ZKTB ORIGINAL RESEARCH

Normal Bone Mineral Density Measurements in Pubertal Males and Females: A Cross-Sectional DXA Study Abstract

Puberte Dönemindeki Erkeklerde ve Kızlarda Normal Kemik Mineral Yoğunluk Ölçümleri: Kesitsel Bir Dxa Çalışması

Dr. Sevin AYAZ, MD, Nuclear Medicine Specialist [1]

1. Department of Medical Imaging Techniques, Toros University, Vocational School; Department of Nuclear Medicine, Mersin City Training and Research Hospital, Mersin, Turkiye

ABSTRACT

Objective: *Our main goal was to present normal BMD measurements in pubertal males and females in order to make contribution to the the database of normative BMD values in our country.*

Material and Methods: *In this study 30 pubertal subjects (14 males, 16 females) with Tanner stage II-V having normal BMD values were enrolled. The mean ages of the male and female groups were 13.6±1.4 and 13.7±1.6 years, respectively (P>0.05). The BMD measurements of lumbar spine (L1-4) and femoral neck were done by dual x-ray absorptiometry (DXA). Lumbar and femoral BMD measurements of male and female subjects were compared. Lumbar and femoral neck BMD values were correlated with the age, weight, height and body mass index of the subjects within each gender groups.*

Results: *There was no significant difference between mean ages, mean weight, mean height and mean BMI of male and females (P>0.05). The mean lumbar BMD value was statistically higher in pubertal females compared to males (P<0.05). There was significant correlation between the mean age and the mean lumbar BMD measurements in female group (P<0.05). There was significant correlation between the mean weight and the mean BMD measurements (lomber and femoral BMD) in male group (P<0.05).*

Conclusion: *In conclusion, DXA is a useful, fast and accurate diagnostic tool for performing BMD measurements of lumbar spine (L1-4) and femoral neck in pubertal males and females.*

Keywords: *bone density, femur neck, lumbar vertebrae, puberty*

ÖZET

Amaç: *Ülkemizdeki normal kemik mineral yoğunluğu (KMY) veritabanına katkıda bulunmak için puberte döneminde erkeklerde ve kızlarda normal kemik mineral yoğunluk (KMY) ölçümlerini sunmayı amaçladık.*

Gereç ve Yöntemler: *Bu çalışmaya puberte döneminde olan, normal KMY değerlerine sahip, Tanner evre 2-5 arasındaki 30 olgu (14 erkek, 16 kız) dâhil edildi. Erkek ve kız gruplarının yaş ortalamaları sırasıyla 13.6±1.4 and 13.7±1.6 yıl idi (p>0.05). Lomber (L1-4) ve femur boynu KMY ölçümleri dual enerji X-ışını absorbsiyometri (DXA) ile yapıldı. Erkek ve kızların lomber ve femoral KMY ölçümleri karşılaştırıldı. Her cinsiyet grubu içinde lomber ve femoral KMY değerleri yaş, ağırlık, boy ve vücut kitle indeksi (VKİ) ile korele edildi.*

Bulgular: *Erkek ve kızların ortalama yaşları, ağırlıkları, boyları ve VKİ'leri arasında anlamlı farklılık bulunmadı (P>0.05). Pubertal kızların ortalama lomber KMY değerleri erkeklerinkinden anlamlı olarak daha yüksekti (P<0.05). Kızların grubunda ortalama yaş ile ortalama lomber KMY ölçümleri arasında anlamlı korelasyon mevcuttu (P<0.05). Erkeklerin grubunda ortalama ağırlık ile ortalama KMY ölçümleri (lomber ve femoral) arasında anlamlı korelasyon mevcuttu (P<0.05).*

Sonuç: *Sonuç olarak DXA, pubertal erkek ve kızlarda lomber (L1-4) ve femur boynu KMY ölçümlerinde yararlı, hızlı ve doğruluğu yüksek bir tanısal araçtır.*

Anahtar Kelimeler: *kemik dansitesi, femur boynu, lumbar vertebra, puberte*

Contact:
Corresponding Author: Sevin AYAZ, MD.
Adress: Toros Unv., Vocational School; Dept. of Nuclear Medicine, Mersin City Training and Research Hosp., Mersin, Turkiye
e-Mail: sevinayaz@yahoo.com
Phone: +90 (537) 763 9443
Submitted: 25.01.2019
Accepted: 06.02.2019
DOI: http://dx.doi.org/10.16948/zktipb.517609

