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Bone Mineral Density of the Spine and Femur in Healthy Saudi Females: Relation to Vitamin D Status, Pregnancy, and Lactation

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Abstract. Bone mineral density (BMD) measurements of the anterio-posterior lumbar spine and the proximal femur using dual-energy x-ray absorptiometry, as well as relevant clinical and biochemical parameters, were determined in 321 healthy Saudi females in order to establish reference values and to study the effects of physical and lifestyle factors on BMD. Mean ± SD of age, body mass index (BMI), number of pregnancies, and total duration of lactation were 35.4 ± 11.3 years, 26.5 ± 5.2 kg/m^2, 3.1 ± 3.1, and 23.7 ± 42.4 months, respectively. Mean ± SD of serum calcium, 25-hydroxyvitamin D (25OHD), and PTH levels were 2.37 ± 0.09 mmol/liter, 24.5 ± 17.2 nmol/liter, and 52.0 ± 30.8 pg/ml, respectively. Peak BMD values were observed around age 35 years at the spine and earlier at the femur. Compared with USA females, Saudi females had lower weight-matched Z scores at the spine (−0.126 ± 1.078, $P = 0.04$), femoral neck (−0.234 ± 0.846, $P < 0.0001$), and Ward's triangle (−0.269 ± 1.015, $P < 0.0001$). Further, the prevalence of osteopenia and osteoporosis in subjects ≥31 years old were 18–41% and 0–7%, respectively, depending on the site examined. Severe hypovitaminosis D (25OHD level ≤20 nmol/liter) was present in 52% of the subjects. However, there was no correlation between 25OHD level and BMD at any site. Parathyroid hormone (PTH) levels correlated significantly with 25OHD levels ($r = -0.28$, $P < 0.0001$) and with weight-matched BMD Z scores at the spine ($r = -0.17$, $P = 0.005$), femoral neck ($r = -0.16$, $P = 0.007$), and Ward's triangle ($r = -0.2$, $P = 0.0008$), suggesting that the distribution of 25OHD levels in the cohort is below the threshold needed for maintaining normal BMD. On the other hand, number of pregnancies and total duration of lactation correlated with weight-matched BMD Z scores at the spine ($r = -0.17$, $P = 0.003$; $r = -0.1$, $P = 0.08$, respectively). We conclude that BMD in healthy Saudi females is significantly lower than in their USA counterparts. This may be due in part to increased number of pregnancies and longer duration of lactation together with prevalent vitamin D deficiency.

Osteoporosis, a major health problem worldwide [1, 2], is characterized by low bone mass and microarchitectural deterioration of bone structure [3, 4]. Bone mass is determined by peak bone mass and the rate of bone loss; both are in turn influenced by genetic, environmental, and hormonal factors [5]. Ethnic and racial variations of bone density are therefore expected [6–15].

Vitamin D deficiency, an established risk factor for decreased bone mass, is common in Saudi Arabia [16]. Furthermore, the high rate of pregnancy and longer duration of breast feeding in Saudi females compared with western females may affect calcium balance and bone density [17–21].

The aims of the study were to (1) establish normative data for bone mineral density (BMD) at the anterio-posterior lumbar spine and femur in Saudi females using dual x-ray absorptiometry (DXA), (2) compare BMD of Saudi females and their USA counterparts, and (3) examine the relationship of BMD to vitamin D status, pregnancy, and lactation.

Materials and Method

Subjects

Three hundreds and twenty-one healthy Saudi female volunteers were recruited from the city of Riyadh, Saudi Arabia through advertisements in local newspapers and local hospitals. Informed consent was obtained from all subjects (or their parents), and the study was approved by the Research Advisory council, King Faisal Specialist Hospital and Research Centre. A questionnaire including age, age at menarche, age at menopause, number of pregnancies, months of lactation, smoking, alcohol intake, medical history, and drugs, was obtained from all volunteers. Subjects who had a medical illness or were on drugs known to interfere with calcium metabolism were excluded from the study. All subjects were ambulatory and none was pregnant or had a history of fracture. Subjects were weighed on an electric scale wearing minimal clothing. Height was measured to the nearest centimeter using a stadiometer. Body mass index (BMI) was calculated as weight (kg)/height (m)^2. Blood was drawn in the fasting state to determine serum calcium and calcitropic hormones levels. The blood was drawn on recruitment which occurred over all four seasons of the year.

