Bone mass measurement using quantitative ultrasound in healthy Saudi women

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ABSTRACT

The objectives: To study the prevalence of osteopenia and osteoporosis in healthy Saudi women, a community-based screening was carried out.

Methods: Three thousand and two hundred sixty-nine women in the young women in peak bone mass (PBM) age group and 3131 in the postmenopausal age (PMA) group were screened using Achilles Insight (GE, USA). Subjects included in the study were healthy and residents of eastern province. The screening was conducted between January 2006 and December 2007. The study took place in King Fahd University Hospital, Al-Khobar, Kingdom of Saudi Arabia.

Results: In the PBM age group, 2090 (63.9%) were normal, 791 (24.2%) were osteopenic and 388 (11.9%) were osteoporotic. Osteopenia was more common in single urban women compared to those who were married and living in rural areas (p<0.01 and p<0.001). Women with college education had significantly normal bone mass than women with less than high school education (p<0.01). In the PMA, 948 (30.3%) were osteopenic and 720 (23%) were osteoporotic. Osteopenia was more common in women in urban areas as compared to industrial and the rural areas (p<0.01). Those women whose education was less than primary had significantly more osteoporosis when compared to women with college education (p<0.001).

Conclusion: In the PBM, 11.9% were osteoporotic and in PMA group 23% were osteoporotic. Factors that influenced the risk for osteopenia and osteoporosis included level of education, number of children, and place of living.
Osteoporosis is a disease in which the net loss of bone exceeds bone formation and it occurs in women after estrogen loss in postmenopausal age (PMA).1,3 Postmenopausal osteoporosis (PMO) is a major public health epidemic worldwide. Osteoporosis has been labeled as a silent epidemic, which can be prevented if early interventions are made. Most women with PMO present with a fracture as the first indication of the disease.4 Careful preventive measures, such as identifying risk factors, early diagnosis by screening methods, and proper management strategies are crucial.5,6 With better economic conditions and improvement in the health care delivery of Saudi Arabia, the citizens are living longer, which has put them at greatly increased risk of osteoporosis.7,8 The prevalence of PMO and its related complications in Saudi Arabia is not well established and few structured, studies about PMO in Saudi Arabian women have been reported.9,10

Based on the reports from previous small studies, we hypothesized that the prevalence of osteoporosis in Saudi females is higher than the other parts of the world.9,11,12 Studies have demonstrated that quantitative ultrasound (QUS), measurements can discriminate normal subjects from osteoporotic patients and it has ability to predict osteoporotic fracture risk and can be used to identify subjects with a high risk of bone fragility.13 The present study is undertaken to evaluate the true prevalence of osteopenia and osteoporosis in healthy Saudi Arabian females at peak bone mass (PBM) age and postmenopausal age group from all areas of Eastern Province using quantitative ultrasound of the Calcaneum (Os Calcis).

Methods. The study was based on the measurement of stiffness index (SI) and T-scores for the diagnosis of osteopenia and osteoporosis using QUS, Achilles Insight (GE, USA), which provides images of the calcaneum and measures broadband ultrasound attenuation (BUA) and speed of sound (SOS) values in a circular region. Physicians and nurses were selected and trained for the screening techniques. The screeners were stationed at shopping Malls, health centers in the cities of Dammam, Al-Khobar, Thoqba, Qatif, Saihat and in the Al-Hassa region, and outpatient department of King Fahd Hospital of the University, Al-Khobar, King Fahd Hospital, Al-Hofuf, and Qatif Central Hospital. Women in the PBM age group were also screened at the College of Girls, Dammam and King Faisal University, Dammam and Al-Hassa. Screening was carried out in the period between January 2006 and December 2007. Convenient available sample without randomization was used in this community based cross-sectional survey. The benefits of the screening were explained to the participants and a verbal consent was obtained. The inclusion criteria in the screening program were Saudi women in the age group of 25-35 years (young age; peak bone mass age group) or ≥50 years of age and being postmenopausal, not on medications which affect the bone mass such as steroids or hormonal therapy, having no known diseases, non smokers and resident of eastern province. Women who were already diagnosed to have osteopenia or osteoporosis by WHO criteria and were on therapy were excluded from the study. After the verbal consent, the questionnaire was filled by the screener, which included a brief medical history was obtained, data about marital status, number of children, and abortions, place of birth and place of living, and level of education was obtained and documented. Weight and height were then measured using SECA Model 220, (Germany) and the body mass index (BMI) was calculated. Achilles express calculates SI of the Os calcis using BUA and SOS. The assessment was carried out at the right foot. If the subject had history of fracture or any bony disorder of the right foot then the left foot was used for the study. The QUS devise was calibrated on a daily bases and the measurement was performed in a temperature controlled environment (room temperature) using gel-coupled QUS system. The precision of the instrument was 97% at the time of measurement of the SI and T-scores. Three thousand and two hundred sixty-nine women in the peak bone mass (PBM) age group and 3131 in the postmenopausal age group were screened. The data was entered into the database and analyzed. Women were classified according to the T score, normal if T score is ≥1.0, osteopenic if T score between -1.0 and -1.8, and osteoporotic if T score ≤1.8. The data was calculated for the means and standard deviation to summarize quantitative variables and the percentage for categorical variables. Ordinal logistic regression was employed to determine whether the BMI, marital status, number of pregnancies, level of education and area of residency have an effect on the prevalence of the osteopenia or osteoporosis. The data was analyzed using SPSS (Statistical Package for the Social Sciences),14 version 14.0, Chicago, Illinois. Statistical significance was taken as p value of <0.05 with confidence interval of 95%. The study was approved by the Research and Ethical Committee of College of Medicine, King Faisal University, Dammam and was funded by King AbdulAziz City for Science and Technology, Riyadh.

