



REVIEW OF LITERATURE

The literature pertaining to the present study on **Bone Mineral Health of Women and Impact of Intervention Strategies** is reviewed under the following headings:

A. Low Bone Mass Density – The Global Burden

1. Prevalence of Low Bone Mass Disorder
2. Etiology and Complications
3. Techniques for Assessing Bone Health

B. Women and Bone Health Issues

1. Women and Wellness
2. Bone Health and Ageing

C. Strategies to Enhance Bone Mineral Density

1. Dietary Management
2. Life Style Management and Exercise
3. Nutrition Education and Diet Counselling
4. Medical Treatments

D. Studies Related to Bone Health

A. Low bone Mass Density – The Global Burden

1. Prevalence of Low Bone Mass Disorder

India is the second largest populated country in the world. High population is posing a greater risk of diseases among the people. Hence the Indian government has set National Health Priority to combat various diseases. Osteoporosis is not a national health priority (NHP) in India. Among the NHPs, the one which most closely impacts osteoporosis is the nutritional program for schoolchildren (IOF report, 2013).

Worldwide, lifetime risk for osteoporotic fractures are 30 – 50 per cent in women and 15 – 30 per cent in men (Randell *et al.*, 1995). According to WHO,

osteoporosis is second only to cardiovascular disease as a leading health care problem. By 2050, the worldwide incidence of hip fracture in men is projected to increase by 310 per cent and 240 per cent in women (Gullberg *et al.*, 1997). Osteoporosis afflicts an estimated one-third of women aged 60 to 70 and two-thirds of women aged 80 or older (Kanis *et al.*, 2000).

Approximately 200 million women worldwide suffer from osteoporosis. According to WHO, Asian Osteoporosis Study (AOS) (2004) 1 out of 8 males and 1 out of 3 females in India suffers from osteoporosis, making India one of the largest affected countries in the world.

Osteoporosis is a systemic skeletal disease characterized by low bone mass and microarchitectural deterioration of bone tissue with a consequent increase in bone fragility and susceptibility to fracture (Kanis *et al.*, 2008). Osteoporosis which literally means “porous bone” is a disease in which the density and quality of bone are reduced as the bones become more porous and fragile. The loss of bone occurs “silently” and progressively (Audesirk, 2008).

Osteoporosis is a major public health problem coupled with substantial morbidity and socio-economic burden worldwide (Johnell and Kanis, 2004). As age advances, the incidence of osteopenia and osteoporosis, the silent disease increases (Atik *et al.*, 2006).

Osteoporosis is now a widespread condition, affecting an estimated 75 million people in Europe, the US and Japan. Women are four times more likely to develop osteoporosis than men, due to the sudden drop in bone protective hormones they experience after the menopause. In addition, diabetes can also increase the risk of osteoporosis by interfering with osteoblast activity – these are the cells that help to maintain bone strength (www.nutripeople.com).

Fifty million people in India are estimated to be prone to osteopenia and osteoporotic condition. Indian Council for Medical Research (ICMR) conducted large multi-center studies and found that Indians have lower BMD compared to North American people. Indians tend to have lower BMD owing to possible genetic differences, nutritional deficiency and smaller skeletal size. Also, urbanization has

caused lot of lifestyle changes e.g., reduced physical activity, more indoor living, and lower sun exposure (IOF report, 2013).

According to International Osteoporosis Foundation (2004) osteoporosis is one of the most important diseases affecting elderly people worldwide. It is a disease in which the density and quality of bone are reduced, leading to weakness of the skeleton and increased risk of fracture, particularly of the spine, wrist and hip.

In Europe, Japan and the USA osteoporosis is an established worldwide problem that affects more than 75 million people. Osteoporosis is three times more common in women than in men, partly because women have a lower peak bone mass and hormonal changes that occur at the menopause. It causes more than 2.3 million fractures annually in Europe and the USA. Asians and caucasians are supposed to be more prone to develop osteoporosis (Rajasekaran, 2007).

In the United States, an estimated 44 million people are at risk for osteoporosis and 10 million have it, with women being affected at four times the rate of men. Although the disease can strike at any age, one in two women and one in eight men older than 50 years will have an osteoporosis related fracture (Gruver, 2004).

Osteoporosis affects 1.4 million Canadians. One in four women and atleast one in eight men over 50 years of age has osteoporosis, but the illness can occur at any age (Yurn, 2005).

Osteoporosis has become one of the most prevalent and costly health problems in Asia. Unsurprisingly, Asia is the region expecting the most dramatic increase in hip fractures during coming decades by 2050 one out of every two hip fractures worldwide will occur in Asia (Lau *et al.*, 2006).

Osteoporosis has reached epidemic proportion, 300 per cent increase in the last 30 years (www.demko.com). Total prevalence rate of osteoporosis in the middle-aged and elderly in China was 16.1 per cent in 2002. The prevalence rate among males was 11.5 per cent and among females was 19.9 per cent with the advances in quality of life and health conditions in China, the population has been

experiencing ageing, and osteoporosis has therefore become an important public health problem (www.cmj.org).

Osteoporosis afflicts women more than men because women have less bone mass and begin to lose bone mass earlier than men (Compston, 2005). Hispanic white and Asian people are most likely to experience osteoporosis. Hispanic and non-Hispanic black people also can develop osteoporosis and related fractures, but have a lower risk when compared to non-Hispanic whites and Asians. Caucasian and Asian individuals have a greater risk of developing osteoporosis than people of other races, with Northern Europeans and North Americans of greater risk (Shreyasesamin, 2005).

Healthy South Indian males above the age of 50 years were assessed for Bone mineral density and Vitamin-D levels. The BMI of men indicated that they were healthy and normal, yet the BMD measurements indicated that they had low bone mass disorders. The vitamin-D levels were also lower than the acceptable level of 20 ng/dl. This condition needs to be treated with a balanced diet including milk, vegetable, and cereals coupled with good exercise (Sahana *et al.*, 2014).

Low bone mass disorders like Osteopenia and osteoporosis were prevalent among elderly adult women. But now a days young women are also diagnosed for low bone mass density. This condition is aggravated during pregnancy which can be checked by increased consumption of dietary calcium rich products. A study among young pregnant women in the age group of 16 to 25 years revealed osteopenic condition. The blood calcium level directly correlated with osteopenic state. Hence there is an important need to supplement calcium for pregnant women (Kabylova *et al.*, 2010).

It is estimated that as many as two million people are suffering from osteoporosis in Korea. The prevalence of hip fractures has increased about 4 folds during the past 10 years (www.iyaku.j.com).

The prevalence of osteoporosis in Sri Lanka is unknown due to lack of investigation facilities. A large epidemiological studies done in Sri Lanka, Galle

prospective osteoporosis survey found 42.4 per cent in the entire sample of 350 women and 61.5 per cent in women over 50 years to have osteoporosis (www.iyaku.j.com).