Bone Mineral Density Measurements

BMD measurements were determined at the lumbar spine (L2–L4) anterio-posteriorly and at the left femoral neck, Ward's triangle, and trochanter using DXA with DPX Version 3.6 scanner (Lunar Corp., Madison, WI) according to the manufacturer's operator manual. All measurements were performed at the Section of Nuclear Medicine, King Faisal Specialist Hospital and Research Centre by one of two experienced technologists and reviewed by a nuclear medicine physician. The calibration of the absorptiometer

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Table 1. Clinical and biochemical characteristics[a] of 321 healthy Saudi females

Age (year)	Number	S Ca (mmol/liter)	25OHD (nmol/liter)	PTH (pg/ml)	Pregnancy (number)	BMI (kg/m^2)	Lactation (month)
10–20	29	2.39 ± 0.06	26.5 ± 26.9	44.0 ± 23.5	—	21.8 ± 3.4	—
21–30	91	2.36 ± 0.1	22.8 ± 15.6	45.5 ± 25.4	1.2 ± 1.6	24.6 ± 4.5	6.8 ± 12.5
31–40	98	2.35 ± 0.09	24.1 ± 15.6	55.9 ± 32	3.8 ± 2.7	26.8 ± 4.1	26.4 ± 36
41–50	71	2.37 ± 0.09	24.7 ± 16.2	55.8 ± 36.9	4.6 ± 2.9	28.8 ± 5.5	31.9 ± 40.4
>50	32	2.42 ± 0.06	28.6 ± 18.3	56.3 ± 28.7	6 ± 3.9	30.8 ± 5.8	72.4 ± 84.3
Total	321	2.37 ± 0.09	24.5 ± 17.2	52.0 ± 30.8	3.1 ± 3.1	26.5 ± 5.2	23.7 ± 42.4

[a] Mean ± SD. S Ca, serum calcium; 25OHD, 25-hydroxyvitamin D; BMI, body mass index

Table 2. BMD[a] of lumbar spine and femur of 321 healthy Saudi females

Age (year)	L2–L4	Femoral neck	Ward's triangle	Trochanter
10–20	1.130 ± 0.113	0.981 ± 0.104	0.931 ± 0.145	0.808 ± 0.115
21–30	1.145 ± 1.161	0.930 ± 0.12	0.884 ± 0.149	0.765 ± 0.112
31–40	1.181 ± 0.131	0.937 ± 0.119	0.847 ± 0.137	0.784 ± 0.114
41–50	1.173 ± 0.162	0.947 ± 0.112	0.832 ± 0.125	0.800 ± 0.117
>50	0.997 ± 0.243	0.857 ± 0.117	0.742 ± 0.164	0.761 ± 0.129
Total	1.145 ± 0.167	0.933 ± 0.119	0.851 ± 0.148	0.782 ± 0.116

[a] Mean ± SD (g/cm^2)

was checked daily. The results of the measurements were expressed in g/cm^2. Lunar USA normal database supplied by the manufacturer was used to derive Z scores (matched for age and weight) and T scores (reference age 20–45 years).

Biochemical and Hormonal Measurements

Intact PTH level was determined by a two-site immunoradiometric assay (Intact PTH, Nichols Institute Diagnostics, San Juan Capistrano, CA.). The normal range intraassay and interassay variation supplied by the manufacturer are 10–65 pg/ml, 1.8–3.4%, and 5.6–6.1%, respectively. 25OHD level was determined by radioimmunoassay (Nichols Institute Diagnostics, San Juan Capistrano, CA). The normal range, intraassay, and interassay variation supplied by the manufacturer are 16–74 ng/ml, 8.1–10.2%, and 10.9–15%, respectively. The subjects were divided according to their serum 25-hydroxyvitamin D levels [22] into those with severe hypovitaminosis D (25OHD level ≤20 nmol/liter) and those with moderate hypovitaminosis D or adequate vitamin D stores (25OHD level >20 nmol/liter). All hormonal and biochemical measure-ments were performed in the clinical laboratory at King Faisal Specialist Hospital and Research Centre.

