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**Original Article**

# Comparison of vertebral and femoral bone mineral density in adult females

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**Abstract.** [Purpose] This study assessed vertebral and femoral bone mineral density in adult females. [Subjects and Methods] A total of 314 females in their 40s to 70s were divided into normal, osteopenia, and osteoporosis groups and their vertebral and femoral bone mineral densities were compared. [Results] Comparisons of T scores revealed significant differences among measurements of the third lumbar vertebra, femoral neck, Ward's triangle, and femoral trochanter. Pearson correlation coefficients were used to assess differences between the vertebral and femoral measurements, and significant differences and positive correlations were observed among third lumbar vertebra, femoral neck, Ward's triangle, and femur trochanter in the normal group. [Conclusion] Females in the normal, osteopenia, and osteoporosis groups showed significant differences in their third lumbar vertebrae. The lack of significant differences among measurements in the osteoporosis group in this study suggests that patients with osteoporosis require careful and accurate diagnosis.
**Key words:** Osteoporosis, Osteopenia, Bone mineral density

## INTRODUCTION

Bone mineral density (BMD), a measure of the mineral content of bones, is a criterion for clinical diagnosis of osteoporosis; it is also used to assess responses to treatments, including rates of bone loss and gain. Osteoporosis is approximately five times more common in females than in males. By age 50, more than 1/3 of the females in Korea are in menopause. Because bone mass decreases by 50% within 5 years after menopause, they are highly susceptible to osteoporosis; thus, measures to prevent osteoporosis in females prior to the onset of menopause are of vital importance[1].

Due to the increasing aging population in today's society, the number of patients with osteoporosis is increasing, with consequent increases in the frequency of spinal or hip joint fractures due to decreased BMD and bone mass. Therefore, BMD examinations are important for preventing fractures and providing interventions to improve BMD. Moreover, appropriate measures based on accurate BMD measurements enable the early prevention and treatment of osteoporosis-related complications[2].

To prevent osteoporosis, bone and body health must be maintained through appropriate nutrient intake and regular exercise[3]. Moreover, various factors may also affect BMD, such as weight, body fat, and muscle mass[4]. Radiographic BMD measurement is considered an important tool for diagnosing osteopenia and determining the effect of therapy[5]. Among the many methods, dual-energy X-ray absorptiometry (DXA) is the most sensitive and appropriate standard method[6]. The vertebrae and hip joints are typically measured since they represent important areas that affect both morbidity and mortality.

Cancellous bone is present in the vertebral body, which makes it useful for assessing treatment response, and it offers greater accuracy for recreating a patient's posture compared to measurements in the hip joint area[7]. Vertebral BMD may be elevated in older patients due to arterial calcification and degenerative changes; in such cases, BMD measurements of the hip and lumbar areas taken laterally via DXA can offer more accurate results. Femoral BMD is generally measured from four areas: the proximal femoral neck, the entire hip area, the condyle, and Ward's triangle. The proximal femoral neck and condyle are composed of cortical and cancellous bone, respectively[7].

The T-score, a measure often used in BMD measurements, is typically expressed as mean ± standard deviation based on comparisons to maximum mean BMD found in young, healthy adults of the same ethnicity and gender. Relative to T-scores of young, healthy adults, measured T-scores are defined as follows: normal if $\geq -1.0$, osteopenia if $-1.0$ to $-2.5$, and osteoporosis if $< -2.5$ (Shin, 2006). Z-scores, another measure, are unlike the T-score in that they represent a value that is relative to the mean BMD of a healthy control group of the same age, gender, and ethnicity[7].

Previous studies on BMD have reported T-scores as being useful for measuring osteoporotic fractures and changes in morphological characteristics of the proximal femur[8], as well as comparing correlations of vertebral and femoral BMD according to fractures in elderly patients with osteoporosis[9]. However, few studies have examined the correlations between vertebral and femoral values in groups with different BMDs.

Therefore, the present study used T-scores, which are reportedly highly associated with the risk of fracture[7], to assess the correlations between vertebral and femoral values in three groups classified as normal, with osteopenia, and with osteoporosis based on their BMD levels to provide clues for the accurate diagnosis of BMD and prevention of problems associated with decreased BMD.

