Extensive Hypovitaminosis D in Partly Veiled Saudi Arabian Premenopausal and Postmenopausal Women: Influence on Bone Health

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Abstract: The link between vitamin D and bone health is well established. However, little is known about the bone health, vitamin D status, and lifestyle characteristics of women living in Saudi Arabia. To characterize: i) bone health indices; ii) vitamin D status; iii) potential influential of sunlight exposure and physical activity level. A total of 100 premenopausal aged 20–30 years and 112 postmenopausal aged 45-60 years were included. Bone mineral density was determined at the lumbar spine and femoral neck. Serum levels of 25-hydroxyvitamin D, intact parathyroid hormone, and ionized calcium and phosphorus were measured. The subjects interviewed about their physical activity levels and lifestyle. Using the WHO criteria, 37% of the premenopausal and 52% of the postmenopausal were osteopenic at the lumbar spine. Vitamin D deficiency was highly prevalent in Saudi women, with 98% of women being below the IOM recommended level of 50nmol/L. There was a significant correlation between duration of sunlight exposure (min/day) and axial BMD and calcaneal bone mass in partly veiled women. These data indicate that younger and older Saudi Arabian women had poor bone health and that their vitamin D status and lifestyle factors do not promote skeletal integrity.
[Sawsan O. Khojah, Jalal A. Khan, Khadijah S. Balamesh , Jacqueline L. Berry, Michelle Gibbs and Susan A. Lanham-New and Fouad M.A. Dehlawi. **Extensive Hypovitaminosis D in Partly Veiled Saudi Arabian Premenopausal and Postmenopausal Women: Influence on Bone Health.** *Life Sci J* 2013;10(4):3159-3166]. (ISSN:1097-8135). http://www.lifesciencesite.com. 422

Key words: Osteoporosis, osteopenia, Saudi women, vitamin D, sunlight exposure, lifestyle factors.

1. Introduction

Association between vitamin D and bone health is well known[a]. There are few data available concerning the bone health, vitamin D status, and lifestyle characteristics of women living in Middle Eastern countries. Ghannam *et al.*[b] created a database of bone mineral density (BMD) values at the lumber spine (LS) and the proximal femur in Saudi girls and women to establish normative data for Saudi females and to compare these data with data from their counterparts in the US. The prevalence of osteopenia and osteoporosis in Saudi women were 18–41% and 0–7%, respectively, depending on the site examined. Furthermore, healthy Saudi females had significantly lower BMD values at the spine, femoral neck (FN) and femoral Ward's triangle (FW) than age- and weight-matched females in the US [b and c] giving significant concern for bone health in Saudi women that requires further investigation. Ardawi *et al.* (2005)[c] concluded that the prevalence of osteoporosis at the LS in Saudi women and men was 30.5% and 49.6%, respectively. The mean BMD values for the LS and the femoral sub regions in both Saudi men and women were lower than those reported previously in people in the US and northern Europe. [d] None of these studies, however, examined the influence of physical activity, and other lifestyle factors on skeletal health.

There are some data suggesting that vitamin D deficiency is common in Saudi Arabia, although it has not been analyzed according to age group. In 1983, Sedrani *et al.*[e] showed that 25(OH)D levels were significantly lower in elderly Saudi subjects than in younger subjects. In 1984, Fonseca [d] reported that the median concentration of plasma 25(OH)D was 15 nmol/ L (range: 5–45). In the literature, vitamin D deficiency is defined as 25(OH)D <50 nmol/L).[f and g] Ghannam *et al.* [b] reported that hypovitaminosis D (25(OH)D <50 nmol/L) was present in 52% of healthy Saudi women in their study. The implications of vitamin D status on bone health indices in this population remain undefined. Further research is urgently needed to investigate the extent of vitamin D deficiency and the prevalence of poor bone health in Saudi pre- and postmenopausal women.