Statistical Analysis

Data were analyzed using JMP version 3.1 (SAS Institute, Cary, NC). Values were expressed as mean ± standard deviation (SD). To test if BMD of healthy Saudi females is different from BMD of USA healthy females, Z scores of Saudi females (derived using USA normal database) were compared with zero using the *t*-test. The percentage of individuals with osteopenia or osteoporosis were calculated according to World Health Organization (WHO) criteria [23]. Correlation was measured by Pearson's correlation coefficient. Linear and polynomial regression were used to calculate the best curve fit for BMD versus age and BMI. The two-tailed *t*-test was used to compare BMD in the subgroup with severe hypovitaminosis D with the rest of the cohort. Differences were considered statistically significant at $P < 0.05$.

Results

Three hundred and twenty-one healthy Saudi females were recruited for the study. All had normal serum calcium and phosphate levels. Two percent of the subjects had mildly elevated alkaline phosphatase levels. Mean alkaline phosphatase and albumin levels were 72.7 ± 32.9 U/liter and 40.7 ± 2.4 g/liter, respectively. The mean ± SD of height and weight were 158.1 ± 6.2 cm and 66.4 ± 13.0 kg, respectively. The cohort was divided into five age groups. The relevant clinical and biochemical characteristics of each age group are shown in Table 1.

Bone Mineral Density of the Lumbar Spine and Femur

Table 2 summarizes BMD at the anterio-posterior lumbar spine (L2–L4) and three sites of the femur. Peak BMD at the lumbar spine was seen in the 31–40 year age group. BMD at Ward's triangle had an apparent peak in the 10–20 year age group. For BMD at femoral neck and trochanter, there were two apparent peaks—one in the 10–20 year age group and one in the 41–50 year group.

BMD values of the femoral neck and trochanter in the 10–20 year group had normal distribution with minimum, median, and maximum values of 0.783, 0.998, and 1.232 g/cm^2 (femoral neck) and 0.583, 0.807, and 1.038 g/cm^2trochanter). The corresponding values in the next age group (21–30 years) were 0.686, 0.926, and 1.257 g/cm^2 (femoral neck) and 0.530, 0.766, and 1.068 g/cm^2 (trochanter) which also had normal distribution. The means of the two groups were statistically different for both femur neck and trochanter.

Comparison of BMD in Healthy Saudi Females and Their USA Counterparts

Table 3 shows BMD T and Z scores of healthy Saudi fe-

Table 3. BMD T and Z scores[a] of lumbar spine and femur

Age years	T				Z			
	L2–L4	Neck	Ward	Trochanter	L2–L4	Neck	Ward	Trochanter
10–20	−0.031 ± 0.843	0.283 ± 0.856	0.560 ± 1.207	−0.430 ± 2.415	0.551 ± 0.601	0.274 ± 0.462	−0.290 ± 1.362	0.210 ± 1.465
21–30	−0.364 ± 0.985	−0.420 ± 0.996	−0.198 ± 1.148	−0.225 ± 1.017	−0.188 ± 0.926	−0.397 ± 0.891	−0.233 ± 1.063	−0.132 ± 0.917
31–40	−0.128 ± 1.020	−0.357 ± 0.992	−0.490 ± 1.050	−0.050 ± 1.034	−0.102 ± 0.966	−0.309 ± 0.876	−0.358 ± 0.967	−0.099 ± 0.933
41–50	−0.228 ± 1.349	−0.284 ± 0.916	−0.603 ± 0.960	0.102 ± 1.060	−0.159 ± 1.315	−0.117 ± 0.841	−0.239 ± 0.887	−0.035 ± 0.926
>50	−1.447 ± 1.590	−1.024 ± 0.972	−1.298 ± 1.258	−0.261 ± 1.171	−0.484 ± 1.336	−0.216 ± 0.716	−0.192 ± 0.999	−0.006 ± 0.929
Total	−0.368 ± 1.223	−0.421 ± 0.993	−0.493 ± 1.134	−0.099 ± 1.105	−0.126 ± 1.078	−0.234 ± 0.846	−0.269 ± 1.015	−0.057 ± 0.978

[a] Mean ± SD (compared to USA females). The reference age for T scores is 20-45 years. Z scores are weight-matched

males using healthy USA females as controls. The prevalence of osteopenia (T score lower than −1 SD) and osteoporosis (T score lower than −2.5 SD) in healthy Saudi females, according to age group, are summarized in Table 4.

