

Osteoporosis Self-Assessment Tool for Asians: Comparison to Quantitative Ultrasound Bone Densitometry in Urban Indian Women

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ABSTRACT: Osteoporosis is the specific bone metabolic disorder which can be diagnosed using bone mineral density evaluation techniques mainly the gold standard, dual-energy x-ray absorptiometry (DEXA). Unfortunately, it becomes difficult to screen people with DEXA due to its limited access, high cost and involvement of ionizing radiation. Osteoporosis self-assessment Screening tool for Asians (OSTA) serves as one of the successful screening technique based on age and weight to predict osteoporosis risk. Quantitative Ultrasound (QUS) bone densitometry measured at calcaneus (heel) bone is an approved Bone Mineral Density technique to screen the subjects at community level in detecting osteoporosis. Based on this background, the present research focused on application of OSTA in Tirupati urban women, India in the age range of 35 to 74 years. The results highlighted that employing OSTA may be the beneficial tool for the physicians to identify the persons at risk and to initiate early treatment to minimize the consequences of morbidity and mortality. Women might at higher risk of osteoporosis who need to be screened and correspondingly the researcher had made considerable efforts in predicting the osteoporosis risk among women both through OSTA and bone density testing.

Keywords: OSTA, QUS, osteoporosis, bone health, bone density

INTRODUCTION

Osteoporosis is the most common bone metabolic disorder especially affecting the women contributing significant morbidity and mortality rates. The evaluation of the disease mainly focus on identifying risk factors, assessment of biochemical bone turnover markers, testing bone mineral density (BMD) using dual-energy x-ray absorptiometry (DEXA), vertebral fracture assessment with vertebral fracture assessment tools and prediction of fracture risk with many other risk assessment tools (Rajan *et al.*, 2020). It is emerging as the major public health problem marking the incidence over 200 million globally. Pathetically in India alone about 50 million people suffer from osteoporosis and greater than 4.5 million of above 60 years experienced vertebral fractures and higher than 250,000 individuals sustain towards hip fracture every year on account of osteoporosis (Upadhyaya *et al.*, 2020) which demand for identifying the tools for predicting risk levels.

The literal meaning of osteoporosis is porous bone and the World Health organization (WHO) defines as 2.5 standard deviation of bone mineral density against the mean peak bone mass of young healthy adults. The WHO identifies it as the second global health problem next to cardiovascular diseases (Prasad and Meenakshy, 2015). Osteoporosis is considered as 'silent killer' being asymptomatic unless the first fracture occurs often associated with lowered bone density, reduced

bone quality results in weakening bones (Meeta *et al.*, 2020) which predisposes to fragility fractures. In fact osteoporosis risk increases from 2 percent at 50 years age and to 25 percent above the age of 80 years (Blackie, 2020) reflecting maximal age related bone loss. Consumption of foods rich in proteins, vitamins and minerals may be helpful in reducing bone turnover through increasing bone formation rather than bone resorption. Pulses are considered as poor man's meat being highly nutritious, low cost and play role in providing good bone health as they are rich in carbohydrates, proteins, fat, vitamins and minerals (Srivastava, 2020). Asians and Whites are more susceptible than Africans and the situation challenged for the exploration of easy simple risk assessment tools which may be beneficial for physicians to prioritize the individuals prone to high risk towards bone density evaluation.

The highly popular clinical risk assessment screening algorithms are Fracture Risk Assessment Tool (FRAX), Garvan Fracture Risk Calculator (Garvan) and Qfracture algorithm. Osteoporosis Self-assessment tool (OST) was first developed by Koh *et al.*, (2001) from postmenopausal women of eight Asian Countries and the performance among Asian men (Kung *et al.*, 2005) was first assessed by Kung *et al.*, (2005). The tool is referred as OSTA (Osteoporosis Self-assessment Tool for Asians) when applied to evaluate the risk levels among Asians (Subramaniam *et al.*, 2018).