Disclosure. This study was funded by the King AbdulAziz City for Science and Technology, Riyadh, Kingdom of Saudi Arabia with a grant # 60-22-AT.
Results. In the PBM age group, 3269 women were screened out of which 2090 (63.9%) were normal, 791 (24.2%) were having osteopenia and 388 (11.9%) were having osteoporosis (Table 1). The SI in the normal group was 104.4 versus 79.3 in osteopenic and 64.5 in the osteoporotic women (p<0.001). The average age was 29.2±3.3 years in the normal subjects, 29.5±3.3 years in the osteopenic women, and it was 29.3 years in the osteoporotic women. The BMI in the osteopenic females was lower as compared to the normal group (p<0.001). Out of 1123 single women in PBM group, 761 (36%) were normal compared to 64% (1329 out of 2146) who were married. Osteopenia was more common in single women compared to those who are married (p<0.01). The prevalence of osteoporosis in the single and married females in the PBM group was similar. Comparing the place of living between rural, urban, and industrial areas, women who were living in the urban areas had higher prevalence of osteopenia (p<0.001).

Table 1 - Demographic data of women in peak bone mass age group (N=3269).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group A normal (n=2090)</th>
<th>Group B osteopenia (n=791)</th>
<th>Group C osteoporosis (n=388)</th>
<th>P-value between A and B</th>
<th>P-value between A and C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>29.2 ± 3.3</td>
<td>29.5 ± 3.3</td>
<td>29.3 ± 3.3</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>26.9 ± 6.4</td>
<td>25.9 ± 5.6</td>
<td>26.4 ± 6.91</td>
<td>0.002</td>
<td>NS</td>
</tr>
<tr>
<td>Stiffness index</td>
<td>104.4 ± 12.8</td>
<td>79.3 ± 4.2</td>
<td>64.5 ± 9.2</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>T-Score</td>
<td>0.1 ± 0.79</td>
<td>≤1.3 ± 0.23</td>
<td>≤2.3 ± 0.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z-Score</td>
<td>0.1 ± 0.82</td>
<td>≤1.3 ± 0.27</td>
<td>≤2.2 ± 0.64</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data are expressed as mean ± standard deviation. NS - not significant.

Table 2 - Osteopenia and osteoporosis related to level of education in peak bone mass age group.