Risk factors for bone health can be divided into non-modifiable and modifiable risk factors. Non-modifiable risk factors such as age, sex, and ethnicity are important for identifying high-risk individuals. Age in particular is an important risk factor for both osteoporosis and fracture.[h] Modifiable risk factors, such as low bone mass, physical activity, nutrition, and body weight can be addressed by interventions that can lessen their impact on bone health. For example, body weight is a significant predictor of bone density and fracture risk,[i] and physical activity can favorably influence the development and maintenance of bone mass and delay the progression of osteoporosis.[j]

The aims of this study were to characterize the following in pre- and postmenopausal women: i) bone health indices at the LS and FN via determination of BMD by dual-energy x-ray absorptiometry (DXA) and calcaneal bone mass by broadband ultrasound attenuation (BUA) to investigate the extent of osteopenia and osteoporosis; ii) the status of vitamin D and its metabolites in order to assess the impact on bone health indices; iii) the influence of body weight, and height on BMD; and iv) the potential influencing lifestyle factors, including physical activity level; v) The effect of sunlight exposure on bone health indices.

2. Material and methods

2.1 Subject selection

A total of 100 premenopausal women aged 20–30 years and 112 postmenopausal women aged 45–60 years were included in the study. All volunteers were recruited from the city of Jeddah using local advertisements and by distributing forms after lectures at the community meeting about the aim of the proposed investigation. The study was approved by the University Ethics Committee and was performed according to the tenets of the Declaration of Helsinki (1964). Informed signed consent was obtained from all subjects. Women with any chronic health condition or taking any medication likely to affect bone metabolism were excluded from the study.

2.2 Anthropometrics and bone mass measurements

The weight and height of each woman was recorded and her body mass index (BMI) was calculated. BMD was determined at the LS (L2-L4), FN, femoral Ward's triangle (FW), and femoral trochanter (FT) using DXA (Lunar Corp., Madison, WI, USA; DPX version 4.7). The precision of the DXA machine was 1%. Calcaneal bone mass was measured by BUA using CUBA^{plus+} V4 software. The precision of this instrument was 2.4% and 1% for BUA and velocity of sound (VOS), respectively. According to WHO criteria [11] a woman is classified as having osteoporosis if she has a t-score ≤ — 2.5. An intermediate state of low bone mass (osteopenia) is defined by a t-score between — 2.5 and — 1.0. A t-score ≥ — 1.0 was taken to be normal.

2.3 Blood and urine samples

Blood and urine samples were obtained after an overnight fast. Blood was drawn in the fasting state 5ml each into plain and lithium-heparin (LH 851. IU) evacuated tubes. After collection, the sample was allowed to clot for 70 min at room temperature and then centrifuged at 3000×g for 10 min to separate the serum and plasma. The extracted serum and plasma were stored at -85°C until they were assayed for calcium and calciotropic hormones.

2.4 Measurement of 25(OH)D, 1,25(OH)$_2$D, PTH, calcium, and phosphorus

Vitamin D metabolites were measured by in-house assays as described in detail previously. [l, m and n] Briefly; samples were extracted using acetonitrile and applied to C18 Silica Sep-paks. Separation of metabolites was by straight phase HPLC (Waters Associates, Milford, MA) using a Hewlett-Packard Zorbax-Sil Column (Hichrom, Reading, Berkshire, UK) eluted with hexane: propanol: methanol (92:4:4). Serum 25(OH)D2 and 25(OH)D3 were measured separately by application to a second Zorbax-Sil Column eluted with hexane: propan2ol (98:2) and quantified by UV absorbance at 265 nm and corrected for recovery. The sensitivity is 5 nmol/L and intra-and-inter assay CV 3.0 % and 4.2 % respectively, Berry et al (2000).[n] Following separation by HPLC, 1,25(OH)2D was quantified by radioimmunoassay as described in detail elsewhere, Mawer *et al* (1990).[m] The adult reference range is 48-120 pmol/lL, sensitivity 3 pmol/assay tube and intra-and-inter assay CV 7.8% and 10.5% respectively. The assay laboratory is accredited to ISO 9001:2000 and ISO 13485:2003 and participates in the Vitamin D Quality Assurance Scheme (DEQAS). Serum intact PTH was measured using the OCTEIA immunoenzymometric assay (Immunodiagnostic Systems Ltd., Boldon, Tyne and Wear, UK): normal adult reference range, 0.8 –3.9 pmol/liter; sensitivity, 0.06 pmol/liter; intra- and interassay coefficients of variation, 4 and 6%, respectively (manufacturer's values). Serum concentrations of calcium adjusted for albumin and inorganic phosphate were measured using the Hitachi 917 autoanalyzer (Hitachi, Tokyo, Japan). Reference ranges for corrected calcium and phosphate were 2.2–2.6 and 0.7–1.4 mmol/L respectively.