Osteoporosis is a growing bone health problem in Asians which has been paying much attention in search of simple effective screening tools to overcome the problem of limited availability of dual-energy x-ray absorptiometry technology. Osteoporosis self-assessment tools for Asians (OSTA) found to be the first screening algorithm based on weight and age only (Chin, 2017). The usage showed beneficial in both men and women especially highly reflected by high performance and sensitivity to identify postmenopausal osteoporotic risk prone groups using a multinational Asian cohort. However, the OSTA may be influenced by age, sex, ethnicity and bone mineral density measurement site to define osteoporosis. The role of physician occupies a much crucial role to fulfil the gap and the application of OSTA in the given clinical settings effectively may serves as cost-effective and easily mode of early prediction of osteoporosis risk. The OSTA is popularized widely in Asians community as it is free osteoporosis risk assessment index to predict risk levels of low bone mass conditions. Furthermore, who are identified as moderate to high risk categories by OSTA may be evaluated for conformity using Quantitative Ultrasound (QUS) bone densitometry (Sherchan et al., 2013) which is more affordable with relatively free or at low cost in Diagnosing poor bone health consequences of osteopenia and osteoporosis .

MATERIALS AND METHODS

A. Locale of the study and sample

The study was conducted in Tirupati urban area of Chittoor district, Andhra Pradesh state in India. Field based survey was carried to select the women in the age range of 35 to 74 years randomly who were voluntarily willing to participate and ready to cooperate in the research investigations. The women were categorized into four different age groups as young (35-44 years), middle age (45-54 years), aged (55-64 years) and elderly (65-74 years). The size of the sample comprised of 260 women belonging to sixty young, eighty each of middle age and aged and forty elderly women.

B. Weight Measurement

The weight was measured in kilograms using standard calibrated balance-beam scale. Initially before proceeding with the weighing process, the scale was checked for zero calibration and then requested the individual to stand straight on the weighing balance. The readings were recorded immediately for each subject as per standard procedure without any parallax error.

C. Osteoporosis Self-assessment Tool for Asians (OSTA)

The OSTA tool was one of the pre-screening tool based on two simple parameters using the individual age and weight (Bhat et al., 2016, Su et al., 2015). This tool might be helpful to the physicians for actively assessing the osteoporosis risk levels among Asian women (Chandrana et al., 2020) thereby to determine the need of BMD measurement even before the occurrence of fracture.

The calculation of OSTA index and the degree of risk levels prediction were evaluated from the criteria provided by Koh et al., (2001). The formula of OSTA calculation was given below.

$$\text{OSTA} = (\text{Weight in Kilograms} - \text{age in years}) \times 0.2$$

(Truncated to an integer)

Interpretation of OSTA

Low risk of osteoporosis	: Score ≥ 0
Moderate risk of osteoporosis	: Score -1 to -3
High risk of osteoporosis	: Score ≤ -4

Based on the above criteria, the women were identified for their risk levels in each age group as low risk, moderate risk and high risk of osteoporosis.

D. Assessment of BMD by Quantitative Ultrasound (QUS) Bone Densitometer

The bone mineral density (BMD) measurement is well established as the best modality of osteoporosis assessment. In spite of several modalities are being used to test BMD , the two techniques of Quantitative ultrasound bone densitometry (QUS) and dual energy X-ray absorptiometry (DEXA) became popular and widely used as both evaluated based on WHO-criteria of BMD-T score (Kruger et al., 2013, Narayanan, 2019). Though the DEXA device is considered as the gold standard of BMD (Choksi et al., 2018, Fathima et al., 2019) the major associated drawbacks are limited access, costly and involves ionising radiation. In such instances QUS emerged as the better alternative preliminary screening tool to test the BMD and evaluate for osteoporosis as it is portable, relatively much cheaper and not involves any radiation (Kavitha et al., 2017, Steiner et al., 2019). The International Society for Clinical Densitometry recommended that the calcaneus (heel) was the only ideal validated anatomic site for bone mass screening using QUS method as it was weight-bearing and trabecular rich site (Krieg et al., 2008. Abdulameer et al., 2018). The current investigation was also followed QUS technique measured at calcaneus bone following the WHO classification of osteoporosis.

