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Original Research Article

A DEXA scan at 20 years of age in select subjects may show a z-score "shift to the left" giving time after ethnic corrections to regain optimal peak BMD at 30 years

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ABSTRACT

Background: Osteoporosis is a silent pandemic, and it's vital to detect osteopenia early. This study shows the importance of a DEXA baseline scan at 20 years of age as a part of a PREVENTIVE MEASURE to gain time to reach the optimum Peak BMD at around 30 years.
Methods: Among 5,000 patients tested in a mixed or ambispective study determining BMD between 2000-2026, by the IRT Academy by NGO KRUSHI OWS. The exclusion criteria were patients with known causes of bone weakness due to congenital diabetes, Thyroid deficiencies, renal dysfunction, familial history of bone weakness.
Results: Osteopenia was prevalent in 60% (n=3,000), Osteoporosis was found in 15% (n=750), and Normal Bone Density was found in 25% (n=1,250). The analysis showed that 75% of study patients had low bone density, highlighting the consequences of low bone mass for individuals, families, and insurance companies.
Conclusions: If the osteopenia stage, a precursor to osteoporosis, is missed or neglected, the opportunity to reach optimal peak BMD is lost forever, making this study an important call for attention from osteoporosis foundations worldwide.

Keywords: Osteopenia, Osteoporosis, DEXA scan, T score, Z score

INTRODUCTION

Osteopenia is a precursor of osteoporosis, and if diagnosed with precision, it can be found in growing foetuses, children, and young adults, but sadly it is often unrecognised and uninvestigated. Peak bone mass is generally achieved by the 3rd decade of life and inadequate attainment of PBMD predisposes to osteopenia and later osteoporosis; if it occurs in the young, the susceptibility to fragility fractures increases even in adolescence or early adulthood, as the rapid growth of the bone with lagging bone density leads to a 'transient deficiency of cortical bone mass in growing adolescents or a latent physiological osteopenia of growing bones during adolescents.[1-4] Also, in this case report by Sheikdon et al transient osteoporosis of the hip was reported in a 17-year-old female.[5] The objective of this study is to identify low Z-scores early in young adulthood and rectify them before peak BMD is achieved.

A low Z score or low bone mineral density should alert the clinician to start timely correction so the patient reaches peak BMD by 25 to 30 years, after which bone density falls gradually in both genders, though with different plateau and decline patterns.

METHODS

This is a mixed or ambispective study done by the Research Centre of KRUSHI Orthopaedic Welfare Society, an NGO based in Andhra Pradesh, India, between April 2000 and 2026. Statistical analysis, including data collection, organisation, analysis, interpretation, and presentation, was done. The Selection criteria included 5000 screened patients at the KOWS research centre and 200 articles from databases such as PubMed.

This study emphasises the importance of using quantitative ultrasound BMD-measuring equipment in mass screening camps as a screening tool only and, in selected patients, DEXA (Dual Energy X-ray Absorptiometry) for confirmation, if available. All participants provided informed consent. Patient privacy was protected, and the study adhered to the Helsinki guidelines. Ethical approval was obtained from the Krushi Orthopaedic Welfare Society Ethics Committee, Visakhapatnam, Andhra Pradesh, India.

RESULTS

The Demographic data focused on both males and females around 20 years of age, Indian Ethnicity, students studying in tribal, rural and urban colleges without income, unmarried and non-religion-centric, with nuclear families, with normal-appearing health status with symptoms of fatigue, bone and joint pain, fractures following minor trauma, vertebral pain and normal inflammatory markers.

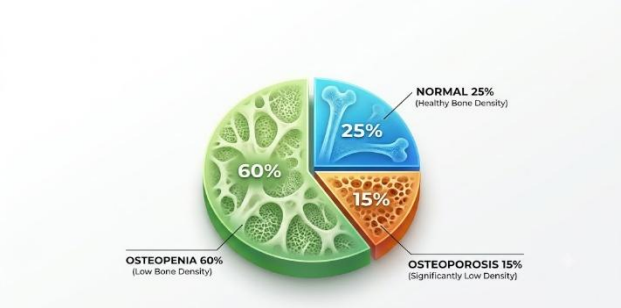


Figure 1: Pie Diagram showing IRT Academy data from the osteopenia study conducted between 2000 and 2026, showing normal BMD in only 25% of young adults before 30 years of age, osteopenia at 60%, and Osteoporosis at 15% with a history of frequent fractures.

Osteopenia was prevalent in 60% (n=3,000), Osteoporosis was found in 15% (n=750), and normal bone density was found in 25% (n=1,250).