2.5 Lifestyle data

A written questionnaire was used to collect information about the women's characteristics and their lifestyle data. Specifically, subjects were asked to record the amount of time they spent walking, swimming, jogging, cycling, or performing other aerobic exercise (hours per week). Information about the duration of sun exposure (min/day) was also collected. The following data were also recorded: age, marital status, educational level, and veiling (fully veiled/partly veiled/unveiled).

2.6 Statistical analysis

Statistical analysis was conducted using the SPSS software package (version 15; SPSS Inc., Chicago, IL, USA). Descriptive statistics (means, medians, SDs, and ranges) were determined for all variables. Multilinear regression analysis was conducted to examine the relationship of percent changes in BMD with risk factors. Pearson's coefficient of correlation was used to study the linear correlation between 25(OH)D and PTH in the premenopausal and postmenopausal women. ANOVA was used to examine the differences between groups for different variables. In the tables, data are presented as mean (±SD) for each group.

3. Results

The anthropometric data are shown in Table 1. The women were of average height and weight for the local population. The average BMI for the group of postmenopausal women was 30.9 ± 5.5 kg/m^2, which is higher than normal according to the WHO classification. These women were considered overweight (obese class 1). The average BMI for the group of premenopausal women was 24.0 ± 5.7 kg/m^2 [the normal range is from 18.5-24.9 kg/m^2]. 42% of women were partly veiled (showing only their faces and their hands); 57% were fully veiled and <1% of the women were unveiled.

3.1. BMD at the lumbar spine and femur

Table 1 shows that BMD and QUS measurement variables were significantly higher in premenopausal women compared with the postmenopausal women: LS, P< 0.01; FN, P<0.01; FW, P<0.001; BUA, P<0.001; VOS, P<0.001. There was a high prevalence of low bone mass in both the pre- and postmenopausal groups (LS t-score, P<0.01) (Table 1).

The percentage of women classified as osteopenic and osteoporotic was calculated according to WHO criteria,[k] 37% of premenopausal women and 52% of postmenopausal women were osteopenic at the LS. A similar pattern was found for the FN in that 23% of premenopausal women and 32% of postmenopausal women were osteopenic. At the calcaneus, 36% of premenopausal women and 62% of postmenopausal women were osteopenic (Figure. 1). At the LS, 2% and 13% of the pre- and postmenopausal women were osteoporotic, respectively.

Table 1.Clinical characteristics, anthropometrics, and bone density indices in the premenopausal (n=100) and postmenopausal (n=112) women

