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Bone Mineral Density in adult Patients Reporting to Orthopedic Outpatient Clinic Using Calcaneal Ultrasound Bone Densitometer: A Record Based Study at a Tertiary Care Hospital.

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ABSTRACT

INTRODUCTION: Osteoporosis is a major global public health problem associated with significant morbidity, mortality, and socioeconomic burden. Measuring bone mineral density (BMD) is the most valuable tool in the diagnosis of osteoporosis.

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AIMS: The present study was undertaken to assess BMD using a calcaneal ultrasound bone densitometer and to identify some associated correlates.
MATERIALS & METHODS: A records-based study of BMD measurements by ultrasound bone densitometer data was undertaken and analysed for the association between osteoporosis/osteopenia and age, sex, body mass index (BMI), occupation, dietary habits, drug intake, smoking, alcohol use, and systemic illness in the study subjects.
RESULTS: The study included 350 patients, 145 males and 205 females. Ageing, menopause, smoking, alcohol use, sedentary lifestyle, vegetarian diet, and low-income/socioeconomic background were associated with significantly lower BMD T-scores among the study participants, who were at a higher risk for osteoporosis. No significant relationship could be found between BMD and sex, BMI, chronic medical conditions, and prescription medication use in our study sample.
CONCLUSION: Risk groups such as elderly (>60 years) and post-menopausal women could be targeted for prevention measures and would benefit from preventative pharmacological therapy such as bisphosphonates, hormone replacement therapy, calcitonin, and Parathyroid hormone therapy (PTH), a high-protein diet, a more active lifestyle, and exercise. Smoking cessation and alcohol abstinence would also benefit users in maintaining healthy BMD.

KEYWORDS: Osteoporosis, Osteopenia, Bone mineral density, Body mass index, Calcaneal ultrasound bone densitometer

INTRODUCTION:

Osteoporosis is associated with significant morbidity, mortality and socioeconomic burden and is a major global public health problem.[1] There is increased risk of bone fracturing, even under small stress due to decreased bone strength. The quality of life has a major impact due to bone pain and fragility. Even though seen as ``an old woman's disease'', osteoporosis occurs in both women and men and can do so at any age.[2]

The relationship between environmental and lifestyle factors and either bone density or fracture incidence has been found.[3] Recent modernization of India has limited sun exposure due to working indoors and has reduced physical activity. [1] The potential risk factors for osteoporotic fracture, such as lower body weight, cigarette smoking, caffeine intake, use of long-acting sedatives, and inactivity, have been identified.[4]

The most important tool in the diagnosis of osteoporosis is measuring Bone mineral density (BMD).[1] The major risk factor for osteoporosis and its related fractures is low bone mineral density.[5] The World Health Organization defined osteoporosis in terms of bone mineral

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density as a T-score ≤ −2.5 and/or a previously fragility fracture and osteopenia as a T-score between -1 to -2.55.[6] Dual energy X-ray absorptiometry (DEXA) scan is currently the most widely used tool for both axial and appendicular skeleton, but ultrasound has been described as a most cost effective and radiation free safe approach to measure bone density with accuracy in screening test as it is portable.[7] The only site recognized by the International Society of Clinical Densitometry (ISCD) is Calcaneus for the assessment of bone density using quantitative ultrasound (QUS) bone densitometry. Moreover, QUS screening conclusively confirms or rules out osteoporosis and osteopenia in any population.[8]

The lack of facilities for measurement of BMD has limited studies on this issue in this part of the country. Hence, the present study was undertaken to assess BMD using calcaneal ultrasound bone densitometer and to find out some correlate associated with it.

MATERIALS AND METHODS

Study was undertaken after taking approval from institutional Ethics and Scientific committees. The records from the camp organised from 23 May 2022 to 26 May 2022 in the Department of Orthopaedics, Mandya Institute of Medical Sciences were retrieved. 350 patients records conforming to the inclusion-exclusion criteria during the study period were found.

