RESEARCH ARTICLE

F.U. Med.J.Health.Sci.
2021; 35 (3): 183 - 188
http://www.fusabil.org

Effect of Age Distribution on T-Score Changes at Different Skeletal Sites in Turkish Women

Nil ATAKUL [1, a]
Berna Sermin KILIÇ [1, b]

[1] Department of Gynecology and Obstetrics, Istanbul Teaching and Research Hospital, İstanbul, TURKIYE

[a] ORCİD: 0000-0003-3874-8797
[b] ORCİD: 0000-0002-0103-0709

Objective: Studies of young women, including dual X-ray absorptiometry (DXA) are limited in terms of identifying when and where osteopenia starts and the degree of correlation in the T-scores as reproductive women transition into menopausal status. The aim of this study is to evaluate the values of the lowest T-score in the femoral neck, trochanter, and lumbar spine at different age ranges and the correlation with an increase in age by using DXA.

Materials and Methods: In this retrospective cohort study, DXA results of patients between the ages of 45 and 80, who were admitted to the Department of Gynecology and Obstetrics of İstanbul Teaching and Research Hospital were evaluated. The bone mineral density (BMD) measurements were performed in the anterior-posterior direction.

Results: There was a statistically significant difference observed between the T-scores of different skeletal sites between 4 groups of patients ($p<0.005$), except for lumbar vertebrae ($p=0.02$). In all age groups, the lumbar region T-score was the lowest. BMD measurements of lumbar vertebrae among the 4 age groups were unaffected by an increase in age, progressive decline in BMD occurs in the femoral neck and trochanter region with an increase in age.

Conclusion: We suggest that the lumbar BMD should be checked first in all age groups as the lumbar region was most susceptible to osteopenia. We also suggest that clinicians should pay attention to a progressive decrease in BMD density with age in the femur neck and trochanter regions and physicians to consider that lumbar vertebra BMD starts to decrease at younger ages.

Key Words: *Age, T-score, osteoporosis, lumbar vertebrae, bone mineral density*

Türk Kadınlarının Yaş Dağılımının Farklı İskelet sistemi T Skor Değişikliklerine Etkisi

Amaç: Osteopeninin hangi vücut kemiğinde ve ne zaman başladığını anlamak ve üreme çağındaki kadınların menopoz dönemine geçişleri sırasında T-skor korelasyonlarının derecesini belirlemek için genç kadınları kapsayan Dual Enerji X-Ray Absorbsiyometri (DXA) çalışmaları yetersizdir.

Çalışmamızın amacı farklı yaşlarda femur boynu, femur trokanter, lomber omurgada en düşük T-skoru ve yaş artışı ile korelasyonunu DXA kullanarak değerlendirmektir.

Gereç ve Yöntem: Bu retrospektif kohort çalışmasında, İstanbul Eğitim ve Araştırma Hastanesi Kadın Hastalıkları ve Doğum Kliniği'ne başvuran 45-80 yaş arasındaki hastaların DXA sonuçlarını değerlendirdik. kemik mineral yoğunluğu (KMY) ölçümleri DXA cihazı ile anterior-posterior yönde yapıldı.

Bulgular: Dört hasta grubunda farklı bölgelerin T-skorları arasında lomber omurga ($p=0.025$) hariç istatistiksel anlamlı fark bulundu ($p<0.005$). Tüm yaş gruplarında lomber bölge T-skoru en düşük saptandı. 45-50 ve 51-60 yaşlarında femur trokanter, 61-70 ve 71-80 yaşlarında femur boynu en az osteopeniden etkilenen bölgeler olarak saptandı. Dört yaş grubunda lomber omurga kemik KMY artan yaştan etkilenmemiş saptandı. Öte yandan femur boynu ve ftrokanter bölgelerinde artan yaş ile KMY' da progresif düşüş saptandı.