The analysis showed that 75% of study patients had low bone density, highlighting the consequences of low bone mass for individuals, families, and insurance companies.

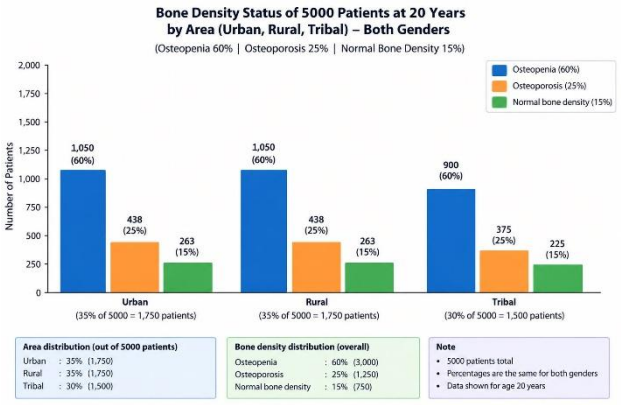


Figure 2: The demographic, gender distribution of the findings in this study are displayed above.

Osteopenia was prevalent in 60% (n=3,000), Osteoporosis was found in 15% (n=750), and Normal Bone Density was found in 25% (n=1,250).

DISCUSSION

Preventive orthopaedics is important in osteoporosis, as it can completely disable a person at any age. The analysis showed that 75% of study patients had low bone density, highlighting the consequences of low bone mass for individuals, families, and insurance companies.

In the article by Panchal et al in the Journal of Preventive Medicine and Holistic Health 2025;11(1):28-37, osteopenia in young adults across India was emphasised as Osteopenia (43.91%) and Osteoporosis (8.40%), out of a total of 5,000 subjects. Our 25-year study has similar findings and is the reason for this research publication. Poor lifestyles, smoking during pregnancy or in regular life, alcoholism, poor diet with low vitamin D levels and lack of physical activity during pregnancy appear to be detrimental to bone mineral deposition during intrauterine life.

Growth hormone deficiency is reported to cause Higher fracture risk in COGHD (childhood-onset GH deficiency), and treatment with GH should minimise osteoporosis in adulthood. Further, optimum PEAK BMD is reached by an optimum GH level at the age of transition to young adulthood by treatment with rhGH in growing children with COGHD.[6]

Trabecular bone loss is seen in patients with Collagen VIα2 chain deficiency by increasing osteoclast differentiation by activating the TNFα signalling pathway.[7] Collagen supplements are more beneficial when taken as an adjuvant with Vitamin D and Calcium supplements.[8] Osteogenesis imperfecta is another common genetic condition related to type 1 collagen.

In utero fetal osteopenia or Osteoporosis does exist and can result from a metabolic bone disease linked with premature birth due to reduced transfer of calcium and phosphorus in the third trimester, or a particular genetic aberration causing demineralisation in the fetus. Once delivered, the newborn may show low birth weight, which is usually caused by maternal low Vitamin D; maternal illness, lack of breast milk or refusal to breastfeed can lead to osteopenia in the newborn or the infant if proper substitute feed is not given.[9-12]

Ethnic BMD variations exist, as seen in Caucasian bones, which are stronger than those of Asians. Hence, the Hologic data, when applied to Asians, gives more false positives, as Asians are reported as having a higher incidence of osteopenia or osteoporosis, and this led the ICMR to release conversion formulas to rectify this error in the T and Z scores. This IRTP research is supported by a publication by Babhulkar et al which concluded that osteopenia in younger populations was more prevalent and that enough awareness to detect it was absent and called for pan-India studies in this regard, which is also a supportive lead to the present study.[13]

The highest BMD was found in the Tobagonian African race and is due to genetic factors (Genes VDR, ERα, and COL1A1), which show 10–20% higher bone mineral density at the hip and spine, with thicker cortical bone and stronger trabecular structure contributing to higher bone mass and lower resorption rates.[14] The hormonal influence resulting in a “Vitamin D paradox” is an interesting condition characterised by efficient calcium conservation and enhanced skeletal sensitivity to parathyroid hormone.[15]

The observation of ‘transient deficiency of cortical bone mass in growing adolescents’ is important because, during active growth, peak bone mineral density reached only 57% of the total bone mineral content while the height velocity grows to 90% of expected adult height and there is more transient weakness in the forearms which may fracture on trivial injuries and this study highlights this Preventive orthopaedics aspect.[16]

After linear growth is reached the bone continues to remodel at a rate of up to 50% per year. Bone remodelling is a delicate balance between resorption and formation and is regulated by PTH, vitamin D, insulin-like growth factor, and calcitonin. The male skeleton has greater resistance to mechanical stress due to higher BMD than in girls, and in boys the appendicular skeleton shows predominant periosteal deposition, making the cortical layers thicker as the periosteal and endosteal surfaces are thickened.