Inclusion criteria:

1.Patients whose records were found

2.Patients who are aged above 20 years

Exclusion criteria:

1.Patients who had calcaneal fractures and lower limb disorders

2.Patient whose records were not proper.

Data regarding age, sex, religion, dietary habits, occupation, menstrual history, and history of systemic illness along with use of medication was retrieved. Data on smoking and alcohol, drug intake along with history of trauma was taken. Body Mass Index (BMI) was calculated for assessment of nutritional status as per WHO guidelines from Height (m) and weight (kg) data. BMD measurement in calcaneus (heel bone) in terms of T-score which was performed by a single technician was taken.

• Normal is a T-score of −1.0 or higher

• Osteopenia is defined as between −1.0 and −2.5

• Osteoporosis is defined as −2.5 or lower**.**

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All data was entered into Microsoft excel and analyzed using simple percentage and proportions. The results were presented with descriptive statistics. Descriptive statistics like mean and standard deviation were calculated for all continuous variables and compared using t-test. Chi-square was applied to find the association between the variables. $P < 0.05$ was considered as significant

RESULTS

Among 350 patients there were 145 males and 205 females with male to female ratio of 0.70 of which 43 (30%) women had attained menopause at the time of study (Table-1). The age of the study population ranged from 20 to 80 years with an average age of 45.37 years and a median of 45 years.

The study population had a healthy, bone mineral density with and average BMD T-score of -0.698 with males showing average T-score of -0.9005 and women having an average T-score of -0.585243. (p-value: 0.228) (Table-2)

Women who had attained menopause were osteopenic with an average BMD T-score of -1.6093 compared to premenopausal women who had a healthy mean BMD T-score of -0.30098. (p-value: 0.00033) (Table-4)

Table 1: Total number of study participants

MALE	FEMALE	TOTAL
145(41.4%)	205(58.5%)	350

Table 2: Statistical analysis of T-scores according to sex:

	Males	Females
Mean	-0.900	-0.585
Median	-1.7	-1.6
Mode	-1.4	-1.6
Standard Deviation	2.321	2.507