<table>
<thead>
<tr>
<th>Bone mass</th>
<th>Primary school (n=871)</th>
<th>Secondary school (n=608)</th>
<th>College education (n=1790)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>546</td>
<td>367</td>
<td>1177</td>
<td>0.035</td>
</tr>
<tr>
<td>Osteopenia</td>
<td>209</td>
<td>151</td>
<td>431</td>
<td>0.91</td>
</tr>
<tr>
<td>Osteoporosis</td>
<td>116</td>
<td>90</td>
<td>182</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Table 3 - Demographic data of women in postmenopausal age group (N=3131).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal (n=1463)</th>
<th>Osteopenia (n=948)</th>
<th>Osteoporosis (n=720)</th>
<th>P-value between A and B</th>
<th>P-value between A and C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Years)</td>
<td>52.8 ± 5.2</td>
<td>53.5 ± 5.7</td>
<td>56.2 ± 8.1</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>BMI (kg/M²)</td>
<td>31.1 ± 6.34</td>
<td>30.2 ± 6.41</td>
<td>30.0 ± 7.07</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Stiffness Index</td>
<td>99.6 ± 8</td>
<td>79.3 ± 5.7</td>
<td>62 ± 13.8</td>
<td>0.01</td>
<td>0.001</td>
</tr>
<tr>
<td>T-Score</td>
<td>0.0 ± 0.72</td>
<td>≤1.3 ± 0.23</td>
<td>≤2.5 ± 0.73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z-Score</td>
<td>0.7 ± 0.83</td>
<td>-0.6 ± 0.5</td>
<td>≤1.6 ± 0.89</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data are expressed as means ± standard deviation.
be appropriate when screening for osteoporosis by QUS. Kim et al29 studied 420 healthy women aged 20-79 years with no known risk factors for osteoporosis and 97 postmenopausal women with vertebral fractures. They compared DXA measurement of the hip and spine with the QUS measurement on 3 calcaneal ultrasound devices and they concluded that for the 3 QUS devices used in the study, a T score of -1.8 would result in the same percentage of postmenopausal women classified as osteoporotic as the WHO threshold for BMD measurement by DXA (T score -2.5). On the other hand, Turk et al30 compared DXA with the QUS in patients with inflammatory bowel disease and found that, when patients with a T score of ≤1.0 scanned by DXA were classified as having bone disease. Quantitative ultrasound was sensitive to identify bone disease in 93% of patients with a specificity of 63% if patients with a T score of ≤ 1.0 scanned by DXA were classified as bone disease. The sensitivity of the QUS to detect osteopenia and osteoporosis was 84% and 72%. Alternatively, lower negative QUS T score cutoff of ≤1.8 identified 83% of osteoporosis at lumbar spine and 100% at hip. In our analysis, we used a cutoff value of ≤1.8 as the threshold for the diagnosis of osteoporosis. Hien et al26 used the same cutoff value in the analysis of the result of their population-based, cross-sectional survey. Ardawi et al27 screened 1980 (1065 females and 915 males) randomly selected Saudis from Jeddah area with an age range of 20-79 years by DEXA and they found that 43.4% of the female patients (50-79 years) were osteopenic and 28.2% were osteoporotic using a Saudi reference value. This findings support the fact that using a threshold of T score of ≤1.8 for the Achilles QUS measurement is valid for the diagnosis of osteoporosis as compared to DEXA. The results of this study showed that 30.4% of women in the PMA group were osteopenic and 23% were osteoporotic, even though the majority of our patients were in the early postmenopausal age group. This study further suggests that using a threshold of T score of ≤1.8 for the Achilles QUS measurement is valid for the diagnosis of osteoporosis as compared to DEXA. Sosa et al28 after screening of 1451 females from Spain using QUS, found that 21.9% of patients aged 51-70 years were osteoporotic if a T score cutoff value of ≤1.8 for the diagnosis of osteoporosis is used. Kim et al29 found the prevalence of osteoporosis among 552 Korean women above the age of 50 years to be 11.8% using QUS with a T score cutoff value of ≤2.5. Also, Sharma et al30 used a T score cutoff value of ≤2.5 using QUS and found the incidence of osteoporosis to be 20.25% among 158 women from India. The result of this community based study showed that the prevalence of osteoporosis in Saudi females at PMA group is similar to what was reported from the other parts of the world.

Discussion. Osteoporosis is a silent disease leading to a major morbidity and mortality in the aging population around the world. In the past, it was believed that osteoporosis is a disease of the Caucasian race and the eastern men and women are protected from this debilitating condition but this has been proven to be far from the truth. Previous studies from different parts of the Kingdom found the prevalence of osteoporosis in the PMA group to be in the range of 35-45%. Those studies were of small sample size and mostly used hospital based population and sometimes without any consideration for the associated diseases that may influence the incidence of osteopenia and osteoporosis.9,12,15-17 Findings from above studies showed that the prevalence of osteopenia and osteoporosis in Saudi population is comparatively higher than what is reported from the western countries using QUS. To prove this, a more structured and large population based study such as the present one was needed. Dual energy x-ray absorptiometry (DXA) is still the gold standard test for the diagnosis of low bone mass (osteopenia and osteoporosis). Dual energy x-ray absorptiometry has low precision error of 1-2% versus 3-4% for the ultrasonography,18 however, access to axial DXA may be limited or costly. Also, it will be difficult to use DXA machine for a community-based screening program. On the other hand, several studies did confirm that calcaneal ultrasound can predict fracture risk with an accuracy rate similar to that of DXA machine.19-21 One issue which is still unsettled is the diagnosis of low bone mass by QUS utilizing the same WHO threshold of T-Score used for the DXA machines. This may not

Table 4 - Osteopenia and osteoporosis related to place of living in postmenopausal age group.