Tartışma: Doğru bir KMY analizi gerçekleştirilmesi için test sınırlaması mevcut olduğunda, belirli bir lokalizasyondaki kemik yoğunluk değerlerlerinden varsayım yapılabileceğini saptadık. Farklı iskelet sistemi bölgelerinin T-skor fark aralıklarının kendi içlerinde yaş ile azalmadığını tespit ettiğimiz ve osteopeniye en duyarlı bölge olduğu için tüm yaş gruplarında öncelikle lomber KMY'nin kontrol edilmesini önermekteyiz. Bu nedenle klinisyenlere önerimiz, özellikle femur ve femur trokanter bölgelerinde yaşla artan KMY dansitesinde progresif azalmaya dikkat etmeleri ve lomber bölgedeki KMY' nun daha genç yaşlarda azaldığını göz önüne bulundurmalarıdır.

Anahtar Kelimeler: *Yaş, T-skor, osteoporoz, lumbal vertabra, kemik mineral yoğunluğu*

Received : 11.04.2021
Accepted : 19.10.2021

Correspondence
Yazışma Adresi

Nil ATAKUL
Department of Gynecology and Obstetrics, Istanbul Teaching and Research Hospital, İstanbul, TURKIYE

nil_atakul@yahoo.com

Introduction

Bone mineral density (BMD), which is defined by the mineral content of bones, is a standard for the clinical diagnosis of osteoporosis; BMD is also employed to estimate responses to treatments, including the rate of bone loss and gain of patients. Dual X-ray absorptiometry (DXA) and dual photon absorptiometry are accurate and cost-effective techniques that can be utilized to measure bone density in the spine and hip (1). Since the lumbar spine (L1-4) and hip joints represent important areas that affect the consequences of osteoporosis, such as pathological fracture in menopausal women,

bone densities are usually measured at these sites by grading the severity of osteoporosis by the lowest T-score. In the human body, the hip and lumbar spine are fractured most among other sites (2). It is estimated that a 0.25 and 1% decline in BMD occurs in premenopausal women each year (3).

Different skeletal sites in the same patients often differ based on the T-score values; depending on which skeletal regions are measured, individual patients have been diagnosed with osteoporosis, low BMD or normal BMD (4-5). The World Health Organization (WHO) Osteoporosis Working Group and other international osteoporosis organizations have stated that the femoral neck is the only site that should be applied in the estimation of osteoporosis prevalence at a population level (6-7). However, it has been hypothesized that different skeletal sites of the body, such as the spine and femur, might have different environmental and/or genetic risk factors, which may affect vertebral and femoral regions in different ways.

Studies of perimenopausal women, including dual X-ray absorptiometry (DXA) are limited in terms of identifying when and where osteopenia starts and the degree of correlation in the T-scores as reproductive women transition into menopausal status. To date studies focused on BMD changes of certain age intervals (8-10) and a certain site. Only several studies (11, 12) have evaluated longitudinal changes in BMD over the whole adult life span and, from those studies, it has been found that in postmenopausal women, in the majority of patients BMD was overestimated from previous cross-sectional data prediction, as observed in the longitudinal reports.

The purpose of this study was to determine the differences in BMD and the lowest measured T-score of the femur neck, femur trochanter, and lumbar spine in Turkish women for the evaluation of the effect of age on different sites and their correlation with BMD with an increase in age using DXA. In order to evaluate which segment of population and site is more susceptible to loss in BMD, it is important to evaluate the pattern of bone loss by age.

Materials and Methods

Research and Publication Ethics: The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of Istanbul Teaching and Research Hospital (file number: 2174, date: 07.02.2010). The clinical investigations described were carried out according to the Declaration of Helsinki. As this study is retrospective, we could not get the informed consent of patients.

In this retrospective cohort study, we evaluated the DXA results of patients between the ages of 45-80 who were admitted to the Department of Gynecology and Obstetrics of Istanbul Teaching and Research Hospital, outpatient clinics between January 2016 and January 2018 for osteoporosis evaluation. 122 perimenopausal and menopausal women were included in the study and divided into 4 groups according to ages, first group compromise of 29 patients ages between 45-50, second group compromise of 33 patients ages between 51-60, third group compromise of 30 patients ages between 61-70 and, fourth group compromise of 30 patients ages between 71-80.