Figure 1: Frequency chart of T-score values in the study population

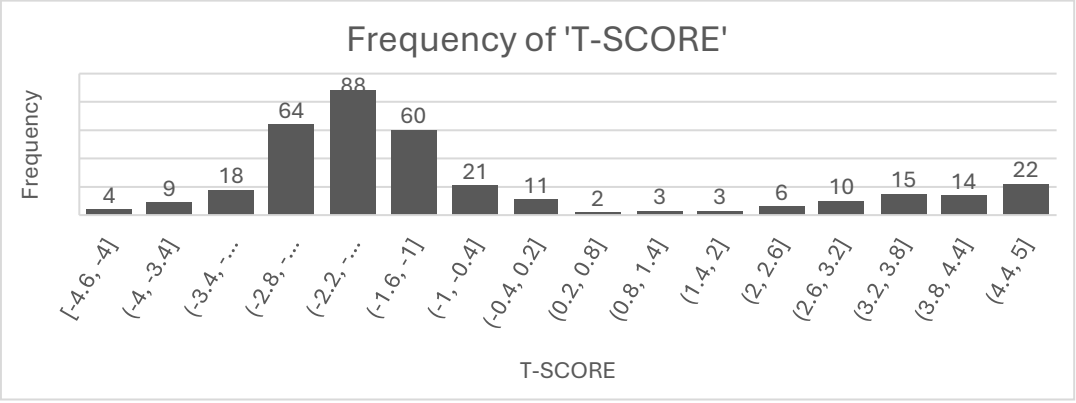


Figure 2: Scatter chart of T-scores of study population

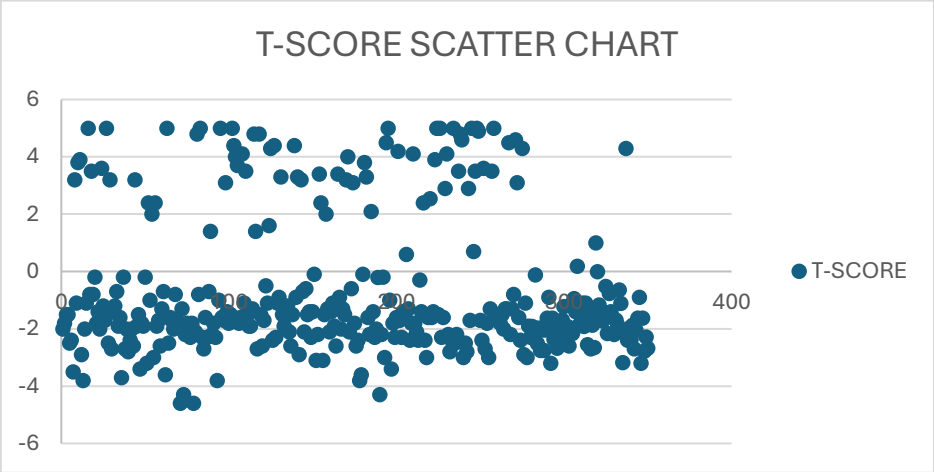


Table 3: Statistical analysis of T-score values of the study population:

Mean	-0.698
Median	-1.6
Mode	-1.5
Standard Deviation	2.448
Minimum	-4.6
Maximum	5
Count	350

Table 4: Statistical analysis of T-score values of Menopausal women:

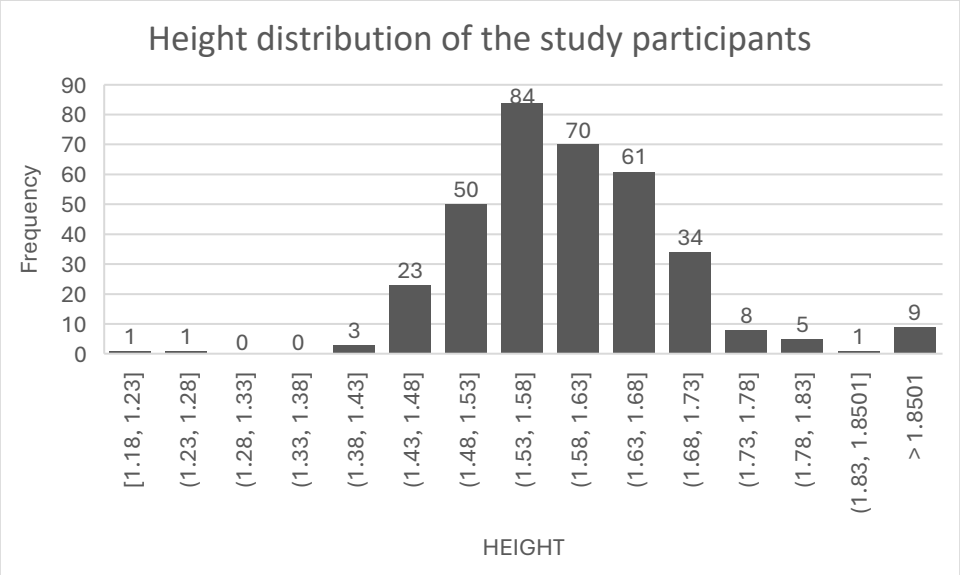
T-scores of pre-menopausal women		*T-scores of menopausal women*	
Mean	-0.3009	Mean	-1.609
Median	-1.5	Median	-2
Mode	-1.8	Mode	-1.9
Standard Deviation	2.589	Standard Deviation	1.869
Total	162	Total	43

The bone mineral density T-score means shows a age dependent pattern with younger age groups having a higher scores, i.e. -0.023 (20-29 years), -0.637 (30-39 years) and -0.098(40-49 years) compared to the elderly population who had were relatively osteopenic with a mean BMD of -1.128 T-score (50-59 years) , -1.435 T-score (60-69 years) and -1.766 T-score (>70 years). By tests of significance t-statistic was 2.089 and p-value was 0.039 for an independent two-sample t-test between age groups 30-39 years and 60-69 years) and an ANOVA single factor p-value of 0.0021. (Table-5)