The number of hip fracture cases for men and women in Malaysia is 88 and 218 per 100,000 populations. 51.8 per cent urban Malaysian women in her menopause age group had mild osteoporosis (Damodaran *et al.*, 2005).

According to Ministry of Health Clinical – Practice Guidelines released in January 2009, the incidence of hip fracture in Singapore has increased 1.5 times in men and five times in women since 1960s. One in five dies within a year after sustaining a hip fracture. About 800 to 900 hip fractures occur every year in Singapore because of osteoporosis (www.iofbonehealth.org).

Japanese data indicates the prevalence of osteoporosis at the lumbar spine to be as high as or greater than in white women, while the prevalence of osteoporosis at the hip is 12 per cent lower (www.aventis.com).

The study on measurement of bone mineral density of Jalna urban people revealed 50 per cent of women with osteopenia and osteoporosis condition. This is high compared to men subjects which is only 30 per cent. Hence there is an urgent need to tackle low bone mineral density prevalent among women (Swati, 2011).

Osteoporosis is responsible for more than 1.5 million fractures annually, including 300,000 hip fractures, approximately 700,000 vertebral (spinal) fractures, 250,000 wrist fractures, and more than 300,000 fractures at other sites. In the presence of osteoporosis, fractures can occur from normal lifting and bending as well as from falls. Furthermore, osteoporotic fractures, particularly vertebral fractures can be associated with disabling pain. This is expected to rise significantly with the increase in ageing population and continued improvement in the life expectancy. The greatest increment will occur in Asia, Africa and Latin America where awareness of osteoporosis and availability of bone status assessment devices is far less than in the west (www.chronic.disease.org).

According to Simon (2008), the epidemic incidence of osteoporosis disables over 20 million American women. Currently, one third of post-menopausal women have osteoporosis. The United States flaunts the highest rate of osteoporosis related fractures in the world.

Fracture rates tend to vary across countries. Wrist and hip fracture rates in the UK are around 30 per cent lower than in the US. Hip fracture rates vary more than seven fold from one country to another within Europe (www.findarticles.com).

Two million Australians are affected by osteoporosis. Every 8.1 minutes in Australia someone is admitted to hospital with a fracture. The number of fractures are increasing at a rate of four per cent per annum. Prevalence rates increase to 2.2 million in 2006 and 3 million in 2021 (Sambrook *et al.*, 2004).

2. Etiology and Complications

World has seen tremendous development in the last century and the human effort is constantly influenced by machines. This has led to comfortable and sedentary living and people tend to choose unhealthy food habits like more of salt, sugar, fat, alcohol, tobacco etc. All these result in the development of diseases and one such critical disease afflicting humans is bone disorders (Joseph, 2014).

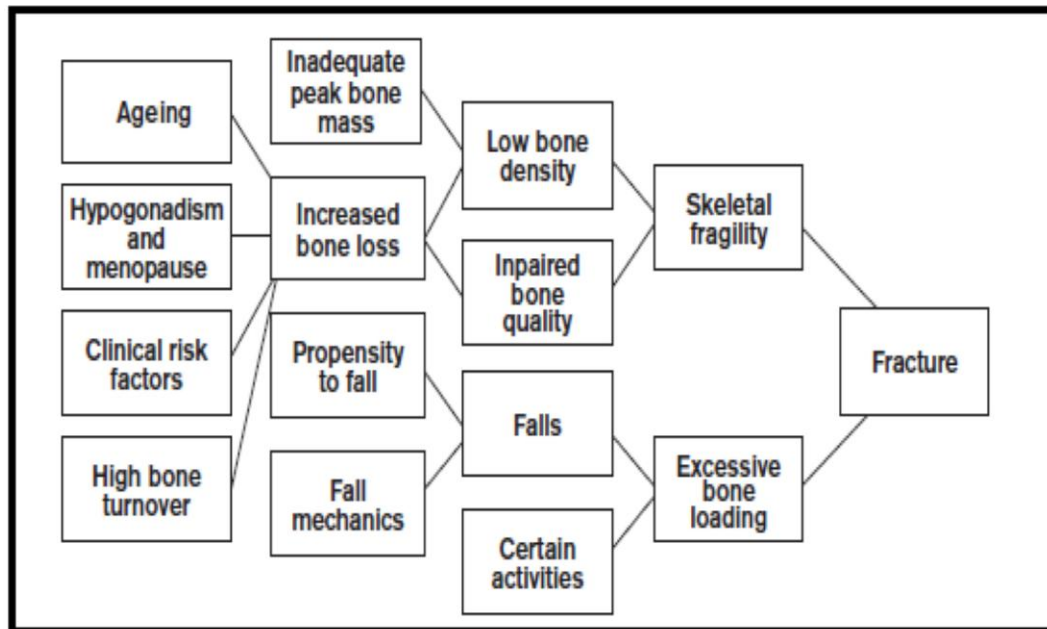
Indians are becoming more prone to life-style diseases that includes cardiac problems, hyper tension, diabetes, and cancers etc caused by unhealthy eating habits, lack of exercise, smoking, and alcohol. Lifestyle medicine is a new area of treatment advocated to combat this problem. Indians are known for their poor attitude towards health and they allow the problems to creep and visit hospitals only when the problems are out-of control (Jhilmam, 2009).

Semple *et al.*, (2004), stated that shifting demographic profile and industrial advancement have lead to numerous health problems, in combination with inactive life style and unsuitable diets have paved way for chronic degenerative disease like osteoporosis, diabetes mellitus, cardio vascular diseases and other disorders.

Peak bone mass is achieved during young adulthood. Bone mass is built until approximately up to an age of 30 years and then as part of the natural ageing process, bones begin to breakdown faster than new bone is formed. After 30 years, bone loss occurs at 0.5 per cent to one per cent yearly (Lin, 2003).

Non modifiable risk factors are factors that are outside a person's control and cannot be reduced or altered which include age, gender, race and family history (Kokkinos, 2010).

There are many root causes for human disease and family history is a significant factor among them. Diseases such as Cardio-Vascular Disease (CVD), diabetes and psychiatric ill health are powerfully associated to family history and a greater risk of getting them. There is a close link between family history and disease prevalence (Kardia, 2003).



Pathogenesis of osteoporotic fracture

Source : Cooper and Melton (1992)

Soft Drinks and Caffeine Intake :

Some studies indicate that soft drinks (many of which contain phosphoric acid) may increase the risk of osteoporosis. Others suggest soft drinks may displace calcium containing drinks from the diet rather than directly causing osteoporosis (Gartland *et al.*, 2007). Studies have indicated that heavy caffeine consumption can have a deleterious effect on bone mass by increasing calcium excretion (Hallstrom, *et al.*, 2006).