WHO-Criteria of BMD – T-Score

Normal	: T-Score of -1 or above
Osteopenia	: T-Score lower than -1 and greater than -2.5
Osteoporosis	: T-score of -2.5 or lower

E. BMD Campaigns

The investigator was in constant touch with the physicians of local orthopaedic hospitals and also the concerned paramedical staff to obtain the information for the day of BMD campaign at the monthly bone health check-ups. The women were motivated and mobilized earlier to undergo BMD testing at the local orthopaedic hospitals on the scheduled dates as per the pre-planned scheduling timings for timely diagnosis of the women.

The women who diagnosed for BMD were categorized into normal with BMD T-score up to -1, osteopenia who had -1 to -2.5 T-score and osteoporosis for the women who had below -2.5 T-score as per WHO classification.

F. Comparative study of OSTA and QUS

The efficacy of OSTA was evaluated by the comparative results between mean ± standard deviation risks scores with QUS mean BMD T-score ± standard deviation in terms of low risk vs normal, moderate risk vs osteopenia and high risk vs osteoporosis. Correspondingly the frequency and percent distribution were also calculated and interpreted in each age group.

RESULTS AND DISCUSSION

The current research aimed at understanding the relationship of OSTA index risk groups and arriving at predicting the accuracy levels of moderate and high risk scores on par with the respective low bone mass category of osteopenia and poor bone mass status of osteoporosis. The results collected and analysed were

compared in each age group accordingly and discussed further under different sub-sections.

A. Comparative mean scores of OSTA and BMD T-score of QUS

The urban women of each age group were categorized into low, moderate and high risk groups based on the mean Osteoporosis Self-assessment Tool for Asians (OSTA). Correspondingly the women groups were also sub-divided into normal, osteopenia and osteoporosis in terms of BMD T-scores obtained from Quantitative Ultrasound (QUS) measured at calcaneus bone. The effectiveness of utilizing OSTA among women was arrived by the comparative results between mean OSTA scores and BMD T-scores viz., low risk vs normal, moderate risk vs osteopenia and high risk vs osteoporosis. The values thus obtained were interpreted and presented in Table 1.

Table 1: Mean scores on Osteoporosis Self-assessment Tool for Asians (OSTA) in comparison to Quantitative Ultrasound (QUS) bone densitometry mean BMD T-scores.

Age Group (Years)	Low Risk (Mean Score± SD) Vs Normal (Mean BMD T Score± SD)		Moderate Risk (Mean Score± SD) Vs Osteopenia (Mean BMD T Score± SD)		High Risk (Mean Score± SD) Vs Osteoporosis (Mean BMD T Score± SD)		Total (Mean Score± SD) Vs Total (Mean BMD T Score± SD)	
	OSTA	QUS	OSTA	QUS	OSTA	QUS	OSTA	QUS
	35-44 (n=60)	2.72± (2.24)	-0.42± (0.14)	Nil	-1.46 ± (0.10)	Nil	-2.59 ± (0.81)	2.72 ± (2.24)
45-54 (n = 80)	1.51 ± (1.68)	-0.46 ± (0.23)	-1.60 ± (0.70)	-1.53 ± (0.16)	Nil	-2.74 ± (0.09)	1.13 ± (1.90)	-0.94 ± (0.83)
55-64 (n = 80)	1.47 ± (1.55)	-0.48± (0.16)	-1.54± (0.65)	-1.63 ± (0.22)	-4.40 ± (0.55)	-2.85 ± (0.25)	-0.29 ± (2.15)	-1.19 ± (0.91)
65-74 (n = 40)	0.25 ± (0.46)	-0.87± (0.15)	-2.67 ± (0.62)	-1.76 ± (0.19)	-5.18 ± (0.95)	-2.59 ± (0.81)	-3.15 ± (2.19)	-2.35 ± (0.82)

The mean OSTA scores showed a clear cut inverse relationship with the progressive age irrespective of the risk category providing a strong evidence that ageing is one of the unavoidable biological risk factor. Similar trend of results were also noticed with QUS BMD T-scores with gradual decline in bone density levels with the advancing age irrespective of bone mass condition. The OSTA mean score in young age (2.72 ± 2.24) represented neither moderate nor high risk condition but the QUS BMD T-score (-1.46± 0.10) denoted occurrence of low bone mass condition of osteopenia and poor bone density condition of osteoporosis (-2.59 ± 0.81). The situation highlighted the fact that the initiation of weakening bones started from the age of 35 years only in the Indian urban women studied which could not be traced from the OSTA score.