Table 5: Statistical analysis of T-scores according to age groups:

Age group: (years)	20-29	30-39	40-49	50-59	60-69	>70
Mean	-0.023	-0.637	-0.098	-1.128	-1.435	-1.766
Median	-1.1	-1.6	-1.4	-1.8	-2	-2.6
Mode	-1.4	-1.8	5	-1.9	-2	-2.6
Standard Deviation	2.322	2.382	2.776	2.153	1.997	2.475
Count	39	90	88	65	48	20

Figure 3: Height distribution of study participants



The average height of the study population was 1.59 metres ranging from 1.18 to 1.85 metres with standard deviation of 0.0843. (Figure 3) The average weight of the study population was 61.09 kilograms with a standard deviation of 11.637. (Figure 4)

The average body mass index (BMI) of the study participant was 23.257 with a standard deviation of 3.916. (Figure 5)

The study population did not show any significant difference in mean BMD T-scores between the various BMI categories of Underweight (<18.5): -0.973, Normal BMI (18.5 to 24.9): -0.796, Overweight (25 to 29.9): -0.526 and Obese (30 and above): -0.565. The single factor ANOVA p-value was 0.728. (Table-6)

Figure 4: Weight distribution of the study population

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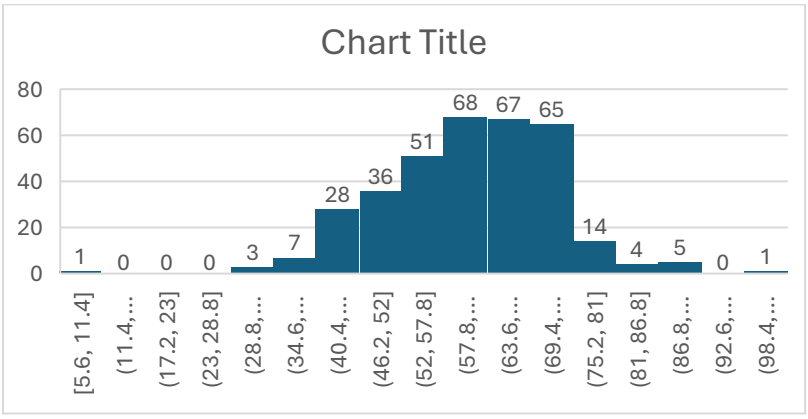

Figure 5: Scatter chart of BMI values of the study population

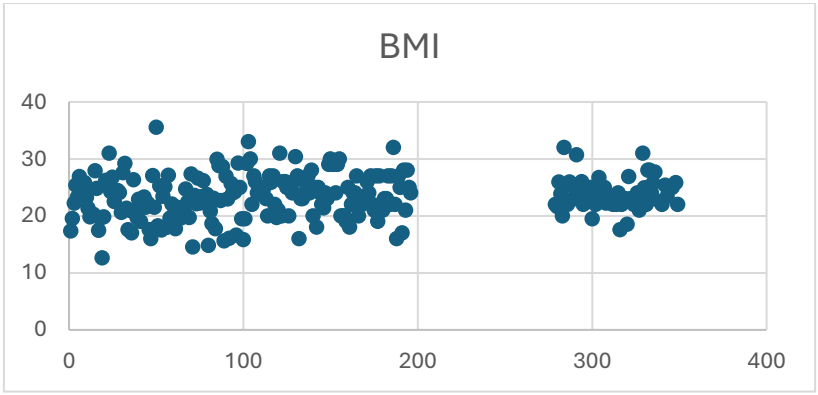

Table 6: Statistical analysis of T-scores according to body mass index (BMI):

BMI	*Count*	*Sum*	*Average*
Underweight (<18.5)	28	-27.26	-0.973
Normal (18.5 to 24.9),	173	-137.74	-0.796
Overweight (25 to 29.9)	122	-64.27	-0.526
Obese (30 and above)	27	-15.27	-0.565

Most of the study population had a mixed diet (92%), while a small minority were reported as vegetarians (8%). (Figure 6)