Nowadays, women use facial sun screens and cover their body with clothes and protect from sunlight. This deprives them from vitamin D. Though this issue is debatable, ultimately vitamin D deficiency is created. About 90 per cent of Indians have low vitamin D deficiency causing rickets, osteomalacia and low bone mass disorders. Moreover, coffee and tea are popular beverages consumed by the Indians and the high caffeine content induces acidity and cause calcium loss in bones (IOF report, 2013).

Calcium and Vitamin D Intake :

Indian adults consume lower amounts of calcium (300–500 mg/day) than the WHO prescribed standard of 1000-1200 mg/day (IOF Report, 2013). Calcium deficiency or factors which interfere with calcium intake may be crucial during adolescence. Many female adolescents may be at increased risk for the development of skeletal inadequacy due to an imbalance between calcium during this period of increased bone modeling and skeletal consolidation (Subhangini, 2006).

Smoking Habits :

Cigarette smokers have lower bone density than nonsmokers. Smoking cigarettes decreases estrogen levels and can lead to bone loss in women before menopause. In postmenopausal women, smoking is linked with increased risk of osteoporosis (Nutrition Research Newsletter, 2014).

Obesity :

Obesity is a recognized risk factor for osteoarthritis and was significantly common among obese women. Research findings show that the prevalence of osteoarthritis was 49 per cent among the study group by Mandal *et al.*, (2009) and 57 per cent in the study conducted by Lena *et al.*, (2009).

Obesity is a common health disorder. Obese women tend to decrease their weight by many methods like dieting, exercise, and medicinal intervention. Few women practice the habit of chronic dieting to reduce weight. This in-turn leads to deprivation of essential vitamins and minerals. A study was conducted to evaluate the diet pattern and bone mass density among chronic dieting obese women. It was observed that 33 per cent of chronic dieting obese women tend to have low bone mass disorders. These methods of dieting have the ill-effects and need to be avoided. In turn, balanced diet and physical exercise should be practiced (Bacon *et al.*, 2004)

Bone Loss :

Age related bone loss starts in the fourth or fifth decade of life. It occurs as a result of increased bone breakdown by osteoclasts and decreased bone formation by osteoblasts. Peak bone mass is attained in the third decade of life and age related bone loss probably starts around the age of 40 years in both men and women (Mosekilde, 2006).

According to Anburajan (2006), age related bone loss, which may average 0.7 per cent per year, is a normal and predictable biologic phenomenon, similar to the graying of hair. Age related changes in bone cells and matrix have a strong impact on bone metabolism. Osteoblasts from elderly individuals have reduced replicative and biosynthetic potential when compared with osteoblasts from younger individual.

Osteoporotic changes are uniform throughout the skeleton, but immobilization of a particular joint following fracture leads to local osteoporotic changes in involved bones only (Dharmalingam *et al.*, 2003).

The bone mass decreases, as the bone structure changes. The bone structure may shrink, warp or may result in kyphosis, the hunched over back. Others include a stooped posture, limbs that seem to be shorter or easily broken bones (Delmas, 2004).

Low bone mass and deterioration of the bone tissue, leading to bone fragility and the increased risk of fractures of the hip, spine and wrist with more bone loss there is more irritation of the nerve endings in the bone, which results in bone, muscle and tendon pains (Beers, 2005).

Hodgson *et al.*, (2008) found that older women who consume chocolate daily had lower bone density and strength.

Immobility :

Prolonged periods of immobility substantially increase an individual's risk of developing osteoporosis. Prolonged bed rest has been shown to reduce bone mineral density by about 0.5 per cent per month. In bed ridden patients, lumbar spine mineral density decreases by about 0.9 per cent per week, or approximately 45 per cent loss per year. However, bone demineralization begins once the individual is able to walk again (Jule, 2005).

3. Techniques for Assessing Bone Health

Measuring the bone density remains the only important tool in the early diagnosis of osteopenia and osteoporosis, so that effective preventive and therapeutic measures can be initiated at the earliest (Lin, 2003).

A bone mineral density (BMD) test is the best way to determine the bone health. BMD tests can identify osteoporosis, determine the risk for fractures, and measure the response to osteoporosis treatment. The most widely recognized BMD test is called a Dual Energy X-ray Absorptiometry or DEXA test. The BMD test is painless, a bit like having an X ray, but with much less exposure to radiation. It measures bone density at the hip and spine (Notelovitz, 2008).

World Health Organisation (2002) reported that osteoporosis is based on bone mineral density in the spine and proximal femur measured with dual energy

x-ray absorptiometry (DEXA). Osteoporosis is classified as a bone mineral density of 2.5 or more standard deviations below normal peak bone mass, that is, a T score ≤ -2.5 and other techniques. Ultrasound of the calcaneus and peripheral DEXA measurements cannot be used in the same way to diagnose osteoporosis but are useful as a preliminary assessment of risk where access to axial DEXA is inadequate.

A bone scan is different from the BMD test, although the term “bone scan” often is used incorrectly to describe a bone density test. A bone scan involves injecting the patient with a dye that allows a scanner to identify differences in the conditions of various areas of bone tissue. A bone scan can show the doctor changes in bone tissue that may indicate cancer, bone lesions, inflammation or new fractures (www.surgeongeneral.gov).

X-ray also may be appropriate if a loss of height or a change in posture is experienced. However, because X-ray can detect bone loss only after 30 per cent of the skeleton has been depleted, the presence of osteoporosis may be missed (www.diagnose.me.com).

Dual Energy X-ray Absorptiometry (DEXA) is the most accurate way to measure BMD. It uses two different X-ray beams to estimate bone density in spine and hip. Strong, dense bones allow less of the X-ray beam to pass through them. The amounts of each X-ray beam that are blocked by bone and soft tissue are compared to each other. DEXA can measure as little as two per cent of bone loss per year. It is fast and uses very low doses of radiation. Single-energy X-ray Absorptiometry (SXA) may be used to measure heel and forearm bone density, but SXA is not used as often as DEXA (www.imagine.com).

Peripheral dual energy X-ray absorptiometry (P-DEXA) is a type of DEXA test. It measures the density of bones in the arms or legs, such as the wrist, it cannot measure the density of the bones most likely to break, such as the hip and spine. P-DEXA machines are portable units that can be used in a doctor’s office. P-DEXA also uses very low doses of radiation, and the results are ready faster than standard DEXA measurements (www.osteo.org).

Dual photon absorptiometry (DPA) test uses a radioactive substance to measure bone density. It can measure BMD in hip and spine. DPA also uses very low doses of radiation but has a slower scan time than the other methods (www.nof.org/osteoporosis).

