RESEARCH ARTICLE

Osteoporosis screening by measuring calcaneus bone mineral density through quantitative ultrasonography in healthcare workers

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Abstract

Objective: To evaluate the frequency of low bone mineral density among healthcare workers, identify gender and age-related trends, and assess the feasibility of implementing routine screening programmes for early detection and prevention of bone health deterioration.

Method: The analytical, cross-sectional study was conducted at the Section of Biochemistry, Department of Pathology and Laboratory Services, National Institute of Cardiovascular Diseases, Karachi, during a one-day screening camp on June 1, 2023, and comprised hospital staff members of either gender, aged 20-70 years who were apparently healthy. Bone mineral density was assessed using a portable stand-alone quantitative ultrasound bone densitometer. The T-scores were interpreted as per World Health Organisation guidelines. Data was compared among normal, osteopenic and osteoporotic groups. Data was analysed using SPSS 29.

Results: Among the 200 subjects included in the study, 123 (61.5%) were male and 77 (38.5%) were female. The mean age was 38.8±9.6 years. Normal bone health was found in 23(11.5%) subjects, osteopenia in 100(50%) and osteoporosis in 77(38.5%). The average T-score was -2.16±0.8. Females exhibited a significantly higher prevalence of osteoporosis 41(53.25%), while males were more likely to have osteopenia 72(58.54%). Those aged between 25-45 years (n=149) exhibited osteoporosis (38.9%) and osteopenia (51%). T-scores and Z-scores showed significant difference across the three groups (p 0.001).

Conclusion: A high prevalence of low bone mineral density among hospital staff was noted, highlighting the need for workplace-based osteoporosis prevention programmes.

Key Words: Osteoporosis, Bone density, Ultrasonography, T-score, Healthcare workers.

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Introduction

Osteoporosis is a common skeletal disorder characterised by low bone mineral density (BMD) and a deterioration of bone microarchitecture, resulting in an increased risk of fractures.[1] Osteoporosis is a significant public health concern, and its prevalence is increasing worldwide. In the United States, it is estimated that approximately 10 million people have osteoporosis, and an additional 44 million have low bone mass (osteopenia), placing them at an increased risk of developing osteoporosis.[2] The prevalence of osteoporosis is exceptionally high in elderly populations and postmenopausal women due to the declining levels of oestrogen. Women in sedentary work constitute a priority target group for osteoporosis prevention among workers.[3] However, little attention has been paid to preventing osteoporosis. Research has estimated that about 75% of osteoporosis cases are still undiagnosed or are diagnosed only when a bone fracture occurs.[4]

One study reported a high prevalence of vitamin D deficiency in the Asian population, which is a secondary cause of osteoporosis.[5] The study included healthy individuals living in an urban centre with sufficient exposure to sunlight. The high prevalence of vitamin D deficiency (69.9%) and insufficiency (21.1%) indicated that a significant proportion of apparently healthy adults were at the risk of developing musculoskeletal and other chronic diseases, which can lead to a substantial decline in their productivity.[5] For this reason, detecting early signs of bone loss appears crucial to minimise serious health consequences.[6] BMD measurement is considered the most reliable method for diagnosing osteoporosis, and its assessment is essential for identifying individuals at a high risk of fracture. Dual-energy X-ray absorptiometry (DXA) is the gold standard for measuring BMD.[7] However, DXA has several limitations, including exposure to ionising radiation, high cost, and limited availability. Therefore, there is a need for alternative methods for measuring BMD.[8]

Quantitative ultrasonography (QUS) is a non-invasive,

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portable and relatively inexpensive method for evaluating BMD.[9] QUS measures the soundwaves transmitted through bone, and the speed of sound and attenuation coefficient are used to calculate BMD.[10] QUS helps predict fracture risk and monitor response to treatment. Several studies have also suggested that QUS is a reliable and practical method for screening osteoporosis in individuals at high risk.[11,12]

The current study was planned to evaluate the prevalence of low BMD among hospital staff using QUS, identify gender and age-related trends in osteopenia and osteoporosis, and assess the feasibility of implementing routine workplace-based QUS screening programmes for early detection and prevention of bone health deterioration.