The population with a mixed diet had a slightly higher average BMD T-score of -0.679 compared to vegetarians with -0.917 (p-value : 0.0412). (Table-7)

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Figure 6: Chart of dietary preference of the study population

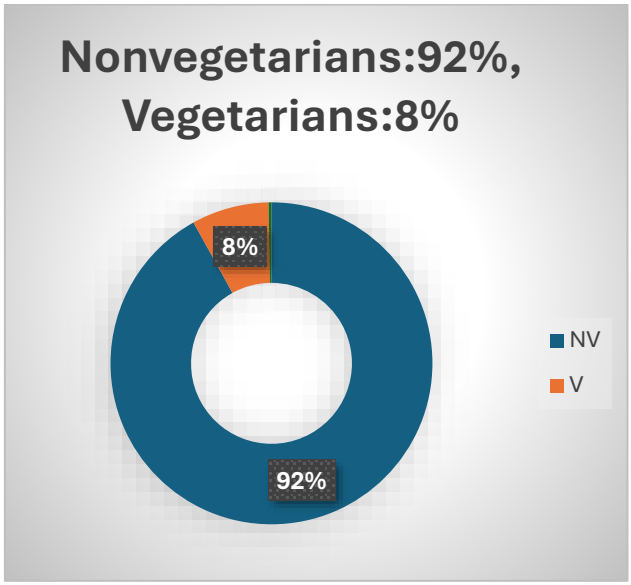

Table 7: Statistical analysis of T-scores according to dietary preference**:**

	Mixed diet	*Vegetarian diet*
Mean	-0.679	-0.917
Median	-1.6	-1.55
Mode	-1.4	-2.6
Standard Deviation	2.465	2.280

Table 8: Statistical analysis of T-scores according to occupation:

	Homemaker	Professional	Agricultural workers	Labourers	Others
Mean	-0.699	-0.509	-0.922	-1.325	0.327
Median	-1.63	-1.3	-1.7	-1.9	-0.95
Mode	-1.6	-1.5	-2.2	-2.1	3.2
SD	2.520	2.275	2.376	1.974	2.917
Count	114	48	91	33	18

The study sample were predominantly composed of homemakers (32.5%) agricultural workers (26%) with mean BMD t-score of -0.699 and -0.922, respectively. (Table-8)

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Professional occupations were 13.7% of the study population (i.e., Doctors, Nurses, Engineers, Lawyers, Pharmacists etc.) had mean BMD t-score of -0. 509.Daily wage labourers were 9.42% of the study population had the lowest mean BMD t-score of -1.325

86.5% of the study population reported had a moderate level of physical activity, 12.28% had a high level of physical activity while only four had a sedentary lifestyle.

The mean BMD T-scores were similar in persons with moderate and high levels of physical activity i.e., -0.679 and -0.855 respectively. In contrast, persons with a sedentary lifestyle were osteopenic with a mean BMD T-score of -1.615. The two sample t-tests p-value was 0.094 and 0.083 between Moderate v/s Sedentary levels and Heavy and Sedentary levels, respectively. The one-way ANOVA p-value was 0.02720. (Table-9)

Table 9: Statistical analysis of T-scores according to level of activity:

	Moderate Activity	*Sedentary activity*	*Heavy activity*
Mean	-0.679	-1.615	-0.855
Median	-1.6	-2.33	-1.6
Standard Deviation	2.465	1.545	2.481
Count	303(86.5%)	4(1.14%)	43(12.28%)

Table 10: Number of patients with co-morbid conditions in the study sample is given below:

NO COMORBIDITIES	252 (72%)
RVD	29 (8.2%)
HYPERTENSION	26 (7.4%)
DIABETES MELLITUS	14 (4%)
DIABETES MELLITUS+HYPERTENSION	13 (3.71%)
HYPOTHYROIDISM	7
IHD	2
DEPRESSION	1
RVD+DIABETES MELLITUS	1
SEIZURE DISORDER	1
ASTHMA	3
HYPERTHYROIDISM	1
TOTAL	350