The BMD measurements of the lumbar spine (L1–L4) and non-dominant hip (trochanter, femoral neck, and total hip) were performed in the anterior-posterior direction by the Hologic QDR 4500 W Elite DXA (USA) device. Protocols were applied to the measurements based on manufacturer recommendations. Measurement on the Hologic spine phantom was less than 1% on all sites for the coefficient of variation of the correct BMD measurements. Osteoporosis is defined as a BMD of 2.5 standard deviations below that of a young adult (maximum T-score of -2.5 according to the WHO (13). Among the patients without osteoporosis, low bone mass was defined by T-scores between -1.0 and -2.5 at either skeletal site.

The exclusion criteria were trauma, bone tumors, rheumatic diseases, avascular necrosis, infection, and hyperesthesia.

Statistical Analysis: The statistical package for the Social Sciences 15.0 software for Windows was employed for the statistical analyses (SPSS, Chicago, IL, USA). The distributions of DXA parameters are described using the mean. In the intergroup analysis for continuous variables, the Kolmogorov-Smirnov test for univariate data was used to assess the normal distribution data. The One-way ANOVA test was used for four groups when the data were suitable for normal distribution. We have provided analysis of histograms for the frequency distributions of the T-score data according to age and skeletal site to graphically demonstrate any skewness to the data distributions. The linear relationship between the variables was evaluated using Pearson's correlation test. Variables were analyzed at a 95% confidence level and a p-value of less than 0.05 was considered significant.

Results

In this study, we observed a very strong correlation between the femoral neck and the femur trochanter in the osteopenia group (r=0.85, p=0.034) and a less correlation between the femoral neck and the trochanter (r=0.58, p=0.042) in the osteoporosis group.

As shown in Table 1, there was no statistically significant difference observed between 4 groups of patients based on BMI values. For the group of patients between 45 and 50 years of age, the T-scores of the lumbar, femoral neck region, and femur trochanter region were -1.1, -0.45 and 0.2, respectively. For the group of patients between 51 and 60 years of age, the T-scores of the lumbar region, femoral neck, femur trochanter were -1.5, -0. 5 and 0.2, respectively. For the group of patients between 61 and 70 years of age, the T-scores of the lumbar region, femoral neck, and femur trochanter were -2.4, -1.1 and -0.2, respectively. For the

patients between 71 and 80 years of age, the T-scores of the lumbar region, femoral neck, and femur trochanter were -1.5, -1. 5 and -0.63, respectively.

As shown in Figure 1, the most concordance among all age groups occurs between the T-scores of the femur neck and trochanter followed by the lumbar vertebrae. The DXA results of the patients in the four age groups declined parallel to previous measurements, except for the 61-70 and 71-80 age groups, where the femur trochanter replaced the femur neck for the least susceptible area for osteoporosis. In the youngest (ages 45-50) group of patients, the most affected regions from low BMD were lumbar vertebrae followed by the femoral neck. The lumbar vertebrae comprise the most susceptible region of the body to osteoporosis in all age groups. The BMD measurements of lumbar vertebrae among the four age groups showed no decline with an increase in age, whereas a progressive decline in BMD occurs in the femoral neck and trochanter region with an increase in age. The degree of concordance among each skeletal site was unaffected by an increase in age.