Variables	Postmenopausal (n = 112)		Premenopausal (n = 100)		P value
	Mean ± SD	Range	Mean ± SD	Range	
Age (year)	49.5 ± 5.0	43.1– 60.2	23 ± 3.5	20–33	P < 0.001
Weight (kg)	75.7 ± 14.5	51.5 –115	60.07± 15.0	38.7–112.2	P < 0.001
Height (cm)	156.4 ± 6.1	142–174.0	159.1 ± 5.8	145–173.0	P < 0.001
BMI (kg/m^2)	30.9 ± 5.4	21.1– 47.2	24.0 ± 5.6	16.0–50.0	P < 0.001
LS BMD (g/cm^2)	1.07 ± 0.18	0.09 –1.57	1.13 ± 0.12	0.81–1.41	P < 0.01
FN BMD (g/cm^2)	0.91 ± 1.6	0.61–1.44	0.96 ± 0.1	0.62–1.32	P < 0.01
FW BMD (g/cm^2)	0.78 ± 0.18	0.45 –1.40	0.92± 0.15	0.53–1.40	P < 0.001
FT BMD (g/cm2)	0.79 ± 0.16	0.66 –1.42	0.77 ± 0.12	0.46–1.10	P < 0.1
TF BMD (g/cm^2)	0.97± 0.16	0.66 –1.42	0.97 ± 0.13	0.61–1.34	P < 0.8
BUA (db/MHz)	69.61 ± 15.86	41.1–120	78.36± 13.49	46–114	P < 0.001
VOS (m/s)	1611.6±28.5	1554–1675	1802.7 ±1508.6	1531–16811	P < 0.001
LS (t-score)	-0.98 ± 1.32	-4.40–3.10	0.57 ± 1.01	-3.20–1.70	P < 0.01
FT (t-score)	-0.23 ± 1.33	-2.80–4.0	0.20 ± 1.11	-3.20–2.90	P < 0.8
BUA (t-score)	-1.19 ± 0.96	-2.93–1.84	-0.68 ± 0.81	-2.62–1.50	P < 0.001
VOS (t-score)	-2.1± 0.66	-3.45 –0.6	-1.14 ± 0.9	-3.98–0.28	P < 0.001
LS (z-score)	-0.86 ± 1.13	-3.9 0–3.0	-0.43 ± 0.9	-3.0–1.60	P < 0.003
FT z-score	-0.127± 1.13	-2.10–3.50	-0.16 ± 0.9	-2.06–1.90	P < 0.7
BUA (z-score)	-1.02± 8.67	-9.0–2.67	-0.93 ± 3.71	-37.0–1.54	P < 0.9
VOS (z-score)	-0.91± 0.64	-2.41–0.73	-1.11± 1.25	-11.67–0.38	P < 0.1

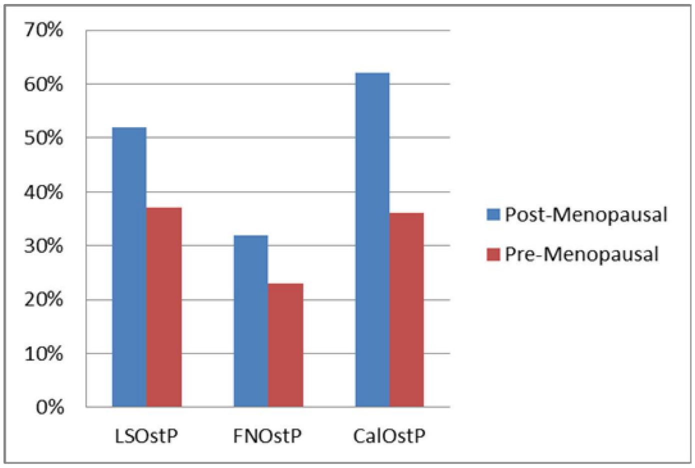

Figure 1. Percentage of women with osteopenia at the three indicated sites (LS; FN; and Cal) in post and premenopausal

3.2. 25(OH)vitaminD levels

Serum 25(OH)D levels were classified according to the literature as sufficient >75 nmol/L (>30 ng/ml), insufficient ≥50 to ≤75 nmol/L (≥20 to ≤30 ng/ml), and deficient <50 nmol/L (<20 ng/ml).[f and g] Deficiency was further defined as severe deficiency <12.5 nmol/L (<5 ng/ml), moderate deficiency ≥12.5 to <25 nmol/L (≥5 to <10 ng/ml), and mild deficiency ≥25 to <50 nmol/L (≥10 to <20 ng/ml). In postmenopausal women, 12.1% had severe deficiency, 38.5% had moderate deficiency, 46.2% had mild deficiency, and 3.3% had insufficiency. In premenopausal women, 13.1% had severe deficiency, 48% had moderate deficiency, and 38.1% had mild deficiency (Table 2, 3).