Seventy-two percent of the study participants had no comorbidities while 29 (8.2%) were known Human immunodeficiency virus (HIV) disease-affected patients on oral antiretroviral therapy (ART).26 (7.4%) of the participants were long-standing hypertensives, 14 (4%) had Diabetes mellitus and 13 (3.71%) had both hypertension and diabetes mellitus. Eight patients (2.2%) had thyroid disorders. The one-way ANOVA p-value was 0.037. (Table-10)

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Patients with diabetes mellitus had a lower BMD mean T-score of -1.518 compared to patients with hypertension (p-value: 0.576) and combined diabetes mellitus and hypertension (p-value: 0.132310175) who had average T-scores of -1.180 and -0.286 respectively and like patients with HIV (T-score of -1.509, p-value: 0.154)

There was no significant difference between mean BMD T-scores between Hypertensives and combined Diabetic and Hypertensives (p-value: 0.085); Hypertensives and HIV patients (p-value: 0.499) either.

Patients with thyroid disorders (i.e., hypothyroidism and hyperthyroidism) had a mean BMD t-score of -0.887 which was significantly different from patients with RVD (p-value: 0.006). There was no significant difference between patients with thyroid disorders and patients with hypertension (p-value: 0.103), diabetes mellitus (p-value: 0.146), and DM+ hypertension patients (p-value: 0.803) (Table-12)

Table 11: Drug intake among the study population:

DRUG INTAKE AMONG THE STUDY SAMPLE	NUMBER OF STUDY PARTICIPANTS
NO DRUG HISTORY (N)	243
ART (ANTI RETROVIRAL THERAPY)	26
ANTIHYPERTENSIVE THERAPY	25
OHA (ORAL HYPOGLYCEMIC AGENTS)	18
ANTIHYPERTENSIVE+OHA	13
THYROXINE	7
ANTIPLATELETS	2
IRON AND VITAMINS	1
ANTIEPILEPTIC	1
MDI (METERED DOSE INHALER)	1
NSAID (NON-STEROIDAL ANTI-INFLAMMATORY DRUG)	7
ART+OHA	1
ANTIPSYCHOTICS	1
ANTITHYROID MEDICATION	1

Table 12: Statistical analysis of T-scores according to systemic disease:

	Diabetes mellitus (DM)	*DM + Hypertension*	*Hypertension*	*HIV (Retroviral disease)*	*Thyroid disorder*
Mean	-1.518	-0.286	-1.180	-1.509	-0.887
Median	-1.95	-1.45	-2.3	-1.9	-1.4
Mode	-0.7	N/A	-3.8	-2.5	-
SD	2.064	2.952	2.656	1.968	2.162
Count	16	14	29	32	8

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11.4% (40 persons) of the study participants gave a history of smoking for > 10 years while 8% (30 persons) of the study participants gave a history of chronic alcohol use. Thirty percent of the population were chronic users of prescription medications for various medical conditions. (Table12,13 and Figure 7)

The average BMD T-score was -1.87 for chronic users of prescription medications and -0.374 for non-drug users (p-value: 0.713); -1.65 for smokers compared to -0.649 for non-smokers (p-value: 0.0008); -1.45 for alcohol users compared to -0.6597 for alcohol abstainers (p-value: 0.0001). (Table-14,15)

Table 13: Number of study subjects with the habit of smoking:

SMOKING HABIT	NO. OF PATIENTS
NO	309
BIDI	33
CIGARETTE	8
Total	350

Figure 7: Alcohol use in the study population:

