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Bone Mineral Density and Its Determinants: A Systematic Review of Risk Factors and Prevention Strategies

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Bone mineral density (BMD) is a measurement of the amount of minerals, primarily calcium and phosphorus, in bone tissue. Factors that can affect BMD include age, gender, genetics, lifestyle factors, and medical conditions. As people age, the density of their bones starts to decline gradually. Due to hormonal changes during menopause, the chance of developing osteoporosis among women is very high. Genetics also play a role in BMD, with some individuals having a higher genetic predisposition to osteoporosis and lower BMD. Physical activity, alcohol consumption, and smoking are some factors associated with BMD. Regular exercise is a protective factor, whereas other two smoking and excessive alcohol are risk factors. It is important to monitor BMD throughout life to identify any potential health concerns and take steps to prevent bone loss. A healthy lifestyle is an important factor that will help maintain sufficient calcium and vitamin D intake and take medication or supplements as directed by a healthcare professional. Regular physical activity such as walking and running can help promote bone health and maintain BMD.

Keywords: Bone mineral density; Determinants; United Arab Emirates.

BMD is a measurement of the amount of minerals, primarily calcium and phosphorus, in bone tissue. It is a key indicator of bone health and strength. A lower BMD can indicate a higher risk of fractures and other bone-related health problems, such as osteoporosis.

Vitamin D plays an important role in the health of the teeth, bones, and muscles by regulating the levels of calcium and Phosphate in the body[1]. Sun provides more than 90% of vitamin D in the body through skin exposure which means adequate skin exposure to the sun's rays is essential to get sufficient Vitamin D[2]. The required duration of sun exposure differs based on the pigmentation of the skin, thus darker skin color requires longer exposure time to the sun compared to lighter skin to receive an adequate amount of vitamin D[3-4].

It is essential to consider that seasonality[5], latitude[6] and lifestyle all play a major role in vitamin D status. Excessive sun exposure can trigger the development of skin cancer and wrinkling. Still, if exposure is regulated, the side effects are minimized successfully. Appropriate regulation to be developed to expose the body parts such as legs, hands and face at least 5-10 minutes, 2-3 times a week.

Vitamin D deficiency is now considered an epidemic among adults and children in the United States[7]. It is known to cause rickets among children, exacerbate and speed the development

of osteoporosis among adults, and causes painful bone disease osteocalcin[8]. Moreover, Non-communicable diseases such as diabetes mellitus, cardiovascular diseases, cancers etc., are associated with vitamin D status[7]. Some food types, such as fish liver oil, some types of mushrooms, and beef liver, are also sources of vitamin D. A good way of attaining vitamin D sufficiency is by increasing dietary and supplemental take of vitamin D[9].

METHODOLOGY

The authors systematically searched the databases PubMed, Scopus, Google Scholar, and Embase to get articles included in this systematic review. The Medical Subject Headings (MeSH) terms used are bone mineral density, BMD, vitamin D, lifestyle, bone turnover, ultraviolet light exposure, clothing and physical activity to retrieve relevant articles. All studies on any indicators of bone mineral density were included. After getting the articles, the authors screened the relevant papers to be included in this systematic review.

In this systematic review, 31 studies were included. Among the studies that are included, twelve were cross-sectional studies, nine reviews, five cohort studies, three case controls, and the remaining were a health report and an experimental study. The rest of the studies were excluded as they did not fit the purpose of this systematic review.

RESULTS AND DISCUSSION

The available literature provides the variables associated with Bone Mineral density in the following sections.

Seasonal variation and vitamin D

A prospective cohort study that assessed the association between vitamin D status and bone turnover markers and BMD among postmenopausal Caucasian women from Scotland reported a significant seasonal variation in serum 25(OH)D[10]. A peak was observed in the summer, whereas the lowest was in spring and winter. However, fasted parathyroid hormone (PTH) showed its peak in spring. Moreover, an inverse relationship was observed between levels of serum PTH and serum 25(OH)D. Fasted serum beta C-telopeptide (CTX) showed no differences according to season.

COD liver oil supplements

A study reported that a higher mean of 25(OH)D had been noticed in those who spent their holidays in sunny destinations and those who reported consuming Cod Liver Oil (CLO) supplements. Oral vitamin D intake has been shown to significantly increase 25(OH)D levels; however, this was noticed only when paired up with CLO supplements, especially in the summer season[10]. A study among women aged 50 to 64 stated that no association was established between food-derived vitamin D and 25(OH)D[11]. 25(OH) D levels did not predict the overall bone mineral density. Some studies have found the accumulated 25(OH)D levels correlated with BMD, but the correlation was attributed to elderly people only[12,13]. Vitamin D deficiency was found to be common among young women[14]. The main determinants of Vit D deficiency observed were increased age, being overweight, poor sun exposure, and lack of physical activity[14].