Z scores were significantly lower than zero (using two-tailed *t*-test) for the whole cohort at the lumbar spine ($P = 0.04$), femoral neck ($P < 0.0001$), and Ward's triangle ($P < 0.0001$). Z scores were also significantly lower than zero at the femoral neck ($P < 0.0001$) and Ward's triangle ($P = 0.04$) for 21–30 year age group; femoral neck ($P = 0.0009$) and Ward's triangle ($P = 0.0005$) for 31–40 year age group; and at Ward's triangle ($P = 0.03$) for 41–50 year age group. However, in the 10–20 year age group, Z scores were significantly higher than zero at the lumbar spine ($P < 0.0001$) and femoral neck ($P = 0.006$). The later observation could not be explained by an earlier age of menarche in Saudi compared with USA females as the mean ± SD age of menarche in Saudi females was 12.8 ± 1.64 years.

Correlation of BMD with Clinical and Biochemical Parameters

There were linear correlations between age and BMD at the spine and femur and polynomial correlations between BMI and BMD at the spine and femur (Table 5). Height was also correlated positively with BMD at the spine ($r = 0.17$, $P = 0.003$), femoral neck ($r = 0.23$, $P < 0.0001$), and Ward's triangle ($r = 0.19$, $P = 0.0005$).

As shown in Table 6, number of pregnancies and total duration of lactation correlated negatively with BMD at the spine and Ward's triangle. To examine the association of BMD with pregnancy and lactation independently, the cohort was divided into those with ≤3 pregnancies (59%) or >3 pregnancies (41%) and those with total duration of lactation of ≤5 months (51%) or >5 months (49%). In the subgroup with >3 pregnancies, total duration of lactation correlated with BMD at the spine ($r = -0.28$, $P = 0.003$). On the other hand, number of pregnancies correlated with BMD at Ward's triangle ($r = -0.21$, $P = 0.01$) in the subgroup with ≤5 pregnancies and with BMD at the spine ($r = -0.3$, $P = 0.0003$) in the subgroup with >5 pregnancies. Furthermore, there was a negative correlation between BMD Z scores at the spine and number of pregnancies ($r = -0.17$, $P = 0.003$) and duration of lactation ($r = -0.1$, $P = 0.08$). The correlation of BMD with the number of pregnancies was further examined in each age group. Number of pregnancies correlated with BMD at the spine ($r = -0.55$, $P = 0.002$), femoral neck ($r = -0.39$, $P = 0.03$), Ward's triangle ($r = -0.45$, $P = 0.02$), and trochanter ($r = -0.36$, $P = 0.05$) in the age group >50 years. The correlation between the number of pregnancies and BMD was not significant in other age groups.

PTH level correlated significantly with BMD at the spine, femoral neck, and Ward's triangle (Table 6). Since there was positive correlation between PTH level and age ($r = 0.13$, $P = 0.02$), we also examined the relation of PTH levels to BMD Z scores. PTH levels correlated with BMD Z scores at the spine ($r = -0.17$, $P = 0.005$), femoral neck ($r = -0.16$, $P = 0.007$), Ward's triangle ($r = -0.2$, $P = 0.0008$), and trochanter ($r = -0.11$, $P = 0.06$).

25-Hydroxyvitamin D levels correlated with serum calcium ($r = 0.23$, $P = 0.0001$), alkaline phosphatase ($r = -0.14$, $P = 0.02$), and PTH ($r = -0.28$, $P < 0.0001$) levels, and BMI ($r = -0.12$, $P = 0.04$). However, 25-hydroxyvitamin D level did not correlate significantly with BMD (or BMD Z scores) at any of the sites examined. The

Table 4. Prevalence (%) of osteopenia and osteoporosis in 321 healthy Saudi females

	L2–L4	Femoral neck	Ward's triangle	Trochanter
Age 31–40 (98)				
T < − 1 SD	19	27	38	18
T < − 2.5 SD	1	2	3.2	0
Age 41–50 (71)				
T < − 1 SD	24	23	38	16
T < −2.5 SD	5.6	1.4	5.9	0
Age > 50 (32)				
T < − 1 SD	66	47	59	22
T < − 2.5 SD	28	6	19	0
Total (201)				
T < − 1 SD	27	29	41	18
T < − 2.5 SD	7	2.5	5.1	0