The relationship between 25(OH)D and serum PTH in pre- and postmenopausal women was analyzed, and significant negative correlations were found (r = -0.23, P<0.02 and r = -0.31, P<0.004, respectively; Figure. 2, 3). The PTH levels were significantly higher in postmenopausal women with 25(OH)D levels that were <12.5 nmol/L than in postmenopausal women with levels that were ≥25 nmol/L (except for in the fourth category, which included just 3 women) (Tables 4, 5). The mean serum calcium for both groups of women pre and postmenopausal was 2.30±0.11, 2.31±0.18 mmol/L respectively.

Table 2. Biochemical characteristics of the premenopausal (n=100) and postmenopausal (n=112) women

	Postmenopausal			**Premenopausal**		
	Mean ±SD	**Range**	**Median**	**Mean ±SD**	**Range**	**Median**
25(OH)D (nmol/l)	24.27±11.1	3.25 – 58	24.25	22.15±9.0	5.75–48.0	20.125
1,25(OH)D (pmol/L)	102.2±35.6	28.8–209.1	98.6	91.1±30	16.8–175.5	88.9
PTH (pg/ml)	61.9±34.3	18–204	53.0	39.35±21.4	10–135	35.0

Table 3.Percentages of Saudi Arabian premenopausal women (n=100) and postmenopausal women (n=112) with the indicated serum 25(OH)D levels

25(OH)D (nmol/l)	**Postmenopausal N**	**percentage**	**Premenopausal N**	**percentage**
<12.5	11	12.1%	11	13.1%
≥12.5 to <25	35	38.5%	41	48.8%
≥25 to <50	42	46.2%	32	38.1%
≥50 to <75	3	3.3%	0	0
≥75	0	0	0	0

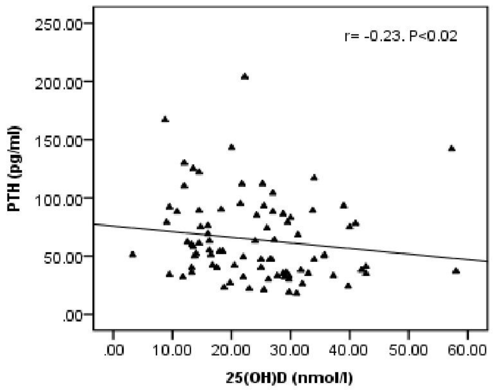

Figure2. Relationship between parathyroid hormone (PTH) and serum 25(OH) D level in postmenopausal women (n=112)

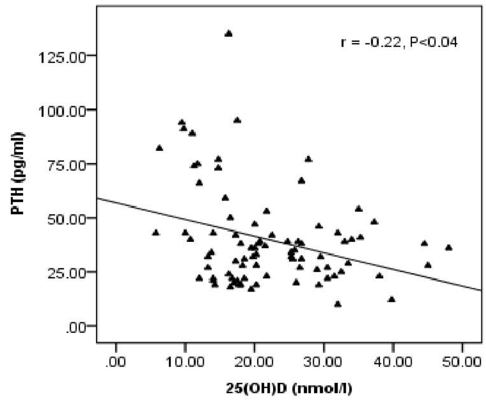

Figure 3. Relationship between parathyroid hormone (PTH) and serum 25(OH)D level in premenopausal women (n=100)

Table 4. Bone health indices according to serum 25(OH)D level in postmenopausal women