The same increased cortical thickness is found in the vertebrae of the axial skeleton. In girls, endosteal deposition is seen predominantly. Sexual structural dimorphism presents as a 10-15% increase in the frontal bone in men compared with women, providing greater mechanical resistance to trivial fractures in males.[17] It is prudent to understand that, from bone formation onward, females are susceptible to trivial injuries and may sustain fractures and failure patterns. The DEXA machine uses dual-energy X-ray absorptiometry and is very accurate, though not mobile at this time. The appearance of a BMD Curve differs in males and females.[18]

Safety of DEXA scan: DEXA scan, or dual-energy X-ray absorptiometry, is very safe, as the radiation dose given by a DEXA scan to a patient is usually only 0.001–0.01 mSv (1–10 μSv) (equal to 100 chest X-rays). It's better to test for the bone density with a DEXA SCAN rather than overlook a silent disease with progressive weakening of the axial and appendicular skeleton. Comparison with similar findings in support of this study.

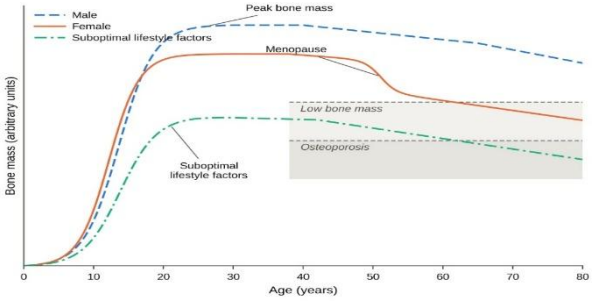


Figure 3 : Different Peak bone mass densities in different individuals are depicted in different genders, where the PBMD reached is higher in males with a higher plateau and then gradually falls, while in females there is a lower PBMD with a flatter, shorter plateau, which suddenly declines after menopause, and at the bottom there is an interrupted curve in either gender where the PBMD is seldom reached to the expected levels and remains in deficit throughout and also declines into insufficiency, earlier osteopenia and earlier severe osteoporosis.

This is why females are always in deficit in their BMD, as the peak BMD is never as high as in males, and they will lose more bone density much earlier; if a 10% higher Peak BMD is achieved, the onset of osteoporosis is delayed by 10 years.[19] The problem in India is that the bones are less dense than Caucasian bones of the Europeans, which were analysed by the NHANES-III database, and when the caucasian data was used to calibrate the Hologic machines for inventing the T score and the Z SCORE and then used for the Indian population, the T and Z scores were lower, which were normal for Indians.[20] This prompted the Indian Council of Medical Research to conduct a retrospective study called ‘Ethnica', where special conversion formulas were developed to get the reliable ICMR (T score) and the ICMR (Z score) and the false positives or over declaration of osteopenia and osteoporosis was eliminated when the ICMR data were incorporated into the software systems of the hologic DEXA and ultrasound machines to avoid drug-induced organ overload and failure.[21] For this in India, the Indian Council of Medical Research (ICMR) provided rough ranges as reference ranges; the T-scores increase by roughly +0.51 (HIP) and by +1.64 (Spine).

Shetty et al used the Indian database from 4 Indian cities versus the Hologic database in postmenopausal women and they found that a high incidence of false-positive osteoporosis when the Hologic Caucasian data was used was in fact osteopenia when the Indian databases were incorporated into the software.[22] This information necessitates the development of Indian BMD machines for our 1.5 billion Indians as part of the 'Make in India' initiative to assist in early detection, as India is one of the leading countries with the highest number of osteopenic and osteoporosis patients in the world. In the article by Kanis et al which highlights the term "Gradient of risk for hip fracture," the authors discuss the prognosis for individuals. If it is 2.6, this indicates that the risk of hip fracture increases by 2.6 times for every 1 SD reduction in hip BMD.[23] The Chinese also showed the same discrepancy like in Indians, which was portrayed in a study by Wang J et al wherein the Chinese women showed a discrepancy in the T score when compared to the Italian women (-3.75 = -2.44), pointing to an overdiagnosis of osteoporosis in the Chinese.[24] Hence, in India or China, this kind of discrepancy gets amplified as these countries have the world's largest populations. Nutritional deficiencies in calcium and Vitamin D in developing countries like India also adversely contribute to bone health. Bone mineral density in the young, as per the WHO, is reported as a Z score, which is the BMD in comparison to the mean BMD for peers at the same age, gender and race and as a T score, which is the BMD in comparison to the expected T score compared to the peak BMD value at around 30 years of age.