The moderate OSTA risk scores were appeared in the in the middle age group but there was no high risk category. The estimation of bone density through QUS could detect both osteopenia and osteoporosis in middle age urban women. The existing scenario denoted a definite indication of triggering lowered bone mass from the age of 45 years and a shift towards poor bone mass of osteoporosis cautioning to follow appropriate preventive strategies for minimizing further predisposing the worsening condition of osteoporosis.

The striking point to be focused that both tools identified the high risk group as well as osteoporosis in both higher age groups of aged and elderly urban women implied the threatening sign of geriatric osteoporosis which need to be corrected at war foot

basis otherwise lead to increased fragility of bones and subsequently higher fractures associated with osteoporosis.

B. Frequency distribution of OSTA and QUS risk levels

The frequency distribution of the urban women was expressed in terms of corresponding risk levels of OSTA and QUS bone density evaluation as low risk vs normal, moderate risk vs osteopenia and high risk vs osteoporosis. The respective number of women in the relevant categories identified from each age group was represented with comparative frequency data in Table 2 and percent levels would be discussed further with graphically representation for better illustrative results.

The frequency distribution well demonstrated that absolutely all the 60 women were at low risk levels as per the OSTA index calculated. But, the actual bone mineral density analysed through QUS found that thirteen women were diagnosed as osteopenic and three women as osteoporotic. On the other hand, the OSTA screening tool showed ten among eighty middle age urban women fall under moderate risk category without identification of high risk. However, the QUS discriminated with fifteen women as osteopenic and ten women as osteoporotic out of eighty middle age urban women.

Surprisingly, in case of aged women, thirty eight only were noted with low risk but forty four of them had normal bone density. The moderate risk score was attained in thirty seven aged women but with QUS analysis only twenty three were fall under osteopenia

category and the remaining thirteen aged urban women suffered from osteoporosis. The OSTA index became successfully identified the high risk condition as five women in aged and seventeen elderly women. Out of forty elderly women studied eight were under low risk

level but only two of them had normal bone density and the remaining six experienced with osteopenia. The moderate and high risk categories calculated through OSTA were almost coincided with the corresponding bone status of osteopenia and osteoporosis respectively.

Table 2 Comparative frequency distribution of Osteoporosis Self-assessment Tool for Asians (OSTA) and Quantitative Ultrasound (QUS) bone densitometry for osteoporosis risk.

Age (Years)	Frequency Distribution					
	Low Risk Vs Normal		Moderate Risk Vs Osteopenia		High risk Vs Osteoporosis	
	OSTA	QUS	OSTA	QUS	OSTA	QUS
35-44 (n=60)	60	44	Nil	13	Nil	3
45-54 (n = 80)	70	55	10	15	Nil	10
55-64 (n = 80)	38	44	37	23	5	13
65-74 (n = 40)	8	2	15	18	17	20

C. Comparative percent values risk scores of OSTA and corresponding QUS bone conditions

The risk levels were expressed in percent values both for OSTA index and QUS BMD-T score criteria in each age group. The comparative percent distribution was depicted graphically in the form of bar diagrams with comparative data viz., low risk vs normal, moderate risk vs osteopenia and high risk vs osteoporosis in the figures 1 to 4 for young, middle age, aged and elderly urban women respectively.

The findings from the figure revealed that absolutely hundred percent of young women were at low risk as per OSTA index but the QUS analysis represented seventy three percent of them at normal range and the remaining twenty two percent were osteopenic and five percent were osteoporotic. As the index being based on age as one parameter, the osteoporotic incidence level

would not be traced out at a young age. However, the prevalence of osteoporosis at this young age was also at nominal level of five percent only and majority about three fourth of young women had normal bone status. Nearly one fourth of them shifted to low bone mass condition which awakened for a better move to restore bone mass and promoting bone health at an early age as early as possible but not the late.

The comparative percent levels observed from the Fig. 2 denoted a shift of twelve percent towards moderate risk in middle age as per OSTA calculation and nineteen percent as osteopenic as per the data obtained from QUS almost scored approximately at the same pace of moderate risk and low bone mass. The important point to be of concerned that twelve percent of them had suffered from osteoporosis which could not be noticed by OSTA score.