	25(OH)D <12.5 (nmol/l) n=11	**25(OH)D >12.5-<25 (nmol/l) n=35**	**25(OH)D >25-<50 (nmol/l) n=42**	**25(OH)D >50-<75 (nmol/l) n=3**	**25(OH)D >75 (nmol/l) n=0**	**P value**
Age (year)	48.27±3.82	49.62±4.28	50.14±5.65	53.00±5.29	---	P< 0.47
Weight (kg)	91.45±15.87	77.77±13.28	71.90±11.32	66.06±14.75	---	P< 0.00
Height (cm)	159.04±7.76	157.45±5.76	155.76±5.23	153.00±7.00	---	P< 0.20
BMI (kg/m^2)	36.05±5.26	31.41±5.43	29.65±4.57	28.66±8.91	---	P< 0.004
LS BMD (g/cm^2)	1.14±0.16	1.12±0.16	1.03±0.15	1.06±0.22	---	P<0.03
FN BMD (g/cm^2)	0.97±0.10	0.96±0.17	0.87±0.13	0.83±0.03	---	P<0.02
FWBMD (g/cm^2)	0.86±0.12	0.82±0.21	0.72±0.16	0.69±0.10	---	P<0.03
FTBMD (g/cm^2)	0.85±0.13	0.84±0.16	0.75±0.13	0.72±0.19	---	P<0.01
LS t-score	-0.43±1.34	-0.62±1.38	-1.39±1.26	-1.10±1.85	---	P<0.04
TF t-score	0.37±1.05	0.14±1.51	-0.60±1.20	-0.86±0.15	---	P<0.03
BUA (db/MHz)	68.27±19.04	74.22±16.06	66.73±14.43	72.00±16.46	---	P<0.22
VOS (m/s)	1614.6±26.8	1607±25.3	1613.8±28.2	1611.6±49.2	---	P<0.78
PTH (pg/ml)	87.00±44.71	67.45±37.65	54.72±27.84	89.50±74.24	---	P<0.05

Table 5. Bone health indices according to serum 25(OH)D level in premenopausal women

	25(OH)D <12.5 (nmol/l) n=11	**25(OH)D ≥12.5-<25 (nmol/l) n=41**	**25(OH)D ≥25-<50 (nmol/l) n=32**	**25(OH)D ≥50-<75 (nmol/l) n=0**	**25(OH)D ≥75 (nmol/l) n=0**	**P value**
Age (y)	24.1±4.03	23.19±3.51	23.03±2.90	---	---	P<0.1
Weight (kg)	59.85±12.5	62.4±14.83	60.76±16.61	---	---	P<0.8
Height (cm)	158.6±6.58	158.73±5.0	158.9±6.55	---	---	P<0.9
BMI (kg/m^2)	23.83±4.83	24.68±5.45	24.04±6.62	---	---	P<0.8
LS BMD (g/cm^2)	1.15±0.15	1.13±0.11	1.13±0.1	---	---	P<0.8
FN BMD (g/cm^2)	0.90±0.14	0.97±0.11	0.97±0.11	---	---	P<0.2
FW BMD g/cm^2)	0.88±0.15	0.94±0.13	0.94±0.15	---	---	P<0.4
FT BMD (g/cm^2)	0.75±0.12	0.79±0.12	0.76±0.11	---	---	P<0.5
LS t-score	-0.39±1.27	-0.56±0.92	-0.58±0.77	---	---	P<0.8
TF t-score	-0.37±1.12	-0.027±1.0	-0.14±1.09	---	---	P<0.6
BUA (db/MHz)	80.54±15.3	77.85±12.0	77.78±14.68	----	---	P<0.8
VOS (m/s)	1655.2±29.5	1651.6±32.2	1653. 2±26.7	---	---	P<0.9
PTH (pg/ml)	65.36±24.5	37.56±23.0	34.12±14.05	---	---	P<0.00

3.3 Effects of weight, and height on BMD

There were significant differences in body weight (P<0.001) and BMI (P<0.001) between the pre- and postmenopausal group. In postmenopausal women, the Pearson product-moment correlation demonstrated a significant positive association between body height and BMD at the LS, FN, FW, and FT sites (P<0.001, P<0.004, P<0.02, and P<0.008, respectively). In premenopausal women there was a significant positive correlation between body height and BMD at the LS and FN sites (P<0.0001 and P<0.03, respectively).

3.4 Relationship between serum 25(OH)D levels and bone health indices

The mean serum 25(OH)D values were divided into quintiles. The mean bone density values for postmenopausal women at the LS, FN, FW, and FT, plus the BUA and VOS values, are shown in Table 4. These data were examined for within-group in BMD, BUA, and VOS according to the 25(OH)D level. There were significant differences in the BMD values at the LS (P<0.03), FN (P<0.02), FW (P<0.03), and FT (P<0.01) according to the 25(OH)D level. The comparable data for premenopausal women are shown in Table 5.