Table 1. Comparison of T-scores for 3 skeletal sites; there was a statistically significant difference found between T-scores of different skeletal sites between 4 age groups of patients (p<0.005) except for lumbar vertebrae (p=0.02)

Age (years) (interval)	45-50	51-60	61-70	71-80	p-value
BMI (kg/m^2)	27±5.3	30±4.2	31±4.7	32±4.3	p=0.240
T-score lumbar vertebrae	-1.1±0.99	-1.5±0.95	-2.4±0.84	-1.5±0.93	p=0.025
T-score femoral neck	-0.45±0.92	-0,5±0.82	-1.1±0.95	-1.5±0.92	p<0.005*
T-score femur trochanter	0.2±0.82	0.2±0.72	-0.2±0.89	-0.63±0.87	p<0.005*

One-Way-Anova, Values are described as Mean±Standart Deviation
*p<0.005
BMI: Body Mass Index

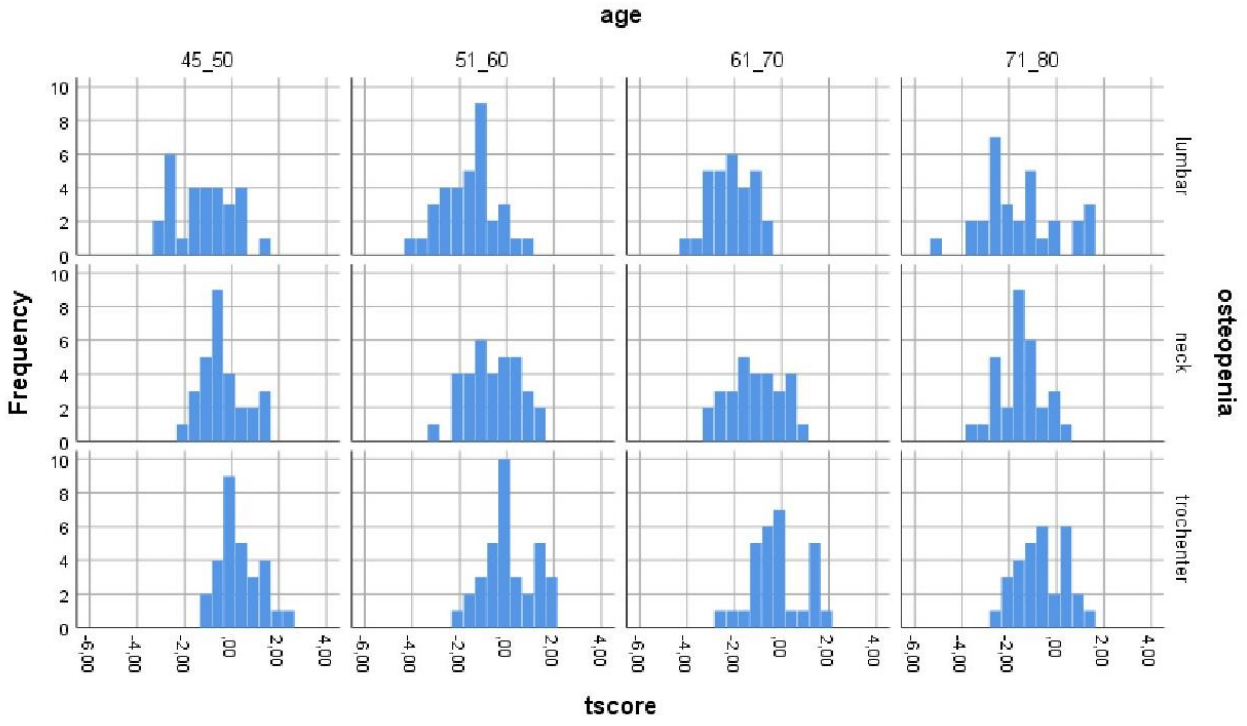

Figure 1. Histogram analysis of patients according to age and site of osteopenia. In all age groups lumbar region T-score was the lowest. Ages between 45-50 and 51-60 femur trochanter was found least affected by osteopenia. Ages between 61-70 and 71-80 femur neck was found least affected by osteopenia.

Discussion

In the retrospective cohort analysis, we examined a large group of women with osteopenia and/or osteoporosis using the T-score measurements. DXA is currently considered the gold standard for measuring bone density (14). However, the measurement at one site of the skeleton of a patient for reliable prediction of fracture risk at another region remains controversial, and which anatomic region is best suited to estimate the risk of fractures in all relevant regions remains ambiguous (15, 16).