## SUBJECTS AND METHODS

The subjects included 314 adult female patients who underwent a BMD examination at "K" Hospital in Daegu (South Korea) through July 2015. The patients were in their 40s (n=32), 50s (n=115), 60s (n=98), and 70s (n=69). Patients with a history of orthopedic surgical treatment or spinal and/or femoral injury or diseases were excluded from the study. After the measurements, 114, 144, and 56 subjects were assigned to the osteoporosis, osteopenia, and normal groups based on their BMD scores. All of them understood the purpose of this study and gave their written informed consent before experimental involvement. The study was performed according to the principles of the Declaration of Helsinki, and ethical approval was granted by local committee of the institution review board of the university hospital.

Prior to BMD testing, hospital medical records were used to determine test and surgical history, and subjects received detailed explanations of the objectives, methods, and time required for the testing. Each examinee changed into an examination gown and was then placed in the supine position on the center of the examination table with a rectangular sponge supporting the legs and the waist contacting the examination table.

A DPX-Bravo (GE, Healthcare Lunar, PA, USA) instrument was used to measure BMD via DXA. The measurement areas included lumbar vertebrae 1–4, the femoral neck, Ward's triangle, and the femoral trochanter. Values from the first and second lumbar vertebrae, which have the highest frequency of fracture, were excluded, and BMD values from lumbar vertebra 3 (L3) were used[9].

Based on computer analysis, T-scores that showed the rate relative to the reference value of a normal person (peak reference; %) were used and BMD measurement from each region were classified according to World Health Organization definitions as normal (T-scores$\geq -1$), osteopenia ($-1>$T-scores$>-2.5$), and osteoporosis (T-scores$\leq -2.5$). Subjects were assigned to the normal, osteopenia, and osteoporosis groups accordingly, and their lumbar and femoral BMD values were compared[10].

Analyses of test results and correlations were performed using SPSS Statistics for Windows version 17.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were used to assess the subjects' general characteristics, while one-way analysis of variance was performed to examine inter-group differences in BMD. Pearson's correlation analysis was performed to analyze the vertebral and femoral BMD measurements. The statistical significance level α was set at 0.05.

## RESULTS

Comparisons of general patient characteristics among the three groups showed that the osteoporosis group had the highest mean age and lowest mean height and weight. Among the 314 subjects, the rate of females with osteopenia or osteoporosis was very high (Table 1). Comparison of T-scores revealed significant inter-group differences in measurements from the L3, femoral neck, Ward's triangle, and trochanter ($p<0.05$) (Table 2). Pearson's correlation coefficients analysis revealed correlations between vertebral and femoral BMD, with the normal group showing significant differences and positive correlations in the L3, femoral neck, Ward's triangle, and trochanter measurements ($p<0.05$). In the osteopenia group, the L3, femoral neck, and trochanter measurements differed significantly ($p<0.05$), with positive correlations that were weaker than those in the normal group. In the osteoporosis group, the L3 measurements were negatively correlated with those of the femoral neck and Ward's triangle and positively correlated with femoral trochanter measurements; however, the differences were not statistically significant (Table 3).

**Table 1.** General subject characteristics

| Group | Age (years) | Height (cm) | Weight (kg) | Number of patients (%) |
|---|---|---|---|---|
| Normal | 54.2 | 156.8 | 60.2 | 56 (17.8) |
| Osteopenia | 58.9 | 157.1 | 58.1 | 144 (45.8) |
| Osteoporosis | 67.4 | 151.9 | 53.1 | 114 (36.3) |

**Table 2.** T-scores according to body parts

| | Normal | Osteopenia | Osteoporosis | |
|---|---|---|---|---|
| L3 | $0.72 \pm 0.89$ | $-1.01 \pm 0.93$ | $-2.57 \pm 1.16$ | ** |
| Femoral neck | $0.38 \pm 0.87$ | $-0.77 \pm 0.84$ | $-1.90 \pm 0.90$ | ** |
| Ward's triangle | $0.31 \pm 1.02$ | $-1.15 \pm 0.91$ | $-2.10 \pm 0.85$ | ** |
| Femoral trochanter | $0.90 \pm 1.01$ | $-0.22 \pm 0.87$ | $-1.17 \pm 0.81$ | ** |