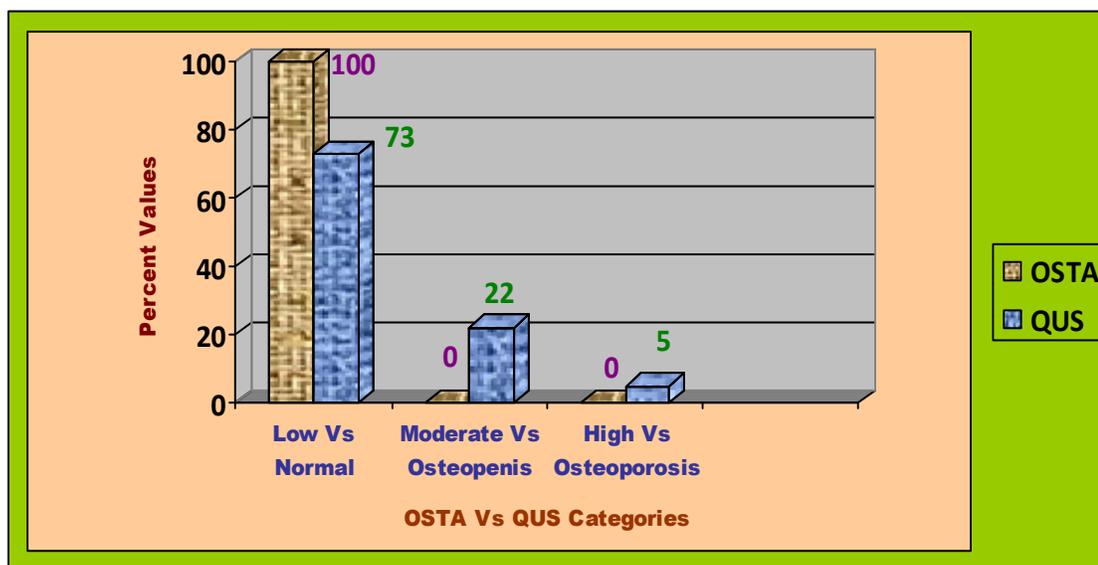


Fig. 1. Comparative percent values of OSTA Vs QUS among urban young women.

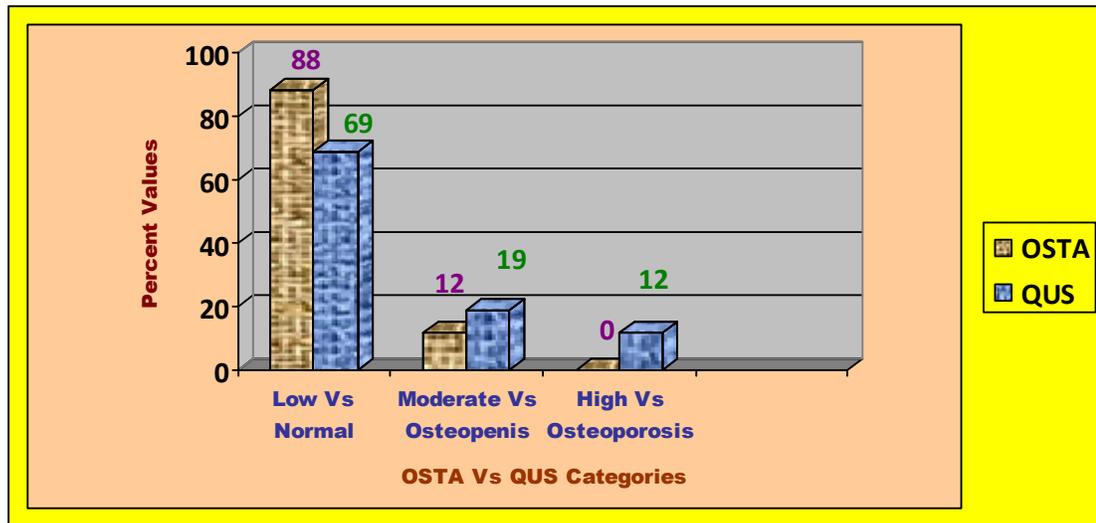


Fig. 2. Comparative percent values of OSTA Vs QUS among urban middle age women.