One would expect to see the best bone mineral density for oneself, and this, at around forty years of age, may look like the report below

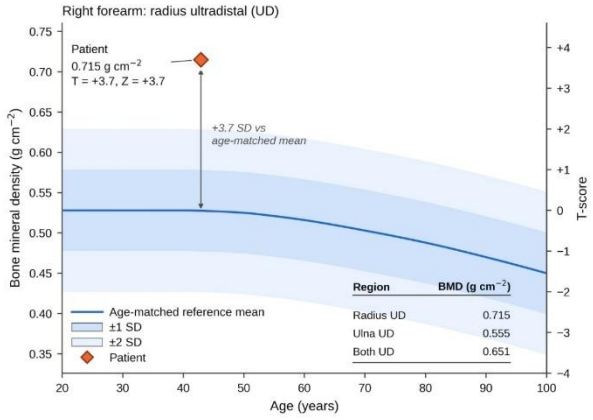


Figure 4: The best BMD T-score of +3.7 in a 45-year-old male patient.

The picture emphasises the best BMD for age, but at the same time, in another individual below, the T-score may show a notable "Shift to the left ", and it means that osteopenia or osteoporosis already exists, and this is a red flag for urgent intervention, as seen in our free BMD camps since 2000.

Two scientific papers were presented in 2003 at the APIOACON and IOACON conferences in India to highlight the point that osteopenia must be detected as early as possible to reduce the risk of untreated osteoporosis developing, at a time when little research was highlighting this aspect and is being continued as COE on Online lectures in clirnet.com and IJCR Central platforms. Stressing the need for mass screening for osteopenia and osteoporosis since 2000, i.e., for twenty-five years.

Formulas that one must know when dealing with Caucasian data and ICMR databases:

Body mass index: Weight (kg) / height in meter^2 was used to calculate body mass index (BMI).

T Score (standard): BMD of subject (gms/cms^2) - Ref BMD / SD (G/cm^2).

Formula for T score [ICMR]: BMD subject - BMD ref / SD ref (ICMR).

Formula for Z score [ICMR]: BMD(Subject)- BMD ref / Standard deviation ref ICMR.

IRT programme wishes to highlight a DEXA scan with T-score shifted to the left, a RED FLAG in DEXA SCANS. Presentation of actual data collected by the IRT programme from some patients:

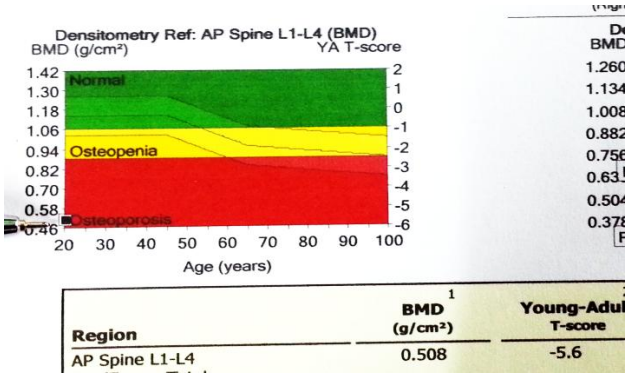


Figure 5: A DEXA scan report of a male patient of 20 years of age from Visakhapatnam, Andhra Pradesh, India showing a T score of -5.6, meaning severe OSTEOPOROSIS, a classic example of a T score that has shifted to the left, which implies that on a trivial injury, his fracture risk is expected to be 15 to 20 times higher than that of a normal man of his age. [Even if it is corrected by the rough guide of + 1.6 to to this T score to suit our Indian patient, the corrected score comes to -4.0, and if the Z score has to be evaluated, then it can be evaluated using the ICMR FORMULA].

We have 2 options for checking one's T-score and Z-score.