INTRODUCTION

Osteoporosis can be a risk factor for health not only for the adult population but for the pediatric age group [1−3], as well. Actually, rather using osteopenia and osteoporosis based on bone mineral density (BMD) findings alone, the use of the term "low for age" was stated to be more proper in younger patients with a BMD which falls more than 2 standard deviations (SDs) under expected [4]. Proper diagnosis of osteoporosis in pediatric age group including pubertals is extremely important to avoid inappropriate treatment [3, 5]. Dual photon absorptiometry has been used to measure lumbar spine bone mineral density (BMD) in children for almost 30 years [6]. BMD measurements have always attracted attention clinically and many researches including different pediatric age and patient groups have been conducted [1, 6−12]. Today, dual x-ray absorptiometry (DXA) has become the the gold standard method for measuring BMD both in adults and children [13−17].

Relatively less ionizing radiation in DXA, besides its accuracy and short examination time which abolishes the need for sedation in younger children are the reasons for its being preferred also in pediatric age group [18]. However, reference-related errors such as using T-score to diagnose osteoporosis which is not suitable for pediatric age group, besides utilizing a reference BMD data pool that does not take gender or ethnic diversities into consideration constitute the most common reasons of misdiagnosis of osteoporosis in pediatric age group including pubertal subjects [5, 19]. Also the peripubertal period is a particular length of time having utmost significance for maintaining the present and future status of bone health [20]. So our main goal was to present normal BMD measurements (primarily the BMD values or bone mineral content as g/cm²) in pubertal males and females in order to make contribution to the the database of normative BMD values in our country. We also aimed to compare BMD measurements of pubertal male and female subjects, and wanted to evaluate the relationship between BMD measurements and age, weight, height and BMI of the subjects.

MATERIAL AND METHOD

Between years 2010 and 2011, 54 consecutive outpatient caucasian pubertal subjects who already underwent BMD measurements and who did not give any history of medications and chronic diseases that might affect bone turnover were recruited in the first selection in this cross-sectional retrospective study which conformed to the ethics granted by the institution. The present study was conducted in accordance with the World Medical Association Declaration of Helsinki (revised in 2000, Edinburgh). All the subjects' parents were informed about BMD measurements and consent was obtained from them. Twenty-four patients were excluded either because their BMD measurements were low for age (consistent with osteoporosis/osteopenia) in lumbar/femoral neck measurements and/or because their percentiles regarding their weight and height were far beyond Turkish standards (under 3 percentile or over 97 percentile) [21]. The rest 30 pubertal subjects (14 males, 16 females) with Tanner stage II-V [22] having normal BMD values according to Gökşen at al [17] and to the data obtained from the National Health and Nutrition Examination Survey (NHANES) 2005–2008 [23], were enrolled in the study. With regard to above mentioned NHANES 2005–2008 data, the lumbar spine (L1-4) and femoral neck BMD of pubertal males were between 25–95 percentile and 15–95 percentile, respectively. According to the same NHANES 2005–2008 data, the lumbar spine (L1-4) and femoral neck BMD of pubertal females were between 25–95 percentile and 5–95 percentile, respectively. Chronological age was calculated as decimal age by means of years [16]. The mean ages of the subjects with standard deviations (SDs) in male and female groups were 13.6±1.4 and 13.7±1.6 years, respectively.

The BMD measurements of lumbar spine (L1-4) and femoral neck were accomplished in anteroposterior projection by a DXA device (Lunar Prodigy Advance; GE Medical Systems-Lunar, Madison, WI, USA). Quality control was done by using an approved phantom every day. For lumbar measurements the subjects were in supine position with the knees elevated and supported for minimizing lumbar lordosis. Lateral lumbar spine measurements were not performed in order to minimize the exposure to ionizing radiation. Femoral neck positioning and measurements were done in accordance with the instructions for proper use of device. For standardization, left femoral neck measurements were included in the study.

The DXA device in the study presented the BMD measurements of lumbar spine (L1-4) as BMD values (g/cm²) and as Z-scores. However, because of the software limitations of the device, we could not get Z-scores of femoral neck BMD but we rather obtained femoral neck BMD values as g/cm². We obtained height and weight of the subjects prior to BMD measurements, and calculated body mass index (BMI) as: weight (kg)/height (m)² [24, 25].