Interestingly the observations from the Fig. 3 represented that forty eight percent of the urban aged women were fall under low risk category but the actual QUS analyses noted that fifty five percent of them had normal bone mass. The moderate risk scores were scored about forty six percent against only twenty percent of them as osteopenic. The OSTA index could traced out well of six percent with high risk category on par with the more prevalence of sixteen percent with osteoporosis. The situation highlighted the fact that a definite high risk proneness from the age of fifty five years which emphasised the necessity of adopting healthy life styles practices to reduce bone turnover process and to lower the osteoclastic activity. The percent levels depicted in the Fig. 4 strikingly pinpointed that majority of elderly were already in a state of either moderate or high risk and similarly either osteopenia or osteoporosis. The OSTA index showed that twenty percent were at low risk level but actually only five percent of them were in normal bone density range. The incidence levels were almost closely examined as thirty eight percent of moderate risk

against forty five percent of osteopenic and forty two percent at high risk against fifty percent of osteoporotic elderly women. The overall findings from the comparative percent values of OSTA high risk mean scores against osteoporosis QUS mean BMD T-scores found to be differed from five to twelve percent. The young and middle age women experienced five percent and twelve percent of osteoporosis respectively against absolutely nil scoring of high risk category. The percent difference reflected at percent difference between high risk (6%) and osteoporosis (16%) percentage. Whereas, it was noticed with eight percent difference among elderly urban women between high risk (42%) and osteoporosis (50%). Being slighter variations of about one tenth difference prediction utility, the OSTA would be one of the adoptable simple descriptive screening tool to arrive at the determination of risk levels among women especially over the ages of 45 years and among the postmenopausal women.

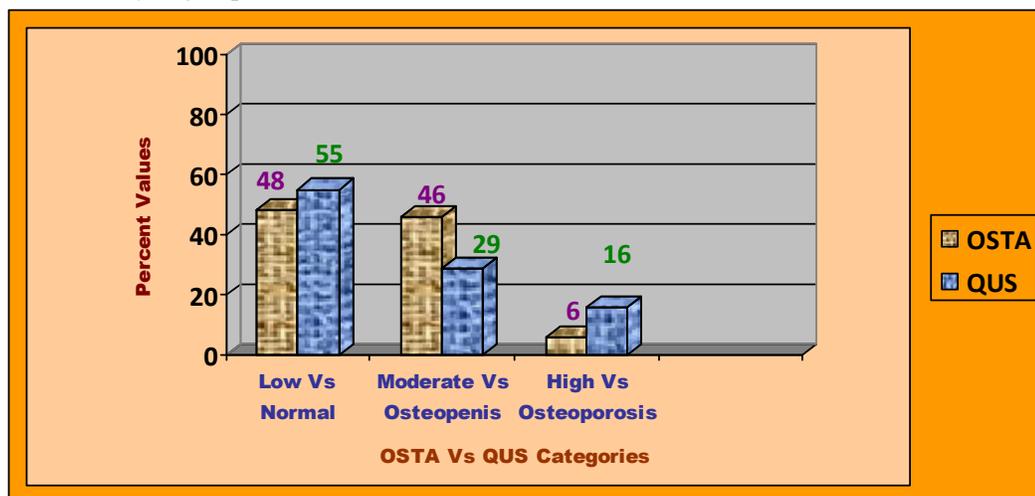


Fig. 3. Comparative percent values of OSTA Vs QUS among urban aged women.

