |
| 5 | 36 | 1.3 (0.3) | 2.1 (0.3) | 0.600 (0.080) | 0.28 (0.05)[b] | 30 | 1.3 (0.3) | 2.2 (0.3) | 0.583 (0.135) | 0.26 (0.04) |
| 6 | 34 | 1.7 (0.3)[a,b] | 2.5 (0.3)[a] | 0.658 (0.079)[a,b] | 0.26 (0.03)[a] | 32 | 1.5 (0.2)[a] | 2.4 (0.3)[a] | 0.615 (0.072) | 0.26 (0.04) |
| 7 | 34 | 2.0 (0.3)[a,b] | 2.8 (0.3)[a,b] | 0.695 (0.068)[a,b] | 0.25 (0.03) | 32 | 1.6 (0.3) | 2.6 (0.3)[a] | 0.611 (0.057) | 0.24 (0.03)[a] |
| 8 | 36 | 2.3 (0.5)[a,b] | 3.2 (0.4)[a,b] | 0.733 (0.083)[a,b] | 0.24 (0.03) | 37 | 2.0 (0.4)[a] | 3.0 (0.3)[a] | 0.673 (0.072)[a] | 0.23 (0.03) |
| 9 | 63 | 2.5 (0.4)[b] | 3.4 (0.3)[a] | 0.747 (0.089)[b] | 0.22 (0.03)[b] | 46 | 2.2 (0.4)[a] | 3.2 (0.3)[a] | 0.675 (0.083) | 0.21 (0.03)[a] |
| 10 | 57 | 2.7 (0.5)[a,b] | 3.6 (0.4)[a] | 0.762 (0.089)[b] | 0.22 (0.03) | 43 | 2.5 (0.6)[a] | 3.4 (0.4)[a] | 0.720 (0.109)[a] | 0.21 (0.03) |
| 11 | 31 | 3.1 (0.7)[a] | 3.8 (0.6) | 0.821 (0.105)[a] | 0.22 (0.04) | 27 | 2.9 (0.7)[a] | 3.7 (0.4)[a] | 0.794 (0.151)[a] | 0.21 (0.03) |
| 12 | 33 | 3.3 (0.6) | 4.1 (0.3)[a,b] | 0.804 (0.117) | 0.20 (0.03)[a] | 30 | 3.2 (0.6) | 3.9 (0.3) | 0.817 (0.153) | 0.21 (0.04) |
| 13 | 34 | 3.7 (0.7)[a] | 4.3 (0.5)[b] | 0.853 (0.118) | 0.20 (0.03) | 31 | 3.4 (0.6) | 4.0 (0.3)[a] | 0.835 (0.119) | 0.21 (0.03) |
| 14 | 30 | 3.9 (0.6)[b] | 4.4 (0.3)[b] | 0.872 (0.118) | 0.20 (0.03)[b] | 34 | 3.5 (0.6) | 4.0 (0.4) | 0.851 (0.099) | 0.21 (0.03) |
| 15 | 30 | 4.2 (0.9)[b] | 4.6 (0.4)[b] | 0.928 (0.142) | 0.20 (0.03)[b] | 34 | 3.8 (0.6)[a] | 4.1 (0.3) | 0.913 (0.116)[a] | 0.22 (0.03) |
| 16 | 30 | 4.5 (0.6)[b] | 4.7 (0.4)[b] | 0.942 (0.091) | 0.20 (0.02)[b] | 36 | 3.8 (0.5) | 4.1(0.3) | 0.931 (0.110) | 0.23 (0.03) |
| 17 | 33 | 4.7 (0.8)[b] | 4.8 (0.4)[b] | 0.982 (0.127)[b] | 0.21 (0.03)[b] | 31 | 3.6 (0.4) | 4.0(0.3) | 0.908 (0.108) | 0.23 (0.03) |
| 18 | 32 | 5.1 (0.7)[b] | 4.9 (0.3)[b] | 1.020 (0.167)[b] | 0.21 (0.03) | 30 | 3.7 (0.4) | 4.1(0.3) | 0.918 (0.101) | 0.23 (0.03) |
| 19 | 31 | 5.0 (0.9)[b] | 4.9 (0.3)[b] | 1.027 (0.169)[b] | 0.21 (0.04) | 33 | 3.8 (0.6) | 4.3(0.3)[a] | 0.898 (0.123) | 0.21 (0.03) |

*Data presented as mean(SD), [a]P<0.05 in comparison to preceding age group, [b]P<0.05 in comparison to girls;*

*FNBA Femoral neck bone area, FNBMAD Femoral neck bone mineral apparent density, FNBMC Femoral neck bone mineral content, FNMD Femoral neck bone mineral density*