<table>
<thead>
<tr>
<th>Bone mass</th>
<th>Group A industrial (n=122)</th>
<th>Group B rural (n=752)</th>
<th>Group C urban (n=2257)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal (n=1463)</td>
<td>62</td>
<td>365</td>
<td>1038</td>
<td>0.36</td>
</tr>
<tr>
<td>Osteopenia (n=948)</td>
<td>34</td>
<td>201</td>
<td>713</td>
<td>0.03</td>
</tr>
<tr>
<td>Osteoporosis (n=720)</td>
<td>26</td>
<td>188</td>
<td>506</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Table 5 - Osteopenia and osteoporosis related to level of education in postmenopausal age group.

<table>
<thead>
<tr>
<th>Bone mass</th>
<th>Primary school (n=2373)</th>
<th>Secondary school (n=158)</th>
<th>College education (n=600)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>1071</td>
<td>86</td>
<td>306</td>
<td>0.004</td>
</tr>
<tr>
<td>Osteopenia</td>
<td>711</td>
<td>46</td>
<td>191</td>
<td>0.68</td>
</tr>
<tr>
<td>Osteoporosis</td>
<td>591</td>
<td>26</td>
<td>103</td>
<td>0.004</td>
</tr>
</tbody>
</table>

significantly more osteoporosis when compared to those with college education (P<0.004).
The previously reported higher prevalence is most likely related to the small size of the studies and the fact that it was hospital based. Few studies, used QUS to assess the prevalence of low bone mass at the PBM age group. The prevalence of osteoporosis was only 0.8% in the age group of 20-29 years and 2.1% in the age group of 30-39 years in the study carried out by Hien et al.\textsuperscript{26} This study indicates that the prevalence of osteoporosis in Saudi females at PBM age is higher than what was reported from the other parts of the world. Possible explanations for the above finding include low exercise activity in these females due to social factors and the high prevalence of vitamin D deficiency in this part of the world.\textsuperscript{30} Both lack of physical activity and low vitamin D level hinders the attainment of PBM. It was shown that low socioeconomic status and educational levels influence the prevalence of chronic diseases in many of the developed and developing countries.\textsuperscript{32,33} Little data is available regarding the influence of the level of education on osteopenia and osteoporosis.\textsuperscript{34,35} Varennia et al\textsuperscript{36} found a higher prevalence of osteoporosis in postmenopausal women having low level of education. In this study, the prevalence of osteoporosis in PBM group was 10.1% in women with college education versus 13.3 in women having less than a primary school education ($p<0.01$). Likewise in the PMA group, the level of education had a significant bearing on the prevalence of osteopenia and osteoporosis. Comparing women who had less than a primary school education versus college educated women, the prevalence of osteoporosis was 24.9% versus 17.2% ($p<0.01$). This finding has a great implication when it comes to targeting the groups of population for the prevention of osteopenia and osteoporosis. The role of pregnancy on the development of osteoporosis has being discussed for a long time. Effects of pregnancy on the maternal bony skeleton are still evolving and many researchers have reported conflicting results regarding the immediate effect of pregnancy on bone mass.\textsuperscript{37-39} Bone remodeling during and after pregnancy was shown to have a positive correlation between parity and bone mineral density.\textsuperscript{15,40-41} In this study, comparing women with ≥6 children versus women who had <6 children, did not show any significant differences between the 2 groups. It is well established that the incidence of various diseases differ between the urban and rural population.\textsuperscript{42,43} Sadat-Ali et al\textsuperscript{42} found that the prevalence of osteoporosis in rural population was less than the urban population, based on the BMD analysis. Similarly, Pongchayakul et al\textsuperscript{44} found the hip BMD to be higher in the rural population compared to the urban population. The above findings were also confirmed by other reports.\textsuperscript{45} In this study, the prevalence of osteopenia in the urban areas was higher as compared to the industrial and the rural areas. This indicates that women in the urban areas need special attention when it comes to prevention of osteopenia and osteoporosis.

The present study has few limitations. Even though, several QUS devices such as the one we used are now in the clinical use for diagnosis of osteopenia and osteoporosis but standardization of instruments is one of the major limitations. The second factor was the software which is in use classify osteopenia and osteoporosis uses different ethnic reference values which may be different from Saudi population. Lastly, to compare the QUS values with DXA was beyond the scope of this study, hence was not undertaken.

In conclusion, the present study was able to highlight important facts about the prevalence of osteopenia and osteoporosis in the eastern province of Saudi Arabia. The prevalence of low bone mass in the PMA group is similar to what was reported from the other part of the world. While the prevalence of osteopenia and osteoporosis is high at the PBM age group, which may indicate that, the development of low bone mass starts at an early age. Educated women and women with higher parity were less osteoporotic and women living in the rural areas were less osteopenic and osteoporotic than the city dwellers. The above findings can help in the planning of prevention programs for the low bone mass. Furthermore, similar studies needs to be carried out at the other regions of Saudi Arabia as part of a population-based survey.

References

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