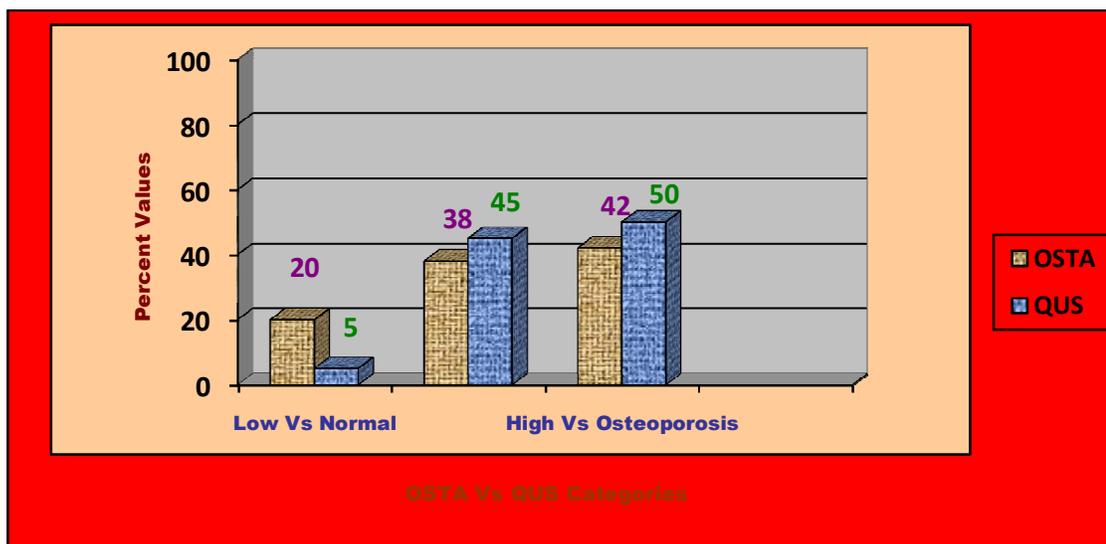


Fig. 4. Comparative percent values of OSTA Vs QUS among urban elderly women.

The common eating disorders encountered among young girls found to be the major health problems and associated with the risk of various ailments such as obesity, depression, osteoporosis etc. (Mughal *et al.*, 2021) which suggest the necessity of maintenance of healthy diet since the young age to protect the bone health in later years. On the other hand the literature on dietary and nutrient intakes demonstrated poor intakes among women and even the urban women also experienced lower levels than recommended dietary allowances (Bharathi, 2021). The present scenario demanded to educate the women on the role of nutrition on bone health to minimize osteoporosis risk. The common eating disorders encountered among young girls found to be the major health problems and associated with the risk of various ailments such as obesity, depression, osteoporosis etc. (Mughal *et al.*, 2021) which suggest the necessity of maintenance of healthy diet since the young age to protect the bone health in later years.

CONCLUSION

The improvements in the medical access to the community, economic viability, better sanitary facilities and enhanced literacy rates have provided a greater scope for the increase in longevity lead to higher proportion of aged population. Meanwhile, the age-related problems become widely accelerated at a faster pace especially bone metabolic disorders occupy major share next to cardiovascular diseases. The drastic changing scenario demanded for the early detection of bone health status to initiate preventive measures. Dual energy X-ray absorptiometry being costlier gradually replacing with the recently recommended QUS technique measured at calcaneus (heel) site became the well accepted bone testing modality to screen the people at community level. The other non-BMD based screening tools are also gaining recognition to overcome the practical problems where the availability for BMD has little scope. OSTA is one such screening tool formulated and standardised through the

individual age and weight and successful in tracing out the patients for the osteoporosis risk condition as low, moderate and high risk for the prognosis of osteoporosis. The research findings highlighted the positive application of OSTA at an ease which showed the percent deviation from the QUS measurements at the rate of five to twelve percent only. Adopting OSTA at the clinical settings may become the most acceptable index as pre-screening tool by the physicians to identify early risk levels and accordingly to decide upon the need of BMD testing and further allowing early treatment and reducing the predisposition of the subjects towards worsening condition of osteoporosis and regulating management strategies from the deleterious effects on the bone. Based upon the risk levels estimated, there is a need to follow appropriate intervention strategies to prevent further worsening the condition and to maintain better bone health among women especially in postmenopausal women.

FUTURE SCOPE

Extending such similar investigations on a large population based studies in different regions through early screening for osteoporosis risk using preliminary screening tools may be helpful to detect the osteoporotic condition in advance and to initiate the treatment protocols at an early period.

The ethnic people of the indigenous tribes have good knowledge on utilization of forest resources in the form of shelter and food (Puri *et al.*, 2021). The forest sources like wild edible plants, flowers, fruits possess the most valuable phytochemicals which may explored for their protective bone health properties and the research may focussed on their usage for the prevention or reduction of osteoporosis risk.

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