Subjects and Methods

The analytical, cross-sectional study was conducted at the Section of Biochemistry, Department of Pathology and Laboratory Services, National Institute of Cardiovascular Diseases (NICVD), Karachi, during a one-day screening camp on June 1, 2023. Those included were hospital staff members of either gender aged 20-70 years who were associated with the NICVD and were apparently healthy, and voluntarily participated in the BMD screening camp conducted during Pathology Week celebrations. Individuals were excluded if they had a history of fragility fractures within the preceding year, were on long-term corticosteroid therapy, had known metabolic bone disorders (e.g., osteogenesis imperfecta, Paget's disease), or suffered from chronic conditions affecting calcium or vitamin D metabolism, such as chronic kidney disease (CKD) and malabsorption syndromes. Pregnant women and individuals with implants or hardware at the calcaneus site that could interfere with QUS measurements were also excluded. Approval was obtained from the institutional ethics review committee. The sample size was calculated using the formula[13]:

$$n=(Z^2\times p\times(1-p))/d^2$$

where osteoporosis prevalence (p) was taken as 36.5%[14], confidence level (Z=1.96) was 95% and margin of error (d) was 7%. The sample was inflated by 10% to account for potential non-responses or incomplete data. A 7% margin of error was deemed acceptable given the exploratory nature of the study and practical considerations related to participant recruitment and available resources. The sample was raised using non-probability convenience sampling technique.

After taking informed consent from the subjects, BMD measurements were obtained using QUS at the calcaneus (heel) (Sonost 3000, by OsteoSys, South Korea). Ultrasonic pulses passed through the bones, and the spongy tissues significantly attenuated and absorbed the signals. BMD was calculated using the speed of sound (SOS) with a coefficient of variation (CV) <1% and broadband ultrasound attenuation (BUA) with CV <2%. A trained technician performed the measurements following standard procedures within a controlled environment. The QUS device generated both T-scores and Z-scores, expressed as standard deviation units relative to their respective reference populations. T-scores were used for BMD classification based on World Health Organisation (WHO) diagnostic guidelines.[15] T-score -1.0 or above was considered normal, between -1.0 and -2.5 was classified as osteopenia, and <-2.5 indicated osteoporosis. Z-scores were used to interpret adjustments for age and gender.

Data was analysed using SPSS 29. Parametric variables were presented as mean ± standard deviation (SD), while non-parametric variables were reported as median with interquartile range (IQR; 25th-75th percentile). Descriptive statistics summarised the data, and independent samples t-test was employed to compare mean T-scores between genders. One-way analysis of variance (ANOVA) was used to assess the significance of T-score interpretation between osteoporotic and osteopenic groups. These tests were used for continuous variables that were approximately normally distributed. Associations between categorical variables (gender and department) and BMD categories were assessed using the Chi-square test, while Fisher's exact test was applied when expected cell frequencies were <5. $P<0.05$ was considered statistically significant, while $p<0.001$ was considered highly significant.

Results

Among the 200 subjects included in the study, 123 (61.5%) were male and 77 (38.5%) were female. The mean age was 38.8±9.6 years. The age distribution showed a skewness of 0.81, indicating a right-skewed distribution. The distribution of study participants across various hospital departments is illustrated in Figure 1. Participation was highest in the ER, Porter Service, and Ward departments (n=19 each), followed by OPD (n=17) and Nursing (n=15). Lower participation rates were recorded in Administration (n=9), S.ICU (n=8), and the Mess (n=4).

Mean T-Score was -2.16±0.8, and mean Z-Score was -2.01±0.8. Normal bone health was found in 23(11.5%) subjects, osteopenia in 100(50%) and osteoporosis in 77(38.5%). The mean age was comparable across the three groups (p=0.512). However, T-scores and Z-scores

Table-1: Comparison of demographic and clinical characteristics among normal, osteopenic and osteoporotic individuals.

Study Variables	Normal (n=23)	Osteopenic (n=100)	Osteoporosis (n=77)	*p Value*
Age, mean±SD	39.1±10.3	38.8±9.6	38.8±9.6	0.512
T-Scores, mean±SD	-0.56±0.48	-1.90±0.37	-2.97±0.38	< 0.001
Z- Scores, mean±SD	-0.42±0.49	-1.76±0.41	-2.81±0.45	< 0.001
Gender				
Male, n (%)	15 (65.2)	72 (72)	36 (46.8)	< 0.05
Female, n (%)	8 (34.8)	28 (28)	41 (53.2)	
Department				
Administration, n (%)	2 (8.7)	6 (6.0)	1 (1.3)	0.633
Housekeeping, n (%)	2 (1.1)	9 (9.0)	3 (1.7)	
Maintenance, n (%)	nil	9 (9.0)	3 (1.7)	
Nursing, n (%)	3 (1.7)	3 (3.0)	9 (5.0)	
Outpatient department, n (%)	2 (1.1)	9 (9.0)	6 (3.3)	
Porter Service, n (%)	2 (1.1)	10 (10.0)	7 (3.9)	
Ward, n (%)	2 (1.1)	10 (10.0)	7 (3.9)	
Others, n (%)	5 (21.7)	9 (9.0)	5 (6.5)	