Quantitative Computed Tomography (QCT) is a type of CT scan that measures the density of a bone in the spine (vertebra). A form of QCT called peripheral QCT (PQCT) measures the density of bones in arms or legs, usually wrist. QCT is not usually used because it is expensive, uses higher radiation doses and is less accurate than DEXA, P-DEXA or PDA (www.osteoporosis.org).

Blood tests may be performed to measure calcium and phosphorus. Blood calcium measurements can identify whether there is too much or too little calcium in the blood. These tests can also determine if the glands regulating calcium levels are functioning properly. Blood calcium measurements involve taking a small blood sample with a needle. Further testing may be needed to rule out treatable conditions that might lead to osteoporosis. If such a condition is found, the diagnosis is secondary osteoporosis. High levels of the chemicals deoxypyridonoline and c-telopeptide in the blood may indicate increased risk for hip fracture. These substances are produced when bone is broken down (www.livestrong.com).

Urinary calcium excretion was increased with teriparatide treatment for up to 12 months, compared with placebo and baseline values, but the magnitude of these changes is unlikely to be clinically relevant or warrant urinary calcium monitoring for most patients. A urine test detecting a substance called N-telopeptide may indicate bone loss (although it is not associated with any risk for fracture) (Devine, 2000).

B. Women and Bone Health Issues

1. Women and Wellness

World Health Organization (WHO) defines Health as “A state of complete physical, mental and social well being and not merely absence from diseases or infirmity” (WHO, 2006).

Undernourishment in women can upshot in reduced productivity, slow recovery from illnesses, greater vulnerability to infections and sensitive threat of adverse pregnancy outcomes. A woman’s nutritional position has interference with her wellbeing in addition to the fitness of her children (Mandel *et al.*, 2011)

A study conducted in Tripura state of India among college going men and women in the age group of 18 to 21 years of tribal and non-tribal people brought interesting findings. Bone density measurement by Ultra-sound method and vital parameters through blood analysis were carried-out. The results were co-related with the nutritional intake of the population. A positive co-relation between nutritional habits and Bone mass density of the study population was established. Compared to males, females had low bone mass density. Quantitative ultra-sound method was used to assess the bone mass density of the population and found to be very effective (Sutapa *et al.*, 2014).

Evans (2012) reported that the occurrence of obesity and overweight as a public health concern is well recognized among adult women, in addition, the adipose tissue is stored in larger quantity in females than among males. Women are more likely to have a larger subcutaneous deposit with the central adiposity measures the subcutaneous and visceral depots.

The incidence of hip fracture has increased by 20 per cent in Hong Kong over the past 20 years about 10 elders fracture their hip every day. The mortality rate for hip fracture patients is 20 per cent. While 70 per cent remain permanently disabled 50 per cent of men and women aged 60 years and over could be diagnosed as “osteoporotic”. Among women aged 65 and over 45 per cent had osteoporosis and 42 per cent had osteopenia (low bone mass) where as among

men aged 65 and over 13 per cent had osteoporosis, 47 per cent had osteopenia (www.hwfb.gov).

New studies have indicated that women who are suffering from depression had lower bone density than non-depressed women, perhaps resulting from higher levels of corticosteroids in their blood (Robert and Anderson, 2005). Wallence *et al.*, (2009), reported that after the menopause, the level of estrogen in the body falls and this can lead to a rapid decrease in bone density. As estrogen levels fall, bone resorption becomes greater than bone formation, leading to a loss in bone mass.

Early menopause (either natural or surgically induced) increase a women's risk of osteoporosis. Most women reach menopause between the ages of 45 and 55, but menopause may occur as earlier as 30s or 40s or may not occur until a woman reaches her 60s. As a rough "rule of thumb" women tend to undergo menopause at an age similar to that of their mothers (www.endocrine web.com).

2. Bone Health and Ageing

Osteoporosis is a skeletal disorder. The skeletal system is composed of 206 bones that vary in size and shape (tubular, flat, cuboid). Bone is the most rigid form of connective tissue. Osteoporosis is coined because of the stone like quality of the bones. The bones are abnormally brittle and fracture like a piece of chalk (Robbins and Cotran, 2005). Bones are at their thickest and strongest in early adult life. That bone is very slowly broken down overtime leading to a decrease in bone density as older. This can cause the bone to become weaker and increase the risk of breaking a bone (Balch and Stengler, 2004).

Bones possess two types of cells – osteoclast and osteoblast. Osteoclast cells are formed from certain blood cells and are responsible for the breakdown or resorption of the skeleton. Osteoblast cells are produced by bone cells and are the bone builders (Manolagas, 2000). Osteoblasts and osteoclasts act in coordination and are considered the functional unit of bone known as the basic multicellular unit (BMU). The process of bone formation and resorption are tightly coupled, and their balance determines skeletal mass at any point in time (Saladin, 2007).

Bone resorption means the process where the bone cells break down the bone tissue and release minerals into the fluid tissue to be available for other uses in the body. They are activated by hormones that are released when the blood calcium levels or mineral levels are too low. The osteoblasts form collagen fibres that become coated with minerals, especially calcium salts, which then begin to harden (Glimcher, 2004).

Bone disorder is a major cause for fractures. WHO has coined a term disability generating diseases that are critical diseases that cause immobility and prolonged bed rest that cause secondary complications like pain, pressure, ulcers, inappropriate bladder, mental stress, and depression. The disability creating diseases are ranked by WHO and bone disorders ranks sixth among the list. Throughout ageing of the population, osteoporosis and related fractures will continue to raise (Eric *et al.*, 2006).

The increase of bone loss normally begins connecting one's early years to late thirties. Starting from middle age to the commencement of menopause, women lose a certain amount of bone steadily every year. Trabecular bone (the spongy bone within the hard, cortical bone) is lost at about one per cent for each year (Melzer *et al.*, 2004).

According to Johnell (2005), approximately 10 million individuals over the age of 50 in USA have osteoporosis of the hip. An additional 33.6 million individuals over the age of 50 have low bone mass or osteopenia of the hip and thus are at risk of developing osteoporosis at any site in the skeleton.

In New Zealand, osteoporosis causes 15,000 fractures each year, of which around 3,000 are hip fractures. It affects more than half of women, and nearly a third of men over age 60. Osteoporosis is estimated to cost New Zealand over \$ 135 million per annum. Upto 20 per cent of aged osteoporosis patients die after a hip fracture and 40 per cent can no longer live independently within a year of their injury (www.uniservices.auckland.ac.nz).

The prevalence of osteoporosis increases with age from six per cent at age 50 to over 50 per cent above the age of 80. Since a postmenopausal women at

age 50 has a remaining lifetime fracture risk for hip, spine or wrist of 40 per cent, it is not surprising that the Society of Obstetricians and Gynecologists of Canada (SOGC) recommends that this segment of the population be assessed for the presence of risk factors for the disease (www.osteoporosis.com). The lifetime risk of any osteoporotic fracture at the age of 50 years has been estimated to be 46 per cent in women and 22 per cent in men in Sweden, with corresponding figures of 40 per cent and 13 per cent in the USA. In addition, the life time risk and the age specific risk of a hip fracture among black men and women is approximately 50 per cent of that among white men and women (www.thejakartapost.com).