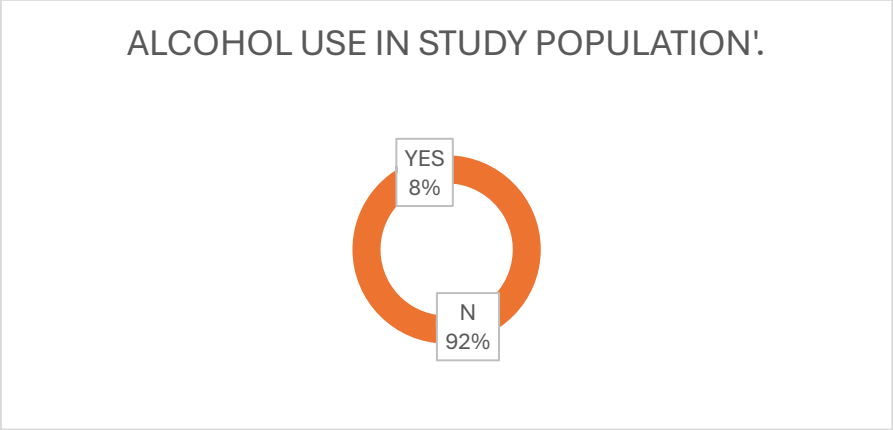

Table 14: Statistical analysis of T-score values of patients with chronic medication use, Smokers, and Alcohol users:

	Chronic medication users	Smoking	Alcohol use
Mean	-1.081	-1.081	-1.113
Median	-1.87	-1.65	-1.45
Mode	-2	-0.8	-2
Standard Deviation	2.390	2.372	2.018
Count	105	40	30

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Table 15: Statistical analysis of T-score values of Non-smokers and Non-alcoholics

	Non-smokers	Non-alcoholics
Mean	-0.649	-0.659
Median	-1.6	-1.6
Mode	-1.8	-1.5
Standard Deviation	2.457	2.484
Count	310	320

58(16.5%) of study participants gave a history of fractures of long bones and spine, of which eight underwent surgery related to the injury. The average T-scores of BMD were -0.769 for persons with a history of fractures compared to -0.693 for persons with no history of bone fracture. (p-value: 0.00073) (Table-16,17)

Table 16: Participants with history of long bone injuries:

HISTORY OF FRACTURES	YES	NO
NUMBER OF PARTICIPANTS	58	292

Table 17: Statistical analysis of T-score values of the study population with and without a history of long bone fractures:

	History of fractures	*No history of fractures*
Mean	-0.769	-0.693
Median	-1.7	-1.6
Mode	-2.1	-1.5
Standard Deviation	2.558	2.434
Count	57	293

DISCUSSION:

Bone Mineral Density (BMD) serves as a vital indicator of bone strength and fracture risk, particularly in the assessment and management of osteoporosis. While dual-energy X-ray absorptiometry (DEXA) remains the gold standard, alternative techniques such as calcaneal bone ultrasound densitometry have gained prominence due to their portability, cost-effectiveness, and radiation-free nature. The calcaneus, being rich in trabecular bone and metabolically active, provides a reliable site for peripheral BMD measurement. This study focuses on evaluating BMD using quantitative ultrasound (QUS) of the calcaneus to identify patterns, risk factors, and clinical relevance in the target population.

The study population comprised 350 adults who had attended a camp for measuring Bone mineral density by QUS organized at the Department of Orthopaedics, Mandya Institute of

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Medical Sciences; organized from 23 May 2022 to 26 May 2022 after regulatory approvals. The records from the camp were retrieved and analyzed.

The study population overall had a healthy BMD with an average T-score of -0.698. There was no significant difference between the sexes with adult males having an average T-score of and the females having an average T-score of. The women who had attained menopause had a lower BMD T-score of -1.609 as compared to premenopausal females with -0.3009 (p-value: 0.00033), consistent with results of previous studies and could be attributed to loss of the anabolic effects of estrogen normally present in young adult females and would benefit from hormone replacement therapy (HRT) and selective estrogen receptor modulators (SERMs) drugs.[9]

There was an inverse relationship between increasing age showing decreasing average BMD T-score values. The more elderly age groups had a lower T-score compared to the younger age groups. This has been hypothesized to be due to the low bone turnover in the elderly increased rate of bone resorption and relative decrease rate of osteoid formation and mineralization. Thus, the elderly would benefit from improved household safety to prevent falls and hip protector devices to prevent osteoporotic fractures of the hip which are common causes of morbidity and mortality in this age group.[10]