STATISTICAL ANALYSIS

The mean values, standard deviations and %95 confidence intervals (Cıs) were calculated for all the quantitative variables. Lumbar BMD values besides Z-scores of male and female subjects were compared statistically by independent sample t-test. Femoral neck BMD values of male and female subjects were compared with each other statistically by independent sample t-test. Lumbar and femoral neck BMD values in male and female subjects were correlated with the age, weight, height and BMI of the subjects within each gender groups using Pearson correlation test. P values <0.05 were accepted as statistically significant. All analyses were done with SPSS software (version 16.0; SPSS Inc; Chicago, IL, USA).

RESULTS

The mean ages of pubertal males and females, their mean weight, mean height and mean BMI with their %95 CIs were given in Table 1.

Table 1: The mean ages of males and females, their mean weight, mean height and mean BMI with their standard deviations and %95 confidence intervals.

	Pubertal males (n=14)	Pubertal females (n=16)	P value*
Mean age ±SD with %95 CI (years)	13.6±1.4 (%95 CI: 12.4−14.8)	13.7±1.6 (%95 CI: 12.8−14.7)	0.882
Mean weight ±SD with %95 CI (kg)	51.1±12.4 (%95 CI: 40.7−61.4)	54.4±8.6 (%95 CI: 49.2−59.6)	0.477
Mean height ±SD with %95 CI (cm)	160.6±12.2 (%95 CI: 150.5−170.8)	159.2±7.2 (%95 CI: 154.8−163.5)	0.730
Mean BMI ±SD with %95 CI (kg/m)²	19.9±4.7 (%95 CI: 16.1−23.6)	21.5±3.7 (%95 CI: 19.3−23.7)	0.360

**P-values < 0.05 are considered as statistically significant. BMI: Body mass index, SD: Standard deviation, CI: Confidence interval.*

There was no significant difference between mean ages, mean weight, mean height and mean BMI of male and females (P>0.05). The mean lumbar and femoral BMD measurements for pubertal males and females with their SDs and %95 CIs were given in Table 2.

Table 2: The mean lumbar and femoral BMD measurements for pubertal males and females with their standard deviations and %95 confidence intervals.

BMD measurements	Pubertal males (n=14)	Pubertal females (n=16)	P value*
L1-4 (g/cm²)	0.930±0.092 (%95 CI: 0.854−1.008)	1.022±0.079 (%95 CI: 0.975−1.070)	0.025
L1-4 (Z-score)	-0.1±0.8 (%95 CI: -0.8−0.6)	0.0±0.7 (%95 CI: -0.4−0.4)	0.811
Femoral neck (g/cm²)	0.964±0.121 (%95 CI: 0.862−1.065)	0.960±0.088 (%95 CI: 0.907−1.013)	0.933

**P-values < 0.05 are considered as statistically significant. BMD: Bone mineral density, SD: Standard deviation, CI: Confidence interval.*

The mean lumbar BMD value was statistically higher in pubertal females compared to males (P<0.05). The correlations between ages, BMI of pubertal groups (males and females) and their BMD measurements of lumbar and femoral neck regions were given in Table 3. There was significant correlation between the mean age and the mean lumbar BMD measurements in female group (P<0.05). There was significant correlation between the mean weight and the mean BMD measurements (lomber and femoral BMD) in male group (P<0.05).

Table 3: The correlations between ages, BMI of pubertal groups (males and females) and their BMD measurements of lumbar and femoral neck regions.

	L1-4 (g/cm²)	Femoral neck (g/cm²)
Age of pubertal male group	r=0.473 P=0.236	r=-0.062 P=0.884
Age of pubertal female group	r=0.571 P=0.042	r=0.397 P=0.18
Weight of pubertal male group	r=0.739 P=0.036	r=0.755 P=0.030
Weight of pubertal female group	r=0.461 P=0.113	r=0.230 P=0.449
Height of pubertal male group	r=0.439 P=0.277	r=0.124 P=0.770
Height of pubertal female group	r=0.437 P=0.136	r=0.551 P=0.051
BMI of pubertal male group	r=0.410 P=0.313	r=0.649 P=0.082
BMI of pubertal female group	r=0.184 P=0.548	r=-0.093 P=0.764