SD: Standard deviation.

were significantly different (p<0.001). Gender distribution across the groups was also significantly different (p<0.05) (Table 1). Females exhibited a significantly higher prevalence of osteoporosis 41(53.25%), while males were more likely to have osteopenia 72(58.54%).

Participants were also categorized into six age groups: <25, 25–35, 36–45, 46–55, 56–65, and >65 years. The highest frequency of osteopenia and osteoporosis was observed in individuals aged 25–45 years. Specifically, among those aged 25–45 years (n=149), osteoporosis was present in 38.9% and osteopenia in 51%. Age and T-scores were further analysed for comparison across the three groups (Table 2). The ANOVA analysis revealed no significant difference in Age across the groups, F(2,197)=0.009, p=.991, suggesting the cohorts were well-matched demographically. However, a highly significant difference was observed for T-scores, F(2,197)=377.42, p<.001.

Discussion

Using QUS at the calcaneus, the current study found high prevalence of low BMD, particularly osteopenia and osteoporosis, among the participants. The overall distribution of bone health interpretations is concerning.

Table-2: One-way analysis of variance (ANOVA) regarding age and T-scores among normal, osteopenic and osteoporotic groups.

		Sum of Squares	df	Mean Square	F	p-value
Age	Between Groups	1.666	2	.833	.009	0.991
	Within Groups	18625.45	197	94.54		
T-Score	Between Groups	115.37	2	57.68	377.42	<.001
	Within Groups	30.110	197	.153		

"Between groups" denotes variation among the three bone density categories, whereas "within groups" represents pooled residual variance within these groups.

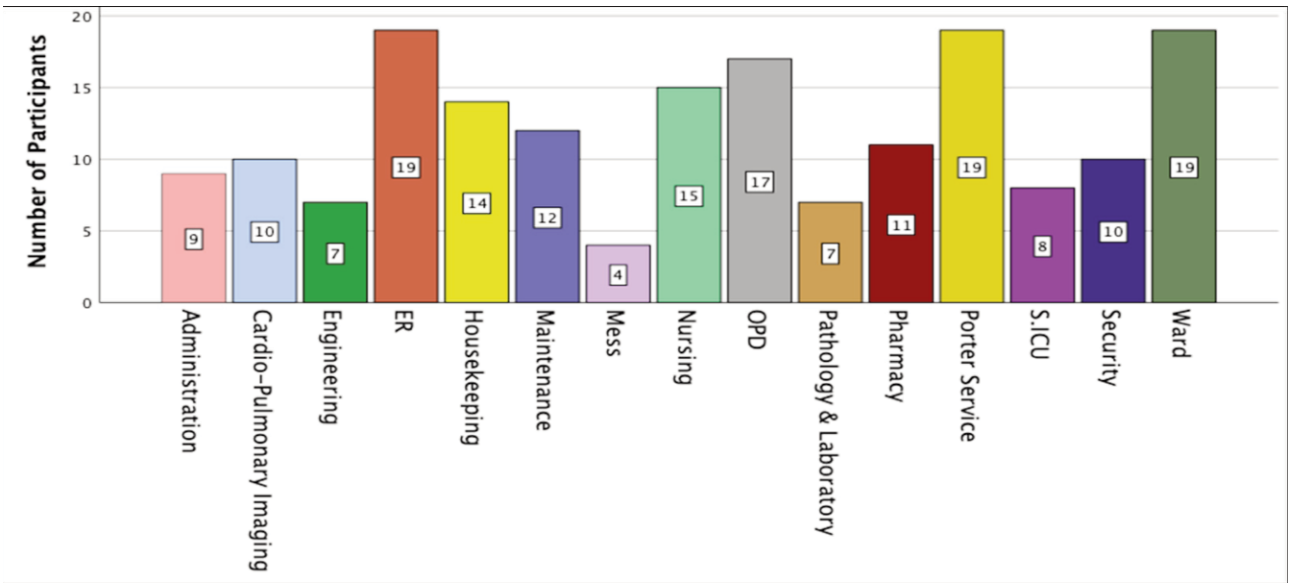

Figure-1: Participants (n=200) during bone mineral density (BMD) screening from various departments within the hospital.
Note. Departments with very small frequencies were excluded from analysis to avoid sparse cells.