The first is an easier piece of equipment to handle and move around: a non-radiation-based modality called

quantitative Ultrasound bone mineral density screening. In 2023, an article by Kushwaha NS et al. also validates the usage of QUS equipment for screening osteopenia and osteoporosis.[26] This study from 2000 is supported by the Osteolaus study by Métrailler et al which supports the use of the heel Achilles ultrasound machine as a QUS combined with clinical risk factors (CRFs) as a pre-screening tool in spaces where the DEXA scan is not available, but it was concluded that it cannot be used for further monitoring.[27]

A DEXA scan is institutional, immovable, and highly expensive, but sensitive and specific to 99%, with a radiation exposure far less than a chest X-ray. Now, the latest tool is the Trabecular Bone Score. FRAX score with ethnic adjustments, along with other assessment tools, are indeed helpful.

We should consider BMD measurement in young patients complaining of fatigue, bone and joint pains, thoracolumbar aches, falls and muscle weakness, loss of height or spinal deformity early in life, and an increase in the scoliosis curves because if we do not recognise the weakness in the bone density, precious time to rectify is lost permanently before the peak bone mass density is reached.

In an article by Hernandez et al it is noted that a 10% increase in peak bone mass density can delay the onset of osteoporosis by 13 years.[28]

In the foetus, infantile osteoporosis is a real entity. In the article by Marvin Miller, the UTAH paradigm emphasises that foetal movements reflect foetal bone strength and that poor mineralisation in infants may also seem to be due to child abuse.[29]

Multifactorial bone fragility disorders in young infants could be due to the following; Genetic causes: Mucopolysaccharidosis (MPS), Osteogenesis Imperfecta; Metabolic Causes: Low Vitamin D; Congenital rickets - X-linked hypophosphatemia; Maternal habits: non-active lifestyle, low maternal vitamin levels, along with other deficiencies, Thyroid abnormalities, diabetes and medications.[30-33]

Dual-energy X-ray absorptiometry (DXA) is used to evaluate bone health, though interpreting results in infants' children with severe short stature and deformities is challenging. In the 2023 article by Ciancia et al Osteoporosis in children and adolescents was described, and anti-resorptive medications were identified as the first-line treatment.[34]

In idiopathic scoliosis the curve severity has an inverse relationship with bone mineral mass during peri-puberty in adolescent Idiopathic Scoliosis, suggesting that prevention of osteopenia could play a role in controlling spinal progression.[35,36]

Interpretation of BMD DEXA scans in children is challenging as the low or high Z scores stare at the viewer [Osteopetrosis][Fluorosis] and the meaning of a Z score must be taken into consideration.

Bone mineral density (BMD) discordance: a DEXA scan often shows osteopenia or even osteoporosis appearing in only one location, i.e., in the Lumbar Spine. At the same time, the distal radius or the neck of the femur has normal or osteopenic T-scores [Bone Mineral Density (BMD) discordance].[37] This is BMD Discordance that confuses the clinician to choose just exercises, nutrients, vitamin D and Elemental calcium, or bisphosphonates,to be introduced and followed up. The incidence of fragility fractures is higher in the Osteopenic group than in the osteoporotic group.[38]

Low testosterone levels due to hypogonadism can cause osteopenia and need therapeutic correction to restore BMD in time and can cause atherosclerotic plaques, calcification, and osteoporosis later as the individual ages.[39,40] Yet TRT, or testosterone replacement therapy in males with osteopenia, is still inconclusive as of today, with larger trials underway. In osteoporosis, the upper end plates are fractured more than the lower end plates (Men > women).[41]

In addition to a better lifestyle with weight-bearing exercises, avoidance of smoking, alcohol, and medications in selective cases, an emerging Therapy is a non-pharmacological option, OSTEOBOOST – a kind of vibration therapy.[42]

A newer tool called REMS, or Radiofrequency Echographic Multi Spectrometry (REMS), is being tested for diagnosing osteoporosis in a European multicentre trial.[43] As per Mobasseri et al for monitoring osteopenia, evaluating bone turnover markers have a significant relationship with lower BMD.[44]

CONCLUSION

In this 25 years research study of young 20 years aged patients suggestive of osteopenia with normal inflammatory markers, vertebral pain, bone and joint pains - early intervention with a DEXA scan for screening for osteopenia is the concluding suggestion of this study as this disease is a silent pandemic without clear cut clinical or laboratory findings and only a high clinical suspicion assists the young patients to reach their Peak Bone Mineral Density before 30 years after which the density is by nature designed to decline and cause further trivial fractures, loss of vertebral height, receding gums, loss of teeth and stamina -The osteoporosis sequelae. This study highlights that 60% of the screened youngsters showed osteopenia and 15 % showed osteoporosis, meaning the detection was actually already late for the best results from nonmedical and medical treatment and that even at this stage early intervention could help them achieve their best Peak BMD.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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