In India, osteoporotic fractures have a higher male to female ratio than among westerners. In India, although the percentage of aged persons to the total population is low in comparison to the developed countries, nonetheless the absolute size of the aged population is considerable. The current elderly population in India constitutes about seven per cent (www.outlookIndia.com).

Our body contains approximately one kg of calcium. 99 per cent of this calcium is present in bones and remaining 1 per cent is available in blood. The calcium in bones are continuously lost after the age of 30 years. A portion of this calcium is synthesized for bone growth, whereas the remaining portion gets lost as body wastes. Hence calcium rich foods, which are required for bone formation should be taken (IOF, 2013).

The lean body mass (non fat lean) of the body parts is made up of water (73 %), protein (20 %), minerals (6 %) and ash (1 %). The body cell mass contains active living tissues containing muscle cells, organ cells and immune cells of the body. The extracellular mass contains all the metabolically inactive body parts such as bone minerals and blood plasma (Tondare and Patil, 2012).

Expatriate Indians have been diagnosed for high bone-loss compared to their western counterparts. Experts found that Indian women, who migrated to western countries, are having the increased risk of accelerated age related bone loss, compared to their counterparts living in the same geographic region. This is attributed to dark skin, dressing habits and lower bone mass (Alikel *et al.*, 1999).

Coylerwright *et al.*, (2008), expressed a positive relationship between menopause and hypertension and that the association between blood pressure and age was steeper in post menopausal women.

Pre hypertension and hypertensive blood pressure were seen to be associated with low levels of cardio-respiratory fitness among women making them vulnerable to cardiovascular events (Hageman *et al.*, 2010).

Major depression affects 5 to 9 per cent of women. The decrease in serum osteocalcin and urinary deoxypyridinoline excretion suggest decreased bone turnover. Compared with the normal women, the mean (SD) bone density in the women with past or current depression had 6.5 per cent lower BMD in spine, lower serum osteocalcin concentrations and lower urinary excretion of deoxypyridinoline. Hence past or current depression in women is associated with decreased bone mineral density (Michelson *et al.*, 1995).

According to Bhawaneswari and Shapiro (2003), breast cancer is a major health hazard for women and they have side effects which affects bone health. Post menopausal women have high prevalence of breast cancer. Medicinal treatments like chemotherapy and hormone therapy can result in decreasing bone mass and hence women are vulnerable for fractures.

In young adults the rates of bone deposition and resorption are about the same. As the level of sex steroids diminishes during middle age, especially in women after menopause, a decrease in bone mass occurs, because, bone resorption outpaces bone deposition (Kaunitz, 2007).

In women, bone loss accelerates around the time of the menopause and the most common risk factor is hormone imbalance after menopause. Progesterone deficiency rather than estrogen deficiency is the main hormonal factor associated with postmenopausal bone loss. The most rapid bone loss occurs in the first five years after menopause, around age 45, when hormones undergo a major decline in production (Sembulingam, 2010).

Twenty to thirty per cent of bone loss in women occurs in the first five years after menopause when the precondition, osteopenia, often develops. So women in

the 46 – 50 years age group are at greatest risk of developing osteopenia (Linda *et al.*, 2002).

Postmenopausal osteoporosis is characterized by low bone mass, structural damage to bone tissues and increased probability of spontaneous fracture. The mechanism leading to net bone loss are osteoclastic over activity and or osteoblastic under activity (Pirello, 2006).

Early menarche is associated with estrogen segregation and this supports bone health. But this did not have a significant effect on osteopenia found among surveyed women. Lactation and prolonged breast feeding deprives bone mass in women. But findings revealed that, when breast feeding is stopped, women tend to regain the bone health. Exercise is found to support peak bone mass at development stage. At later stages, it had little influence on bone mass (Jyoti *et al.*, 2010).

C. Strategies to Enhance Bone Mineral Density

1. Dietary Management

Calcium and vitamin D are the two nutrients that work together to play an especially important role in bone health. Calcium is necessary to build new bone and vitamin D helps body to absorb calcium (Sachan, 2005).

Calcium from dairy products, mineral waters and supplements is almost equally well absorbed. But the former contain other nutrients with positive effects on bone, such as proteins, phosphorus and bicarbonates. The choice goes for the nutrient or supplement with the best acceptance by a given individual (Burckhardt, 2007).

In the views of Jackson (2006), calcium and vitamin D or a combination of both nutrients on the different health outcomes were inconsistent. Synthesizing a dose response relation between intake of either vitamin D, calcium or both nutrients and health outcomes in this heterogeneous body of literature proved challenging.

Increasing daily calcium intake from 80 per cent of the recommended daily allowance to 110 per cent via supplementation with calcium citrate / malate

resulted in significant increases in total body and spinal bone density in adolescent girls (Lloyd *et al.*, 1998).

Food and Drug Administration concludes that “maintenance of an adequate calcium intake throughout life may optimize peak bone mass at skeletal maturity and help to slow the rate of bone loss later in life, and may help to reduce the risk of osteoporosis (www.osteoporosisca/index.philu.id/5526/ca.id/html).