Out of 200 subjects, 50% of the sample was categorised as having osteopenia (50%), and 38.5% had osteoporosis, with only 11.5% falling into the "normal" category, highlighting a significant occupational health concern. These findings are consistent with the broader literature on bone health, showing that early detection of osteoporosis is possible in healthcare workers with considerable bone loss, emphasising the importance of early detection and workplace screening programmes.[4] A study on the diagnostic value of calcaneal QUS supported the tool as an efficient pre-screening tool for osteoporosis.[16]

A local study on calcaneal ultrasound and its relation to dietary and lifestyle factors, anthropometry and vitamin D deficiency in young medical students also provides relevant insights.[17] It found that calcaneal QUS could effectively assess bone health in younger populations, revealing significant correlations between QUS parameters and various lifestyle and dietary factors. It highlighted that vitamin D deficiency, nutritional habits and lifestyle choices significantly impacted bone density in young individuals. This was in line with the current study. Together, these findings suggest that interventions targeting these factors could prevent early onset of bone density issues in younger populations.

A study on the efficacy of workplace osteoporosis prevention interventions highlighted the potential of such programmes in reducing the incidence of osteoporosis through targetted health interventions.[18] The results aligned with the current findings, suggesting that implementing comprehensive screening and prevention programmes in the workplace can significantly improve bone health, and reduce the socioeconomic burden of osteoporosis.

A study validated the use of QUS for BMD assessment as a reliable and cost-effective alternative to DXA), which is considered the gold standard for BMD measurement but has limitations, including high cost and exposure to ionising radiation.[19] Studies have found that QUS effectively identified individuals at high risk for fractures, providing a practical tool for large-scale screenings, predicting fracture risk, and monitoring response to treatment.[20] Moreover, calcaneal QUS is a rapid and cost-effective screening tool that can be used to identify individuals who may benefit from further evaluation with DXA. However, QUS is unlikely to replace DXA as the diagnostic gold standard in the foreseeable future.

The gender disparities observed in the current study, where females exhibited a higher prevalence of osteoporosis compared to males, align with numerous studies highlighting the impact of menopause and hormonal changes on bone density.[21,22] This finding was also evident in a survey which reported significant bone loss in healthcare workers, and emphasised the effectiveness of workplace screening programmes for early detection and prevention of osteoporosis.[4] In the current study, the mean T-score of -2.16 indicated a general trend towards lower bone density among the subjects. The finding is consistent with studies that reported high rates of undiagnosed osteoporosis, especially among women in sedentary jobs and those with vitamin D deficiency.[23-25] The current study also highlighted a significant association between age and BMD, with younger staff members aged <35 showing a higher tendency towards osteoporosis, suggesting that lifestyle factors, such as inadequate physical activity and poor dietary habits, may contribute to this trend.

The current study has several limitations. First, as a retrospective, cross-sectional study, it does not establish causal relationships between low BMD and associated risk factors. Second, the use of QUS, while practical and non-invasive, may not offer the same diagnostic accuracy as DXA, the gold standard for BMD assessment.[26] Third, potential confounding factors, such as dietary calcium intake, physical activity levels, smoking status, menstrual history and serum vitamin D levels, were not taken into account, which may have influenced the interpretation of T-scores.

Despite the limitations, however, the findings underscore the importance of targeted strategies, including promoting physical activity, ensuring adequate nutrition, and addressing vitamin D deficiencies. Implementing routine QUS screenings and comprehensive bone health programmes within healthcare institutions can improve employee health outcomes, reduce the economic burden of osteoporosis, and serve as a model for other workplaces in prioritising the skeletal health of workforce. Future studies should investigate the long-term benefits of such interventions and explore their applicability in diverse occupational settings.

Conclusion

There was a significant prevalence of low BMD among NICVD staff, with 50% of the participants classified as osteoporotic and 38.5% as osteopenic. The gender disparity observed, with a higher prevalence of osteoporosis among female staff, and the alarming trend of younger employees showing early signs of bone density loss, suggest that both hormonal factors and lifestyle choices play a crucial role in bone health.

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NS: Concept, design, data acquisition, analysis, interpretation, drafting, revision, final approval and agreement to be accountable for all aspects of the work.