The number of subjects in each group is shown in parenthesis
T = T-score

Table 5. Regression of BMD on BMI and age in 321 healthy Saudi females

	BMI		Age	
	Best fit	*P* value	Best fit	*P* value
L2–L4	1.075 + 0.0026 BMI	0.14	0.820 + 0.0216 age − 0.0003 age^2	<0.0001
Femoral neck	0.775 + 0.0059 BMI	<0.0001	0.879 + 0.0052 age − 0.00009 age^2	0.0004
Ward's Triangle	0.754 + 0.0037 BMI	0.022	0.896 + 0.0020 age − 0.00008 age^2	<0.0001
Trochanter	0.566 + 0.0082 BMI	<0.0001	0.706 + 0.0047 age − 0.00007 age^2	0.23

BMD (g/cm^2); age (year); BMI (body mass index, kg/m^2)

Table 6. Correlation[a] of BMD with clinical and biochemical parameters in 321 healthy Saudi females

	L2–L4	Femoral neck	Ward's triangle	Trochanter
25OHD	0.03 (0.6)	0.003 (0.96)	0.03 (0.7)	0.04 (0.5)
PTH	−0.14 (0.02)	−0.16 (0.006)	−0.23 (0.0001)	−0.1 (0.08)
Pregnancy	−0.14 (0.02)	−0.1 (0.08)	−0.23 (0.0001)	0.03 (0.6)
Lactation	−0.15 (0.01)	−0.08 (0.17)	−0.17 (0.005)	0.02 (0.7)

[a] Pearson correlation. Numbers in parenthesis are *P* values

cohort was divided into two groups according to 25-hydroxyvitamin D level; 52% had severe hypovitaminosis D. Compared with the rest of the cohort, this group had lower serum calcium (2.35 ± 0.09 versus 2.38 ± 0.08 mmol/liter, $P = 0.001$), and albumin (40.3 ± 2.4 versus 41.1 ± 2.2 g/liter, $P = 0.004$) levels; and higher PTH (59.0 ± 31.4 versus 44.5 ± 28.6 pg/ml, $P = 0.0001$) and alkaline phosphatase (78.6 ± 41.2 versus 66.8 ± 20.7 U/liter, $P = 0.002$) levels. However, BMD measurements of the spine and three femur sites were not significantly different between the two groups. Because the severe hypovitaminosis D group was significantly younger (33.9 ± 10.3 versus 36.9 ± 11.2 year, $P = 0.02$), we also compared Z scores of the two groups. The severe hypovitaminosis D group tended to have lower Z scores at the spine (−0.18 ± 1 versus −0.003 ± 1.2, $P = 0.19$), femoral neck (−0.28 ± 0.83 versus −0.18 ± 0.86, $P = 0.34$), Ward's triangle (−0.41 ± 1.0 versus −0.16 ± 1.0, $P = 0.05$), and trochanter (−0.16 ± 1.0 versus 0.06 ± 1, $P = 0.07$). However, none was statistically significant.

Discussion

We have provided a database of BMD at the lumbar spine, femoral neck, Ward's triangle, and trochanter in healthy Saudi females aged 12–71 years and have made the following observations: (1) spine BMD peaks at age 31–40 years, whereas femur BMDs have two apparent peaks, one at 10–20 years and one at 41–50 years; (2) healthy Saudi females have significantly lower BMD at the spine, femoral neck, and Ward's triangle than age- and weight-matched healthy USA females; (3) the prevalence of osteopenia and osteoporosis in otherwise healthy Saudi females over 31 years old ranged from 18 to 41% and 0 to 7%, respectively, depending on the site examined; (4) although vitamin D deficiency was common in the study population, 25OHD level did not correlate with any of the BMD measurements. However, 25OHD levels as well as several BMD measurements correlated negatively with PTH levels; and (5) number of

pregnancies and total duration of lactation correlated negatively with BMD measurements.

Our study has several limitations. First, the study sample may not be representative of the average healthy Saudi female. Although we advertised in local newspapers and hospitals, most of the respondents were hospital employees or their relatives. Furthermore, the population of Riyadh, the capital of Saudi Arabia, may not be representative of the population of Saudi Arabia at large. It is expected that study participants may have a more westernized lifestyle with less physical activity, calcium intake, and sun exposure, and less caloric malnutrition than average. The combined effect of these factors on BMD would be difficult to predict. Second, our sample size for ages 10–20 years and >50 years is relatively small. Third, the study is cross-sectional rather than longitudinal and the apparent BMD peaks should therefore be interpreted with caution.