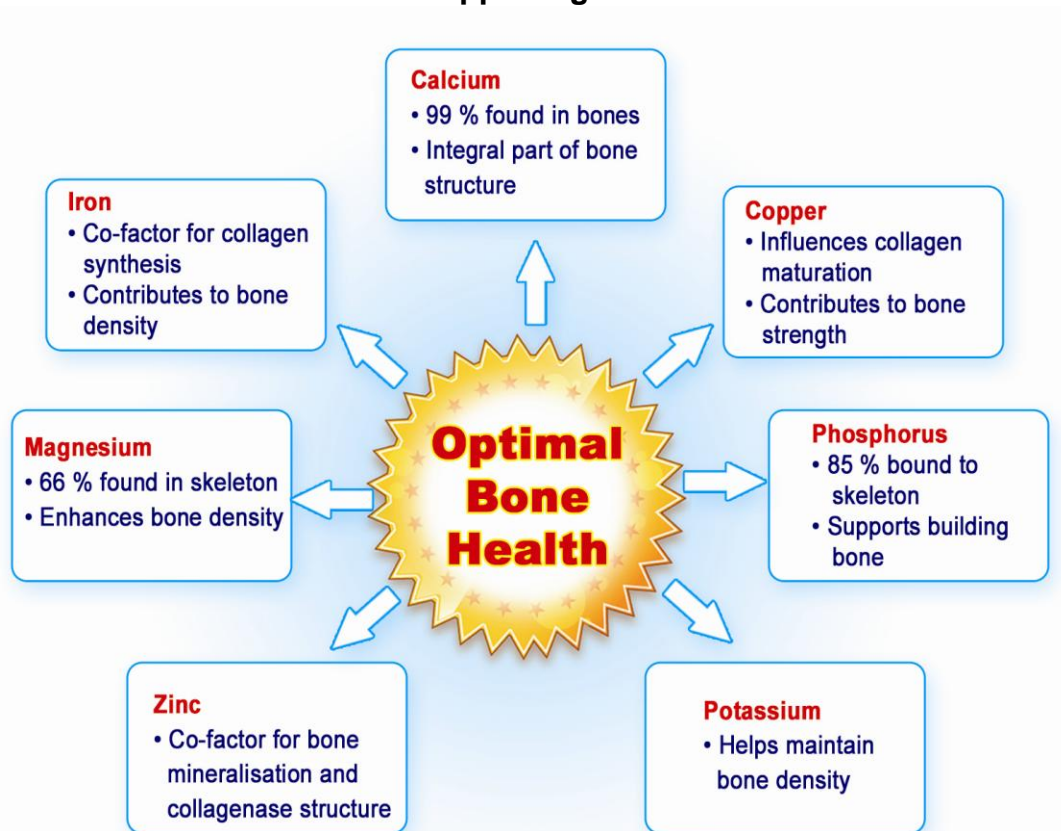
Functional foods play positive roles in maintaining well being, enhancing health and modulating immune function to prevent specific diseases. They also hold great promise in clinical therapy due to their potential to reduce side effects and significant advantages in reducing the health care cost (Ramaa *et al.*, 2006).

Vitamin D is a special nutrient that the body synthesizes when exposed to sunlight and increases the ability of the body to absorb calcium. The serum calcium, phosphorous and 25 (OH) D levels in the rural and urban population of Tirupathi taluk, Andhra Pradesh, India was studied. The results pointed that two thirds of subjects had low level of vitamin D (less than 400 IU units per day). Intake of calcium was found at 300 mg/day, below the recommended levels of 1000 mg/day (Harinarayan, 2004).

Older men take zinc rich foods such as sesame seeds as a regular part of their healthy way of eating in order to contribute towards their bone mineral density. Although osteoporosis is often thought to be a disease for which postmenopausal women are at highest risk, it is also a potential problem for older men. Almost 30% of hip fractures occur in men, and one in eight men over the age 50 will have an osteoporotic fracture. A study of 396 men ranging in age from 45 -92 years found years a clear correlation between low dietary intake of zinc, low blood levels of the trace mineral, and osteoporosis at the hip and spine (Hyun *et al.*, 2004).

A well balanced diet with adequate amounts of calcium is important. Women need to be especially careful to get enough calcium and vitamin D as they age. Post menopausal women and men over the age of 65, need 1200 - 1500 mg of calcium and 400 – 800 IU of vitamin-D per day (Dennison, 2007).

Nutrients Supporting Bone Health



Source : www.funggohpharma.com.sg

Dietary pattern may influence bone turnover and BMD. A healthy dietary pattern with high intakes of fruits and vegetables may lead to less bone resorption, and a poor dietary pattern rich in processed food is associated with a decrease in BMD. So, a healthy diet is required for strong bones (Gass and Dawson, 2006).

To combat low levels of vitamin D, few Indian states have recently initiated vitamin D fortification of edible oil and milk fortification. These will act as an effective means of delivering vitamin D (IOF report, 2013).

A study showed that dietary supplementation with flax seed oil can help to reduce the level of deoxypyridinoline in the urine and normalise bone density. The researchers suggest that the presence of omega 3 fatty acids in flax seed oil may play a role in protecting the processes involved in bone formation and

mineralisation and, therefore, help to offset the negative effects the menopause and diabetes can have on bone health (www.nutripeople.com).

A dietary supplement, also known as food supplement or nutritional supplement, is a preparation intended to provide nutrients that are missing or are not consumed in sufficient quantity in a person's diet. Some countries define dietary supplements as foods, while in others they are defined as drugs (Ziari, 2007).

Epidemiological studies and clinical trials suggest that soy isoflavones have beneficial effects on bone mineral density, bone turnover markers, and bone mechanical strength in postmenopausal women. However there are conflicting results related to estrogen status of the body, metabolism of isoflavones among individuals, and other dietary factors. The long term safety of soy isoflavone supplements remains to be demonstrated (Atmaca, 2008).

According to Wu (2006), sesame seeds are very beneficial in resolving the symptoms of osteoporosis. Sesame seeds contain estrogen like ingredients which regularize the hormonal cycle indirectly, reducing the symptoms of osteoporosis.

Sesame seeds are rich in calcium, magnesium, zinc, etc. Calcium in the sesame helps to protect colon cells from cancer causing chemicals, helps to prevent bone loss, helps to prevent migraine headaches, reduces postmenopausal symptoms in women. Zinc rich sesame helps to increase the bone mineral density especially for post menopausal women (www.pyroenergen.com). Mani *et al.*, (2011), reported a decrease in fasting blood glucose levels by 19.7 per cent upon flax seed supplementation.

Priyanka (2013) found that foods developed based on finger millet mixes contained high amount of iron, calcium and proteins. The sensory evaluation of the products was found to be acceptable and low cost and hence the finger millet based mixes can be recommended for domestic cooking.

Zinc is an essential bone nutrient and the zinc status in bone is known to decline with age and menopause of women. Wheat products are an excellent source of zinc and intake of zinc has a positive influence on bone mass. In

general, zinc is necessary to activate genes involved with protein synthesis and wellness of bones. Women may need 50 to 75 mgs of zinc per day (total in diet and vitamins) and men need up to 100 mgs of zinc ([http:// preventarthritis.org / how-zinc-helps-your-bones](http://preventarthritis.org/how-zinc-helps-your-bones)).

Research indicates that oat straw rich in calcium and other bone bolstering minerals is a tremendous defense against osteoporosis. It has been pointed out that oat straw triggers the release of the luteinizing hormone leading to an overall hormone flow that stimulates cell growth and makes oat straw a great supplement for building bone strength (<http://undergroundhealthreporter.com/oat-straw-benefits-longevity>).

2. Life Style Management and Exercise

For the prevention of non communicable diseases, weight control is an important priority in both men and women. Njelekela *et al.*, (2009) stated that interventions to reduce weight gain must be warranted and should address social, cultural and gender specific aspects of weight gain.

Samira *et al.*, (2014) report that pre-menopausal women had high incidence of osteopenia (25%) and suggested to implement health education campaigns demonstrating the preventive measures of osteoporosis. Epidemiological studies in India have revealed that the incidence of osteoporosis is on the increase particularly with ageing.