3.5 Relationship between physical activity levels and bone health indices

There was a significant difference in physical activity levels between the pre- and postmenopausal groups (P<0.001). In the group of premenopausal women, physical activity was significantly associated with BMD at all five skeletal sites (P<0.001 for all sites). In postmenopausal women, physical activity was also positively associated (Spearman correlation coefficient) with BMD at five skeletal sites: the LS, FN, FW, FT, and calcaneus (P<0.0001, P<0.002, P<0.001, P<0.0001, and P<0.01, respectively). No correlations were found between physical activity and 25(OH)D levels in either group but there was a weak correlation between physical activity and sunlight exposure (0.22 for both groups; P<0.05).

3.6 Multilinear regression analysis of postmenopausal women

Multiple variables that could affect BMD values were examined in postmenopausal women using multilinear regression analysis. Body weight, height, and physical activity remained independent risk factors for BMD at all four skeletal sites (LS, FN, FW, and FT). Body weight showed an association with BMD values at the four skeletal sites, with increasing BMD values of 0.5% per kilogram of body weight. Physical activity was associated with significant increases in BMD at all four skeletal sites (% increase per hour of exercise): 5.4% (LS), 2.2% (FN), 3.0% (FW) and 2.8% (FT). Height was not a significant predictor of BMD at any site measured.

3.7 Multilinear regression analysis of premenopausal women

Multilinear regression analysis was performed in premenopausal women using the independent variables body weight, height, and physical activity level. Regression analysis indicated that these variables influenced the BMD at four skeletal sites, i.e. the LS, FN, FW, and FT. In this group of women, Height was not a significant predictor of BMD at any site measured. Physical activity significantly increased BMD values at the LS and FW sites, showing 4.3% and 2.2% increases in values per hour/week of exercise, respectively, but had no significant effect at the FN and FT.

3.8 Effect of sunlight exposure on bone health indices

The effect of sunlight exposure on bone health indices was also studied in this population. The pre- and postmenopausal women were divided into three sub- groups according to the amount of time they spent in the sun (min/day): i) low, minimal exposure to the sun (0 min/day); ii) medium, medium exposure to the sun (~15 min/day); iii) high, longer exposure to the sun (30–60 min/day). The following percentages of premenopausal women were in each sunlight classification group: low, 39.0%; medium, 28%; and high, 33%. The following percentages of postmenopausal women were in each sunlight classification group: low, 54.6%; medium, 30.5%; and high, 14.8%. There were significant associations between the duration of exposure to the sun, vitamin D status, and bone health indices. This association was stronger at the LS in both premenopausal women (P<0.05) and postmenopausal women (P<0.04) and remained significant for the LS and the LS t-score after adjustment for age, physical activity, weight, and height.

4. Discussions

This study revealed that the women in the premenopausal group were on average of normal weight, but the postmenopausal women were on average overweight /obese. This was not unexpected, as these women are representative of the general population in Saudi Arabia.[p] Although obesity is increasingly common in younger populations, this trend (older/heavier) is similar in other populations across the developed world.[q]

The bone health indices were significantly lower in postmenopausal women than in premenopausal women. There was a higher percentage of osteopenia, 62%, at the calcaneal site in postmenopausal women. Comparison of the FN BMD values of premenopausal women in the two cities of Jeddah and Riyadh showed a slightly lower prevalence of osteopenia in Jeddah, 23%, than in Riyadh, 27%, whereas the prevalence of osteoporosis was higher in Jeddah, 4%, than in Riyadh, 2%.