Cumulative lifetime ultraviolet radiation

Cumulative lifetime ultraviolet radiation (UVR) exposure can lead to diseases like nonmelanoma skin cancer. Nonmelanoma skin cancer has been associated with protection against osteoporotic fractures, especially hip fractures[15]; this indicates that although excessive UVR exposure can cause skin diseases, UVR may be a protective factor against fractures. This theory differs for males to females according to a study done on participants from Southern Tasmania, which examines the relationship between the Beagley-Gibson and BMD with less risk and fracture in older adults[16]. High BG grades are associated with higher UVR exposure. Here, the findings of the study highlighted that male Caucasian participants with high BG grades had a higher chance of vertebral deformities and a higher risk of falls. On the other hand, female participants with high BG grades had a lower prevalence of vertebral fractures and overall fractures. This suggests an association between BG and BMD which depends on gender. Also, the study emphasized the role of cumulative UVR exposure on skeletal health in women is considered.

Physical activity and nutrition

Regular physical activity, especially weight training and callisthenics, has positively

impacted bone mineral density in women, irrespective of age[17]. This is because it favours bone formation and remodelling, therefore, is considered an excellent measure to ensure bone health, especially in older adulthood[18]. It has also been shown that both non-weight bearing and exercises requiring high excursion of force effectively improved the BMD in the spine, especially in postmenopausal women[19]. This particularly considers bone health and BMD in the lumbar spine and the neck of the femur, where those who are more physically active tend to have higher BMD than those who do not[20]. High physical activity level, both in the past and present, increases the chance of normal bone mineral density by sixty times[21]. Moreover, regular physical activity increases bone mass in the younger population and increases the cortical bone's resistivity and thickness at skeletal sites in older adults[22].

Moderate to high intensity (MHPA) is associated with less incidence of osteoporosis, except for males aged 60 years and are