We observed no statistical difference between BMI values in four age groups of patients (Table 1). Low body weight causes bone loss, whereas high body weight causes high BMD (17), which could have interfered with this study results. In a large study of American and Japanese women between 20-83 years of age, Ito et al. (18) determined that BMD began to decrease at the age of 20 in Japanese women probably due to the low BMI in their population. The peak bone mass was sustained until the age of 35 in American women, whereas in postmenopausal women, bone mass was significantly reduced in both Japanese women and American women.

In this study, the most affected region was the lumbar spine in all age groups (Table 1), which could cause progressive spinal deformities and potential neurologic sequel risk in elderly women and became a major concern of neuro-surgeons before they consider potential spinal surgery (19). Among elderly women, vertebrae fractures occur more commonly than any other region of the body in the osteoporosis group. This study shows that decline in vertebral bone density starts in the early ages starting from the mid-40s.

Although we discovered that the lumbar vertebrae are the most affected region in all age groups, we could not detect accelerated bone loss with an increase in age (Figure 1). In older women, we determined that BMD of the lumbar region, especially with an increase in age, exhibits a stable decrease in the range of approximately 35 years, instead of progressive osteopenia and/or osteoporosis compared to other regions. The lumbar vertebrae tend to begin the process of degeneration at approximately age 50, which comprises the cessation of the reproductive period of women. These findings are supported by various studies. Shao et al. (20) suggested that the heights of the lumbar discs of males and females within the ages 20–69 years increased linearly with an increase in age. Koeller et al. (21) discovered that within the lumbar spine, the disc height seems to be almost independent of age. In line with our results, in a longitudinal Denmark study, bone loss in lumbar spine most pronounced in the first decade of menopause and, stay stable throughout women's life (11).

Similar to our findings, Choe et al. (22) showed that for the normal and low BMD group, the L3 T-scores were significantly correlated with the BMD of the femoral neck and trochanter. However, in the osteoporosis group, the L3 T-scores were not correlated with the femoral neck and femoral trochanter. In this study, we also observed a very strong correlation between the femoral neck and the trochanter in the osteopenia group and less correlation between the femoral neck and the trochanter in the osteoporosis group (Figure 1). Choi et al. (23) discovered that the correlation between vertebral and hip joint BMD and age has an inverse relationship. We did not observe a decline in the BMD difference at different sites with an increase in age.

The discordance between the BMD results of the hip and spine had been investigated and reported in several studies (24, 25). A review of postmenopausal women revealed that the discordance between the hip BMD and the spine BMD was common and predicted different fracture patterns. Spinal osteoporosis increases the odds ratio of radiographic spine fracture 2.8-fold, whereas hip osteoporosis increases the risk of hip fracture 3.0-fold (26). Parallel to our findings, osteoporosis was only detected in the hip for nearly 25% of their participants versus the spine region for nearly 40% of their participants. The regression analysis of 3000 premenopausal Scottish women revealed that the BMD change rate at the spine was almost 35% versus 19% in the hip area caused by non-genetic factors (27). In a recent animal study, it has been shown that in ovariectomized rats, especially inter radicular and body areas of mandibles, were less sensitive than the femur with regard to osteoporosis (28). It has been hypothesized that perimenopausal period bone mass measurements estimate the lifetime risk of fracture of a woman (29).

It is important to inform patients that as they age, their DXA results decline parallel to their previous measurements, except for 61-70 and 71-80 age groups, where the trochanter is replaced by the femur neck for the least susceptible area for osteoporosis (Figure 1). To date studies that investigate femur trochanter and neck BMD distinctly are limited (30, 31), usually studies focused on the proximal femoral head. Parallel to our results in a recent study, the femoral neck fracture group was found to be statistically significantly younger than the intertrochanteric fracture group (30). The clinical implications of their study suggest that low BMD in the intertrochanteric region may be protective for femoral neck fractures since the energy of direct impact on the hip might dissipate in the intertrochanteric region before the arrival of energy into the femoral neck. These findings suggest that the hat senile populations are more susceptible to intertrochanteric osteopenia and, this might be a protective factor for traumatic femoral neck fractures.