Vitamin D deficiency was highly prevalent in our study population. The mean serum levels of 25(OH)D were much lower in Saudi Arabian women than in women from Western countries such as France

[r] and the US. [s] However, the levels were similar to levels in other Saudi and Arab women, as reported by Ghannam *et al*. in Riyadh [b] and by the Gannage-Yared study conducted in Beirut.[t] This suggests that there may be cultural factors that affect vitamin D levels, most likely duration of sunlight exposure, since the influence of diet is rather small.[t] Notably, 97% and 100% of premenopausal and postmenopausal women had serum 25(OH)D levels <50 nmol/L. At a latitude of 20º N, Saudi Arabia is a country that has abundant sunlight throughout the year. Despite that women living in these sunny climates are not assured of having adequate vitamin D. Severe vitamin D deficiency, defined as 25(OH)D <12.5 nmol/L, was found in 13.1% of premenopausal women and in 12.1% of postmenopausal women; these two groups had PTH mean values of 39.4±21.4 and 61.9±34.3 pg /ml, respectively. Secondary hyperparathyroidism is a well-known consequence of vitamin D deficiency, [p, q, r, s, and t] and our results showed a significant negative correlation between PTH levels and 25(OH)D levels in pre- and postmenopausal women. There was a gradual continuous increase in serum PTH levels as the 25(OH)D levels declined. Low levels of serum 25(OH)D are associated with high levels of serum PTH, low bone density, and hip fractures. [r]

There was an association between the duration of exposure to the sun and BMD. The association with sunlight was stronger at the LS site in both pre- and postmenopausal women. For cultural and religious reasons, women in Saudi Arabia wear clothes that cover the body and that sometimes cover the face and hands as well. In this study, veiled women had no exposure to the sun, and none of the women lived in dwellings with a courtyard that would give them an opportunity to be exposed to the sunlight without their veils.

Numerous studies have demonstrated the important role of physical activity in BMD development and maintenance. Some studies have reported the beneficial effects of physical activity on growing bone, and regular exercise retards bone loss in postmenopausal women. [u] However, the impact of the amount of physical activity over a lifetime on bone status is not well understood, especially in this population of veiled women. In this study, the influence of physical activity on bone health was investigated using a questionnaire . The results showed that higher physical activity levels were associated with higher BMD, as has been shown in other populations. [v] This finding was consistent for pre- and postmenopausal women at the LS, FN, FW, FT, and calcaneus. These results provide clear evidence of the benefits of increased physical activity at all skeletal sites in women with low vitamin D status and increased risk of impaired bone health.

Body weight is an important risk factor for osteoporosis. In this study, there was a strong relationship between body weight and bone density. Women with the highest body weights tended to have higher bone density, suggesting a protective effect of body weight. This is supported by the positive association between body weight and bone density that has been documented in epidemiological studies.[w] In addition to the effects of body weight, we also found a significant positive relationship between body height and bone density. Our results showed that shorter women may have greater risk of poor bone health and are consistent with the finding from other studies that found height loss was significantly associated with fragility fractures that indicate the presence of an already osteoporotic condition. Loss of height may be an important factor in detecting osteoporosis of the hip, which suggests that height loss evaluation should be routine in outpatient settings.[x] The finding of a relationship between height and bone health in younger women suggests that optimal growth is related to optimal BMD. We consider the height/BMD findings to be especially interesting in that they may reflect the fact that women who were taller achieved a higher peak bone mass; this is supported by other reports. [y] Variations in human height are largely attributed to inherited factors (80–90%). Twin studies also suggest that the genetic contribution to height varies throughout childhood, with birth length and early growth appearing to be more strongly influenced by environmental factors and later growth and height more strongly influenced by genetic variation.

BMD continued to fall with increasing age at all of the five sites at which it was measured. Cross-sectional and longitudinal studies have also reported age-related bone loss. [z]

There are a number of limitations to our study. It is important to note that the Lunar DPX machine used in this study was not standardized to a Saudi population. The sample size was small, but the volunteers were recruited from a range of socio-economic backgrounds. Finally, in our assessment of the duration of sunlight exposures we were not able to collect information regarding the surface area of the skin that was exposed to the sun.

Acknowledgments:

This article was funded by the Deanship of Scientific Research (DSR), King Abdul Aziz University, Jeddah. The authors, therefore, acknowledge with thanks DSR technical and financial support.

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11/15/2013