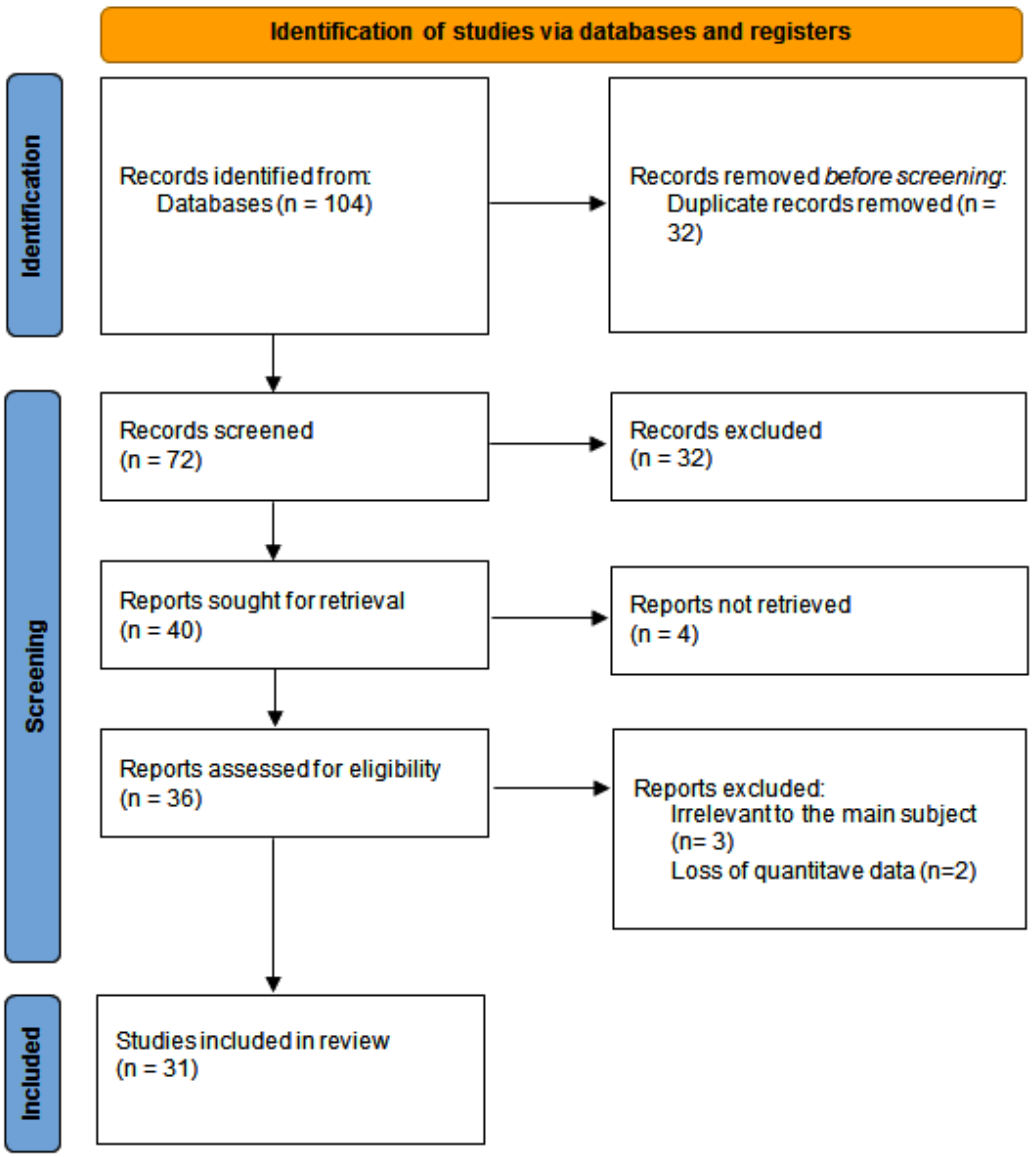

Fig. 1. The PRISMA flowchart of the search strategy details used in the systematic review

underweight[23]. In addition, more prolonged sun exposure has also been associated with a lesser incidence of osteoporosis, specifically in females under 60 years old, obese, nonsmokers, and lower alcohol consumption subgroups[23]. This result is based on a cohort study in South Korea from 2009 to 2015. The frequency and duration of exercise that improves bone strength and mineral density guidelines are not established yet. Given that both sun exposure and physical activity affect overall bone health, it has been recommended to promote practicing physical activity outdoors.

A healthy balanced diet is a key component in developing the skeletal system. Certain nutrients and food groups are crucial to support and improve bone health; these include protein, calcium, vitamins D and K, phosphorus, potassium, and magnesium[24, 25]. Since the diet is a modifiable factor, consuming the essential nutrients through food or dietary supplements is important for building healthy and strong bone tissues.

Clothing

Vitamin D forms part of bone metabolism and positively correlates to bone mineral density[26]. The types of clothing worn can affect the amount of vitamin D that can be obtained from the sun. High vitamin D deficiency was found in women of Arab ethnicity and it has been attributed to low exposure to sunlight. More than 95% of Arabian women cover their bodies for religious and cultural reasons. Therefore, it is suggested that the clothing may be the reason for low vitamin D levels, which then affects their BMD.

A study assessed the impact of clothing on BMD among Kuwaiti females who wear Western-style clothing, who wear a hijab that covers the entire body except for the hands and face, and a group wearing a black veil with the whole body covered. The study's results indicated no significant differences in how long each group was exposed to the sun. This implies that the observed variability results from the type of clothes worn. No significant differences were found in the biochemical markers as well. Many participants in each of the three groups showed signs of vitamin D deficiency; however, the hijab and veiled participants' vitamin D levels were found to be the lowest.[2]

A case-control study was conducted in Morocco among postmenopausal women who wear concealing clothing[27]. An increased risk (OR=2.3) of osteoporosis was associated with wearing a veil. After adjusting with confounding variables, the OR observed was 2.2. According to this research, wearing traditional concealing clothing that covered the head, arms, and legs increased the risk of osteoporosis among postmenopausal Moroccan women.

Lifestyle factors

Lifestyle factors and obesity are also linked with low BMD. A study among Saudi men assessing the association between lifestyle factors and BMD reported little direct sun exposure due to the risk of heat disorders. A validated questionnaire was used to assess lifestyle factors such as tobacco use, physical activity, tea and coffee consumption, dietary calcium intake, and usage of vitamin supplements and medicines. About 87.8% of the healthy Saudi males showed 25(OH)D levels in the serum below what is often thought to represent deficiency[28].

Vitamin D deficiency was more prevalent among men above the age of 50 years and obese, including those taking vitamin D supplements. This shows that the commonly used supplements are inadequate to give the body the required amount of Vit D. Overall, high Vit D deficiency was found among older and obese men who live a sedimentary lifestyle. A positive correlation was observed between BMD of lumbar spines, neck femur and serum 25 (OH)D[28]. A research was conducted in Ajman, United Arab Emirates, to determine the relationship between BMI and the state of BMD, observed that BMD was low in participants with a normal BMI and less among tho who were obese, which was statistically significant[29].

A study among Greek men to assess the effects of lifestyle factors on BMD in young men reported that calcium intake, exposure to sunlight and exercise were independent predictors of bone mass[30]. Another study from Saudi Arabia observed that low dairy product consumption, physical inactivity, smoking, insufficient sun exposure, excessive soft drink consumption, and caffeine intake were some risk factors for bone health[31].

CONCLUSION

In conclusion, this systematic review shows factors affecting bone mineral density. Evidence supports the benefit of exposure to

sunlight, consuming food rich in vitamin D and cod liver oil, engaging in physical activities, and living a healthy lifestyle in general on maintaining the desired bone mineral density to protect the health of bones from diseases like osteoporosis.

Recommendations for further studies are needed to better understand the relationship between BMD as a bone health indicator and the variables affecting its levels.

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