In conclusion, an assumption can be made based on the BMD values from certain locations when testing limitations exist where an accurate BMD cannot be performed. According to this study T- score concordance of different skeletal sites does not change with an increase in age. Therefore, we suggest that the lumbar BMD should be checked first, as the lumbar region was most susceptible to osteopenia in all age groups. The BMD of the subtrochanteric area of the femur can be screened by DXA without the need for further femur radiographs. Clinicians should warn patients who display

osteoporotic development in the femur and who might expect to have BMD reduction in other body parts, such as the lumbar vertebrae with the same level of difference in skeletal sites from previous DXA measurements. We suggest that clinicians should pay attention to a progressive decrease in BMD density with age in the femur neck and femur trochanter regions and to consider that BMD in the lumbar region starts to decrease at younger ages so they should apply physical and therapeutic treatment methods to their patients accordingly.

Study Limitations: As we mentioned above, we excluded patients from this study with major factors that may affect bone density. However, since we could not access all the medical records of the patients, we could not take into account the situations that might little effect on the BMD of study patients, such as smoking, corticosteroid use, alcohol use, and familial history of hip fracture.

Consent for publication

The author's consent to the publication of the data.

Funding

This research received no external funding.

Conflict of interests

The authors declare that they have no conflict of interest.

List of Abbreviations

BMD, bone mineral density; DXA, dual X-ray absorptiometry; WHO, World Health Organization; BMI, body mass index.

References

1. Sartoris DJ, Resnick D. Dual-energy radiographic absorptiometry for bone densitometry: Current status and perspective. AJR 1989; 152:241-246.
2. Zhao R, Zhao M, Zhang L. Efficiency of jumping exercise in improving bone mineral density among premenopausal women: A meta-analysis. Sports Med 2014; 44: 1393-1402.
3. Vondracek SF, Hansen LB, McDermott MT. Osteoporosis risk in premenopausal women. Pharmacotherapy 2009; 29: 305-317.
4. Varney LF, Parker RA, Vincelette A, Greenspan SL. Classification of osteoporosis and osteopenia in postmenopausal women is dependent on site-specific analysis. J Clin Densitom 1999; 2: 275-283.
5. Woodson G. Dual X-ray absorptiometry T-score concordance and discordance between the hip and spine measurement sites. J Clin Densitom 2000; 3: 319-324.
6. World Heath Organization. WHO scientific group on the assesment of osteoporosis at primary health care level: Summary meeting report 2004; 1-17 (WHO, Geneva, Switzerland, 2007).
7. Kanis JA, Burlet N, Cooper C, et al. European guidance for the diagnosis and management of osteoporosis in postmenopausal women. Osteoporos Int 2008; 19: 399-428.
8. Karlsson MK, Obrant KJ, Nilsson BE, Johnell O. Changes in bone mineral, lean body mass and fat content as measured by dual energy X-ray absorptiometry: a longitudinal study. Calcif Tissue Int 2000; 66: 97-99.
9. Singh M, Arora S, Kaur A, Ghildiyal S, Kumar R. Patterns of age- and sex-related variations in bone mineral density of lumbar spine and total femur: A retrospective diagnostic laboratory-based study. J Midlife Health 2018; 3: 155-161.
10. Guthrie JR, Ebeling PR, Hopper JL, et al. A prospective study of bone loss in menopausal Australian-born women. Osteoporos Int 1998; 8: 282-290.
11. Warming L, Hassager C, Christiansen C. Changes in bone mineral density with age in men and women: A longitudinal study. Osteoporos Int 2002; 13: 105-112.
12. Rathnayake H, Lekamwasam S, Wickramatilake C, Lenora J. Trabecular bone score and bone mineral density reference data for women aged 20–70 years and the effect of local reference data on the prevalence of postmenopausal osteoporosis: a cross-sectional study from Sri Lanka. Arch Osteoporos 2019; 14: 91.
13. World Health Organization. Assessment of fracture risk and its application to screening for postmenopausal osteoporosis. Geneva, Switzerland: 2004.
14. Genant HK, Engelke K, Fuerst T, et al. Noninvasive assessment of bone mineral and structure: State of the art. J Bone Miner Res 1996; 11: 707-730.
15. Cummings SR, Black D. Bone mass measurements and risk of fracture in Caucasian women: A review of findings from prospective studies. Am J Med 1995; 98: 24-28.
16. Marshall D, Johnell O, Wedel H. Meta-analysis of how well measures of bone mineral density predict occurrence of osteoporotic fractures. BMJ 1996; 312: 1254-1259.
17. Agarwal S, Uppin RB. Effect of obesity on osteoporosis: A DEXA scan-based report in urban population of Belagavi. Journal of the Scientific Society 2006; 43: 67.
18. Ito M, Lang T, Jergas M, et al. Spinal Trabecular Bone Loss and Fracture in American and Japanese Women. Calcif Tissue Int 1996; 61: 123 -128.
19. Ponnusamy KE, Iyer S, Gupta G, Khanna AJ. Instrumentation of the osteoporotic spine: biomechanical and clinical considerations. Spine J 2011; 1: 54-63.
20. Shao Z, Rompe G, Schiltenwolf M. Radiographic changes in the lumbar intervertebral discs and lumbar vertebrae with age. Spine (Phila Pa 1976) 2002; 3: 263-268.
21. Koeller W, Muehlhaus S, Meier W. Biomechanical properties of human intervertebral discs subjected to axial dynamic compression: influence of age and degeneration. J Biomech 1986; 19: 807-816.
22. Choe HS, Lee JH, Min DK, Shin SH. Comparison of vertebral and femoral bone mineral density in adult females. Journal of physical therapy science 2016; 6: 1928-1931.