** $p < 0.01$

**Table 3.** Pearson correlation coefficients between body parts

| | | Femoral neck | Ward's triangle | Femoral trochanter |
|---|---|---|---|---|
| Normal | L3 | 0.278* | 0.294* | 0.271* |
| Osteopenia | L3 | 0.192* | 0.076 | 0.222* |
| Osteoporosis | L3 | −0.055 | −0.029 | 0.118 |

* $p < 0.05$

# DISCUSSION

Osteoporosis is a metabolic bone disease that increases the risk of fracture due to reduced BMD; it also leads to social problems such as increased medical costs[11, 12]. The use of BMD measurements for diagnosing osteoporosis was first reported by Camerun and Sorrenson[13]; since that time, BMD measurements of the lumbar region, hip joint area, and distal radius region have been generally utilized for the early detection and treatment of osteoporosis.

In the present study, the analysis of BMD measurements according to the general characteristics of the 314 study participants revealed high rates of osteopenia and osteoporosis. These findings were consistent with those of the study by Compston[14], which reported that BMD begins to decrease in the 30s to early 40s, resulting in an increasing number of patients with osteoporosis, with increasing age, and a study by Ito et al.[15], which reported maximum BMD in the mid-30s and a decreasing trend thereafter with a particularly drastic decrease in females around menopause. Moreover, an analysis of groups according to BMD showed that the osteoporosis group had the lowest mean body weight, consistent with previous studies that reported decreasing BMD with decreasing body weight[16, 17]. Inter-group comparisons of T-scores showed significant differences among the L3, the femoral neck, Ward's triangle, and the femoral trochanter. Moreover, groups with a lower mean BMD tended to have a higher mean age. This observation was consistent with the results of a study by Cho et al.[18] that assessed BMD by age group, which showed the biggest difference in BMD between those in their 60s and those in their 70s. BMD measurements of the L3 and femoral trochanter are typically used for early detection and treatment of osteoporosis[19], while Ward's triangle results in poor value readings or accuracy due to its small size[20]. Moreover, the correlations between Ward's triangle and BMD become weaker with increasing subject age[9]. In the present study, the L3, femoral neck, and femoral trochanter had high T-scores in BMD measurements, while the values for Ward's triangle were relatively low, a finding consistent with the results of precedent studies.

In the present study, the rate of patients with osteopenia or osteoporosis was high, demonstrating the need for preventing and treating osteoporosis in females as they age. These findings were consistent with those of the study by Lane et al.[21], which showed that a reduction in BMD by one standard deviation in each category was associated with a 1.5–3-fold increase in the rate of fractures, with fracture rates of 30% for $<-2.5$ SD, which was defined as the threshold at which consultation and treatment were necessary. Similarly, Bechanan et al.[22] suggested that BMD values of 70–100 mg/cm$^3$ required immediate preventive measures and values $<70$ mg/cm$^3$ required active prevention and treatment.

In the BMD correlation analysis by measurement area, the normal group showed L3 T-scores that were significantly correlated with those of the femoral neck, Ward's triangle, and the femoral trochanter. Meanwhile, the L3 T-scores in the osteopenia group were correlated with those of the femoral neck and trochanter. These findings suggest that these values can

be surmised from other locations when an accurate BMD test cannot be performed due to testing area limitations. However, the L3 T-scores in the osteoporosis group were not correlated with those of the femoral neck, Ward's triangle, and femoral trochanter, a finding similar to results from a study by Choi et al.[23] that found that the correlation between vertebral and hip joint BMD declined with increasing age. Furthermore, all three groups showed the highest correlation between lumbar and trochanter T-scores, consistent with the findings of a precedent study that showed the lumbar and trochanter BMD measurements were highly correlated, likely because the ossein of the trochanter has characteristics similar to those of the trabecular bone[9].

The limitations of the present study include the fact that it included females only; thus, the results cannot be generalized to males and children. Other limitations include not considering differences in BMD according to age; using only T-scores, showing results that are inconsistent with BMD diagnosis using Z-score or BMD; and not considering other factors, such as muscle or fat mass, that can also affect BMD. Therefore, future studies should also consider other factors that can affect BMD; these investigations should also be more broad-based to enhance the value and generalizability of our findings.

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