Normative data for BMD in the Saudi (Arab) population have not been well established. Two previous studies examined BMD in a healthy Saudi population [15, 24]. One study measured BMD at the radius by single photon absorptiometry (SPA) [24] and the other BMD at the spine and femur by DXA [15]. Neither study determined levels of calcium or calcitropic hormones which are of particular importance given the prevalence of hypovitaminosis D in Saudi Arabia [16]. The potential effects of pregnancy and lactation on BMD [17–21] were not studied.

The lower BMD in healthy Saudi females compared with USA females that was observed in the current and previous [15] studies could not be accounted for by lower body weight, as is the case in other Asian females [8, 9, 13], since we used weight-matched Z scores. We therefore examined the possible role of vitamin D deficiency. Hypovitaminosis D was prevalent in our study population with a mean 25OHD level of 24.5 ± 17.2 nmol/liter, confirming previous reports [16]. However, we found no correlation between 25OHD level and BMD at any of the sites examined. Moreover, BMD in the subgroup with severe hypovitaminosis D did not significantly differ from BMD of the rest of the cohort.

The fact that 25OHD levels correlated positively with serum calcium levels and negatively with alkaline phosphatase and PTH levels attests to the physiologic importance of the observed low 25OHD level and makes the observed lack of effect on BMD unexpected [25, 26]. Younger individuals in our cohort tended to have lower 25-hydroxyvitamin D levels suggesting a potential confounding by age. However, there was also no correlation between 25OHD levels and BMD Z scores. Confirming previous studies [27, 28], we have found a negative association between 25-hydroxyvitamin D levels and BMI, thus, a possible confounding by BMI cannot be excluded. It is also possible that the individual 25OHD levels obtained in the current study do not accurately reflect the individual long-term mean levels, as substantial variation in 25OHD levels due to seasonality, sunlight exposure, and previous supplementation are expected [28–30]. Nevertheless, the most likely explanation of the observed lack of association between 25-hydroxyvitamin D levels and BMD is that the distribution of 25OHD levels in the cohort is below the threshold needed for maintaining normal BMD [25]. This is supported by the finding that PTH level increases as 25OHD level declines below 110–122 nmol/liter [28, 30]. In fact, a 25OHD level of 50 nmol/liter, which is well above the mean level obtained in our study, has been recently suggested to be the minimum value for vitamin D sufficiency in adults over the age of 49 years [31].

Several studies have shown that lactation can be associated with substantial BMD loss of the lumbar spine and femur [18, 19] that is related to changes in parathyroid hormone-related peptide (PTHrP), estradiol, and prolactin levels [32] but not PTH, 25OHD, and $1,25(OHD)_2D_3$ levels [33], and is largely not affected by calcium supplementation [34, 35]. The lactation-associated loss in BMD usually recovers once lactation is ceased. However, it may take up to 12 and 18 months postparturition, respectively, for the lumbar spine and femoral neck BMD to recover [19, 33]. Furthermore, it is not clear whether BMD is completely restored after weaning [34, 36, 37], especially if lactation continues for more than 9 months [19]. The influence of pregnancy on BMD is still controversial and less well studied [20, 21]. Our cross-sectional study suggests that multiple pregnancies may be independently associated with lower BMD Z scores at the spine. The relatively higher rate of pregnancies and longer duration of lactation in Saudi females could account, at least in part, for the lower BMD values compared with USA females. This could also explain the unexpected finding of higher BMD values at the femur in ages 10–20 years compared with older age groups (Table 2) and lower Z scores at the femur in the reproductive age group compared with younger and older age groups (Table 3). The latter finding supports the view that the effects of pregnancy and lactation on BMD are reversible. Nevertheless, a high yearly incidence of proximal femur fracture of 1/1000 Saudi females >50 years old has been reported [38]. This, coupled with our observation that the number of pregnancies correlated best with BMD at the spine and femur in the >50 age group suggest that the recovery from pregnancy and lactation-induced changes in BMD may not be complete by the early postmenopausal years.

In summary, we have provided normative data for BMD at the lumbar spine, femoral neck, Ward's triangle, and trochanter in healthy Saudi females. The observed BMD values are significantly low compared with USA normative data which could be due, at least in part, to increased number of pregnancies and longer duration of lactation together with prevalent hypovitaminosis D.

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