23. Choi JS, An KC, Lee CS, Choi JM. DEXA T-score concordance and discordance between hip and lumbar spine. J Korean Spine Surg 2003; 10: 75-81.

24. Lin YC, Lyle RM, Weaver CM, et al. Peak spine and femoral neck bone mass in young women Bone 2003; 5: 546-553.

25. Lofman OL, Toss LG. Bone mineral density in diagnosis of osteoporosis: Reference population, definition of peak bone mass and measured site determine prevalence. J Clin Densitom 2000; 2: 177-186.

26. Fink HA, Harrison SL, Taylor BC, et al. Differences in Site-Specific Fracture Risk Among Older Women with Discordant Results for Osteoporosis at Hip and Spine: the Study of Osteoporotic Fractures. J Clin Densitom 2008; 2: 250-259.

27. Giraudeau FS, McGinnis RE, Gray IC, et al. Characterization of common genetic variants in cathepsin K and testing for association with bone mineral density in a large cohort of perimenopausal women from scotland. J Bone Miner Res 2004; 1: 31-41.

28. Lee C, Lee J, Han S, et al. Site-specific and time-course changes of postmenopausal osteoporosis in rat mandible: comparative study with femur. Sci Rep 9 2019; 14155.

29. Cummings SR, Black D. Bone mass measurements and risk of fracture in Caucasian women: A review of findings from prospective studies. Am J Med 1995; 98: 24-28.

30. Cho Y, Lee I, Ha SH, Park JH, Park JH. Comparison of hip subregion bone mineral density to the type of proximal femur fracture. Arch Osteoporos 2020; 15: 122.

31. Li Y, Lin J, Cai S, et al. Influence of bone mineral density and hip geometry on the different types of hip fracture. Bosn J Basic Med Sci 2016; 1: 35-38.