**P-values <0.05 are considered as statistically significant. BMI: Body mass index, BMD: Bone mineral density.*

DISCUSSION

In healthy individuals, bone mass shows a gradual increase during childhood years with its highest levels at the end of adolescent period or early adulthood [16].Kröger et al. [7] reported that the annual increases of BMD and bone volumetric density, in both vertebrae and femoral neck were most marked in females at the time of menarche (during 11–13 years of age), and in males between 13–17 years of age. Puberty is of utmost siginificance in the developmental process of bone [12]. In the present study we did not obtain extreme lumbar and femoral BMD values in both of our male and female were groups, and our results were quite close to those of other wide-scale nationwide studies including thousands of subjects such as NHANES 2005–2008 which was conducted in the United States [23].

In the present study, the mean lumbar BMD value was statistically higher in pubertal females compared to males which was consistent with the results of Hasanoğlu et al [18], due to the fact that puberty begins earlier in the former group as they stated. Since Z-score represents the SDs from the mean for gender, age and height, the use of Z-scores for reporting BMD in children was stated as a must [20]. In the present study, besides obtaining lumbar BMD values as g/cm² we also obtained Z-scores for that region. there was no significant difference between their Z-scores which proved the reliability of Z-score in the diagnosis of osteoporosis in pediatric age group. DXA measurements of the femoral neck was stated to be unreliable in subjects younger than 13 years because of the obstacles in demonstrating the bony landmarks [26]. Since the mean ages of our subjects were higher than 13 years in both groups, we could realibly use femoral neck measurements in our study. We could not find statistically significant difference between femoral BMD of males and females in the present study which was consistent with the results of Hasanoğlu et al [18] who explained this by the abundance of cortical bone in femoral neck compared to lumbar vertebrae, causing slower bone turnover during puberty in the former region. The height adjustment of DXA data is also extremely important to abolish interpretation errors particularly in children with short stature[20]. Because of this we used standardized measuring devices which were recommended by the manufacturer, not only for recording the exact height of children but for precise measurement of their weight.

Though in several studies lumbar and femoral neck BMD of both males and females showed an increase by age, weight, height and BMI [12, 16, 17] in the present study only the mean age of pubertal female group showed positive correlation with lumbar BMD values and only the mean weight of pubertal male group showed positive correlation with lumbar and femoral BMD values (Table 3). We consider that this was the result of limited number of subjects and relatively lower mean age in both groups which was a limitating factor for the presence of enough time that is necessary for a sufficient increase in BMD of pubertal subjects for making positive correlations between BMD and age in males, between BMD of females and their weight, height, BMI, and between BMD of males and their height, BMI. In their study with 65 children and adolescents, Kröger et al [7] reported that their findings were consistent with the theory that the highest bone mass is dominantly acquired in late adolescence, which explained the scarceness of positive correlations between BMD measurements and age, weight, height, BMI in our subjects, most of whom were younger than late adolescents. Since the pubertal process starts earlier in females compared to males, we thought that age had more effect on the BMD of females compared to males in the present study. We believe that further studies with larger pubertal groups can provide more data about the relationship between BMD measurements of pubertal subjects and their age, weight, height and BMI. However we consider that we reached our main goal which was to present normal BMD values in pubertal males and females besides adding data to the pool of normative BMD values in our country.

We had some some limitations in the present study mostly because of its retrospective design. Firstly, we had a relatively smaller study population. Because of this we could not stratify our subjects according to their ages such as year by year. But since we included only the pubertal subjects, their ages were relatively closer to each other which was in favour of studying with a relatively homogeneous group, as compared to a heterogeneous group including subjects from whole childhood period. Secondly, we could not compare our results with those of prepubertal children which could help us understand BMD changes through pubertal period. And thirdly, due to the software limitations of the DXA device, we could not obtain Z-scores of femoral neck BMD, but we rather obtained BMD values as g/cm² which was also useful for calculating mean values and for statistical purposes. Nevertheless, we consider that the findings we obtained will add data to other studies performed in different regions in our country.

In conclusion, DXA is a useful, fast and accurate diagnostic tool for performing BMD measurements of lumbar spine (L1-4) and femoral neck in pubertal males and females. Regarding the same age group, the lumbar BMD tends to be higher in pubertal females compared to males since puberty begins earlier in females.

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I cordially thank Dr. Durmuş Zaimoğlu and Dr. Ümit Yaşar Ayaz for their kind efforts and contributions.