The study population was composed of agricultural workers (26%), homemakers (32.5%), professionals (13.7%), and labourers (13.7%) by occupation (p-value was 0.027). The daily wage labourers (mean t-score: -1.325) and agricultural workers (mean t-score: -0.922) had a relatively low BMD compared to professional workers (mean t-score: -0.509) and homemakers (mean t-score: -0.699). This could be due to the higher socioeconomic condition of the latter 2 groups and the availability of protein and calcium-rich diets.[11,12] Further supportive evidence of the importance of dietary intake showed that individuals with mixed diets had a higher average BMD T-score of -0.679 compared to vegetarians with -0.9175 which was statistically significant (p-value: 0.041).

There was no significant difference in BMD between the persons concerning body mass index (BMI) BMD T-scores (p-value was 0.728). Persons with a Sedentary lifestyle had a low BMD T-score of -1.615 compared to patients who had a moderate or heavy activity lifestyle with mean T-scores of -0.679 and -0.855 respectively (p-value: 0.0272).

The participants with a chronic history of smoking had significantly lower mean BMD of -1.65 compared to non-smokers who had a mean BMD T-score of -0.649 (p-value: 0.0008) Similarly participants with a chronic history of alcohol use had a mean BMD T-score of -1.45 compared to non-alcoholics who had a mean BMD T-score of 0.659 (p-value: 0.0001). These results were statistically significant and were consistent with findings from previous studies. These could be attributed to the cadmium content of tobacco smoke and the inhibiting effect on the vitamin D-parathyroid hormone axis. Thus, smoking cessation and alcohol abstinence will decrease the risk of osteoporosis. [13,14]

Ninety-eight of the study participants had systemic medical conditions with an average BMD T-score of -1.081 and did not have significant differences compared to subjects with no co-morbidities who had a T-score of. The major medical conditions afflicting the study population was retroviral disease (32 persons), Hypertension (29 patients), Diabetes mellitus (16 patients), and Diabetes mellitus with Hypertension (14 patients). Persons living with HIV and on anti-

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retroviral therapy medications had an average BMD T-score of -1.509, Diabetics had a BMD of -1.518 T-score, Hypertensives had a BMD T-score of -1.18 while patients with both Diabetes and hypertension had a BMD of -0.286. The persons with HIV and Diabetes mellitus had a lower T-scores and osteopenia compared to other groups, but this was not statistically significant (p-value: 0.803).

Persons who had suffered and were treated for long bone fractures (T-score of -0.769) did not show a major difference in average BMD compared to subjects with no history of such trauma (T-score of -0.693). (p-value: 0.00073) The probable reason for this is that the fractures in the study subjects were not a result of osteoporosis and was likely due to high-energy trauma in healthy bones.

CONCLUSION:

Aging, menopause, smoking, alcohol use, sedentary lifestyle, vegetarian diet, and low-income/socioeconomic background were associated with significantly lower BMD T-scores among the study participants and were at a higher risk for osteoporosis. These risk groups could be targeted for prevention measures and would benefit from preventative pharmacological therapy such as bisphosphonates, HRT, SERMs and calcitonin and Parathyroid hormone therapy (PTH), high protein diet, more active lifestyle, exercise, smoking cessation, and alcohol abstinence. People over 60 years of age and post-menopausal women were relatively osteopenic and would also benefit from measures to reduce the risk of falls and trivial injuries such as the use of the hip guards, handrails, walking aids, etc, which would otherwise lead to fragility fractures of the hip and spine which are common causes of morbidity and mortality in this age group.

No significant relationship could be found between BMD and sex, BMI, chronic medical conditions, and prescription medication use in our study sample.

The findings of the study were consistent with the results of similar previous studies. The limitations of the study were a small study population and larger sample size, and a more complex study design is required to compare and co-relate the relationship between BMD in patients with systemic medical conditions, effects of long-term drug use, dietary factors, socioeconomic conditions, and history of low energy fractures.

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Conflicts of interest

There are no conflicts of interest.

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