Adoption of intervention strategies like diet supplement and physical activity reduce the risk of cardio vascular diseases. The intervention of diet and physical activity showed significant reduction in Body Mass Index, total cholesterol, HDL, LDL and risk scorers (Thilagamani and Umamaheswari, 2011).

The department of obstetrics and gynecology, Pakistan conducted a BMD testing in health exhibition camp for women. Young females who carried out regular weight bearing exercises before puberty showed a high BMD compared to others. This is attributed to strengthening of their muscular-skeletal structure (Jaleel *et al.*, 2010).

Physical activity is defined as movement that requires any form of skeletal muscle contraction and results in energy expenditure beyond resting levels (Kokkinos, 2010). Physical activity affects the risk of developing osteoporosis. Bone is formed in response to weight-bearing activity (such as walking), bone is broken down in response to inactivity (Asikainen *et al.*, 2004).

Lenz (2007) reported that exercise results in decreased total peripheral resistance which in turn is associated with increased blood vessel diameter and thereby decreased blood pressure.

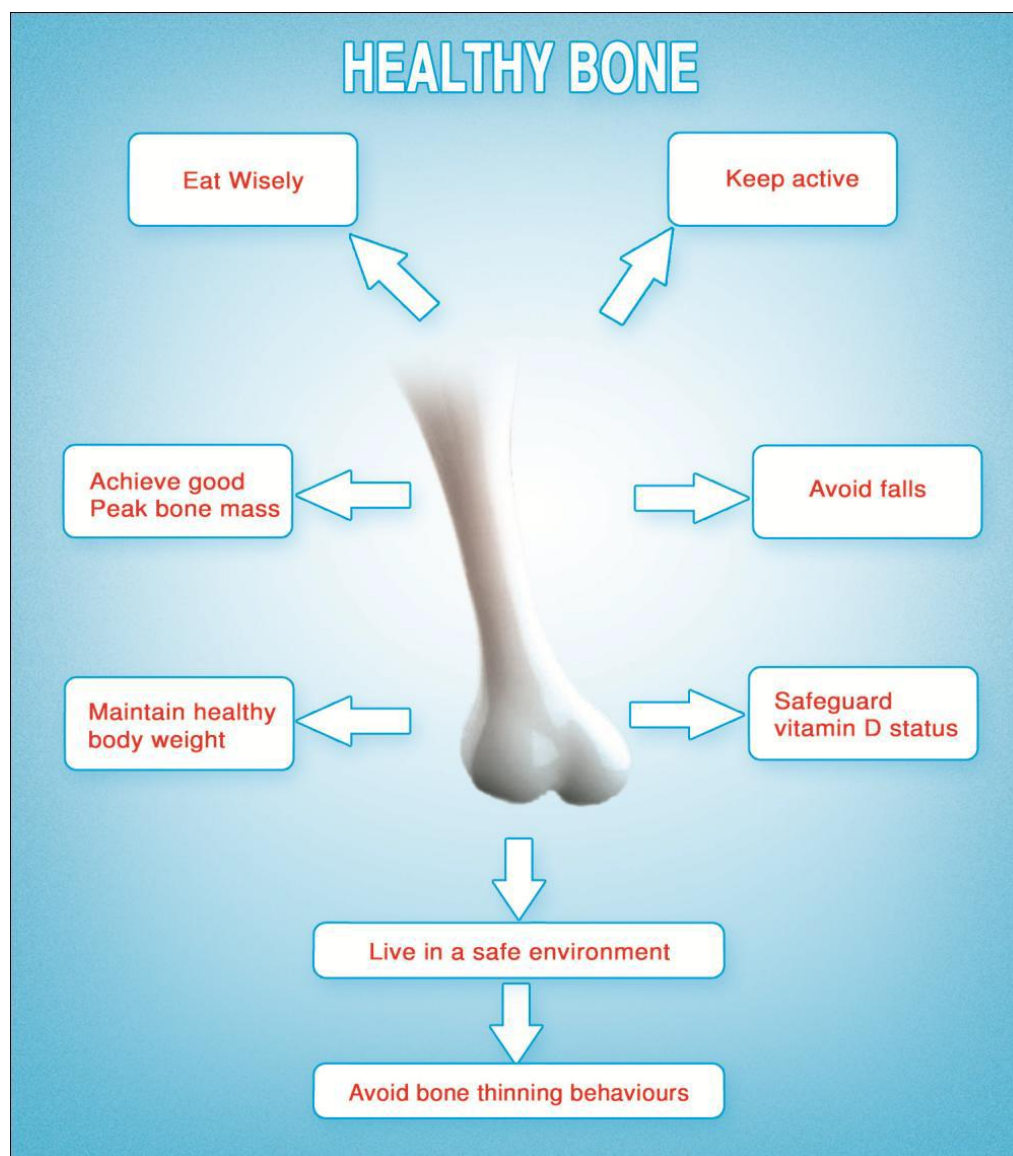
Young girls who carried-out weight bearing exercises like athletics, jogging, gardening etc showed significantly healthier bones (Turner, 2012).

Physical activity is essential in menopause, especially to maintain bone density, bone mechanical load required to efficiently perform their metabolism. Once again, a sedentary life style is an enemy of our health and although the pace and intensity of exercise is determined individually it is important to avoid any kind of immobility (Anon, 2007).

Exercise has a wide variety of beneficial health effects. However, exercise does not bring about substantial increases in bone density. The benefit of exercise for osteoporosis has mostly to do with decreasing the risk of falls, probably because balance is improved and or muscle strength is increased (Lindsay *et al.*, 2002).

Prevention is likely to remain the most effective method of dealing with osteoporosis. The two approaches to prevention are maximizing peak bone mass at skeletal maturity and reducing the rate of age and menopause related bone loss (Matkovic, 2008).

It is essential to prevent osteoporosis rather than doing treatment. This is achieved by quitting smoking, stopping drinking habits, following regular exercise, and consuming a balanced diet rich in calcium and vitamin D (Thomas, 2008).



c. Nutrition Education and Diet Counselling

Health promotion / disease prevention presumes a high level of self regulation and a willingness to control one's behavior to avert risk of death or disability (Nelkin, 2003).

Diet Counselling involves constant interaction between the counsellor and clients / patients about therapeutic diets to produce a change in food behavior. It is also targeted at healthy people who could also benefit from changes in food intake and habit for preventive health to reduce the risk of developing chronic diseases (Ndiokwelu and Ndiokwelu, 2006).

According to Malathy *et al.*, (2011), patients counseling is a route that improve them to cope with their disease and make informed decisions regarding diet and lifestyle management and modification.

The goal of treatment of osteoporosis is the prevention of bone fractures by reducing bone loss or preferably, by increasing bone density and strength. Although early detection and timely treatment of osteoporosis can substantially decrease the risk of future fractures. None of the available treatments for osteoporosis are complete cures. In other words, it is difficult to completely rebuild a bone that has been weakened by osteoporosis (Kenny, 2009).

Recommendations for optimizing bone health include a comprehensive program that consists of a well balanced diet rich in calcium and vitamin D. physical activity and a healthy lifestyle (not smoking, avoiding excessive alcohol use and recognizing that some prescription medications). Physical therapy or rehabilitation medicine is to help with daily activities, safe movement and exercises to improve the strength and balance (www.niams.nih.gov).

d. Medical Treatments

Estrogen Replacement Therapy (ERT) is used to be the only FDA approved treatment to prevent osteoporosis. There are now many other drugs and medications for osteoporosis, but estrogen remains a fairly common treatment to conserve bone mass and prevent osteoporosis related fractures in post menopausal women (Pauline *et al.*, 2007).

According to Harris *et al.*, (2001), estrogen may be used along with biphosphonate medicines that retards bone loss. Research studies elucidate that taking a biphosphonate with hormone therapy leads to increased bone mass when compared to either taking a biphosphonate or hormone therapy. HRT was supporter to combat the estrogen deficiency in women. But, there is social dogma against HRT among women. This prevents them from strengthening themselves after post-menopause stage (Gupta, 1996).

According to Miggiano and Gagliardi (2005), if the diet is unfeasible to reach the requirements, then there is a need for supplementation of calcium and vitamin D. In addition, other vitamins and minerals are also necessary for normal bone metabolism. Some drugs may interfere with calcium and other nutrients and create an unfavourable result on bone health.

Madhukar (2007) reported that calcium supplementation has a beneficial effect on bone density and may reduce vertebral fractures. It has no clear effect on non-vertebral fractures, although the number of patients studied may be too small to predict the outcome. This was a well conducted systematic review of calcium supplementation to increase bone density and reduce fracture risk in post menopausal women who take calcium.

Vitamin D deficiency is associated with increased risk of hip fracture and studies have demonstrated that an increase in calcium intake of 800 – 1000 mg/day with supplementation of 400 – 800 units of vitamin-D daily will decrease the risk of vertebral and non-vertebral fractures and increase bone mineral density (Holick, 2006).

Yamaguchi (2010) found that zinc acexamate has the restorative effect on bone loss under various pathophysiologic conditions including ageing, skeletal unloading, aluminium bone toxicity, calcium and vitamin-D deficiency, adjuvant arthritis, estrogen deficiency, diabetes and fracture healing. Zinc compounds may be designed as new supplementation factor in the prevention and therapy of osteoporosis.

Osteoporotic post menopausal women, with the complication of primary biliary cirrhosis, showed that Micro Crystalline Hydroxyapatite Concentrate (MCHC) supplementation not only helped reduce bone loss but it actually helped to increase cortical bone thickness by 6.1 per cent (Epstein *et al.*, 2002).

Cauley *et al.*, (2003), reported that among post menopausal women, estrogen deficiency creates more bone loss. New clinical methods for hormone replacement have been developed and it has its share of benefits and risks.

D. Studies Related to Bone Health

Habibzadeh (2011) conducted a study among forty young women between the age group 20-25 years subjected for bone mass density analysis. The study showed that 20 per cent of obese women had osteopenia which is very low compared to 60 per cent of osteopenia in thinner women. Thus under nutrition can contribute to bone loss and young women will have time to recover from the bone loss if high peak bone mass gets developed at a younger age.

Turner (2012) studied the BMD of women in University of Arkansas, and came up with significant findings that two per cent of young females already had osteoporosis and further 15 per cent had osteopenia. Women who used birth-control hormone injections showed high bone loss. It was inferred that women using such injections should check for their bone mineral density levels and make a judicial decision on such usage.

A study was carried out to identify the bone condition of women of Jammu, India. Osteopenic and osteoporosis was mainly prevalent in women in age group 55 to 64 years. After 65 years, the incidence of osteopenia and osteoporosis was 100 per cent which indicates that low BMD is an age related factor (Sudhaa *et al.*, 2006).

In a Saudi Arabian study Bone Mass Density and vitamin-D levels of 100 women above the age group of 40 years, who visited a hospital was measured. Additionally, their food habits, meal pattern, smoking habits, physical activities etc were surveyed. It was observed that 58 per cent of women had low bone mass density. Moreover, the vitamin-D content was also lower than the acceptable level. The unique clothing pattern (Full body covered dress) of women prevents the exposure to sunlight. Sunlight is a major source of vitamin-D. The author proposes a method to improve bone mass and vitamin-D. Medicinal supplements were effective in improving vitamin-D levels. Calcium supplementation through milk is

an easy and effective method to increase bone mass. Also, increased physical activity through exercise can strengthen the bones (Anitha *et al.*, 2014)

Periodontal tissue disease is associated with gums close to teeth. The association between osteopenia and periodontal tissue was studied, since calcium plays a close relation between teeth and bones. No statistical evidence was found between the occurrence of periodontal and osteopenia (Weyant *et al.*, 1999).

The role of diet in preventing bone fractures was studied - Socio-economic status, physical activity, menopause, diet intake were surveyed among young adult and post menopausal women and 26 per cent of young adult women were diagnosed for osteoporosis. This figure indicates that women, who did not reach menopause, even had risks of bone disorders. The dietary habits of these women were studied, but a clear co-relation between calcium intake and fracture incident could not be achieved (Deepti *et al.*, 2006).

The awareness on health issues among Indians is alarmingly low. Small surveys conducted in India indicate that approximately 10 to 15 per cent of urban populations are only aware of osteoporosis. This, awareness varies widely with respect to the level of education and family history of the disease. A study revealed that Indians get information about osteoporosis mainly through the television and radio (55%). This number is fairly high compared to information obtained through family, friends, and newspaper and doctors (approximately 20 per cent each). Unfortunately, 20 per cent of information coming from physicians is not a healthy indicator. An increased involvement of doctors in educating patients about osteoporosis is the need of the hour (Sapna *et al.*, 2010).

Chee *et al.*, (2003) stated that ingestion of high calcium skimmed milk was found to be effective in reducing the rate of bone loss at clinically important lumbar spine and hip sites in post menopausal women. Supplementing with milk had additional benefits of improving the serum 25 – hydroxy vitamin D status.

Calcium intake and serum calcium levels of women approaching menopause (40 – 50 years) and young adults (20 – 30 years) were studied by Irvinder (1993). Adult women showed lower calcium intakes and serum calcium levels. It was inferred that a positive relation existed between calcium intake and serum calcium levels among premenopausal women and young adult women where the mean serum calcium levels was 8.46 mg/100 ml and 9.62 mg/100 ml and that of mean calcium intake was 404 mg/day and 561 mg/day.