

I. INTRODUCTION

Health is a “Complete state of physical, mental, social and spiritual wellbeing and not merely the absence of disease or infirmity” (WHO,2018). “Health is a dynamic state that results from the body’s ongoing adjustment and adaptation in reaction to stress and changes in the environment in order to preserve homeostasis or internal balance. According to McEwen (2003) “A healthy organism is capable of mounting a defensive reaction, reducing the potential for injury and restoring homeostasis”. Illness occurs when the physiological condition is out of balance or damaged.

Health is a critical indication of long-term growth and it is impacted by a variety of factors such as nutrition, economic position, age and lifestyle (COHAB, 2010). Achieving optimal growth and development, maintaining structural integrity, the capacity to overcome illnesses are all aspects of good health (Srilakshmi, 2018). Though various factors influence ones growth and development, proper bone health is utmost essential for maintaining good health.

According to Weiner *et al.*, (2008) the term “bone” refers to a hard, thick, and dynamic connective tissue that aids in the creation of the skeleton in humans and vertebrate animals. Bones serve as a protective framework for critical organs such as the brain, spine, heart and lungs. Bones serve as a place for muscle attachment, as well as a site for the creation of blood cells. Bones also serve as a storage site for minerals including calcium, phosphate and carbonate, making them an excellent organ for maintaining mineral homeostasis.

Osteoporosis is most prevalent bone disease in humans. It is a significant public health issue. Women and the elderly are more likely to have it. According to Klibanski *et al.*, (2001) “Osteoporosis is a disease that is characterized by low bone mass, deterioration of bone tissue and disruption of bone microarchitecture: it can lead to compromised bone strength and an increase in the risk of fractures”. Just as hypertension is a risk factor for stroke, osteoporosis is a risk factor for fracture.

A large number of people of all different races and genders are affected by osteoporosis and its incidence is expected to rise as the population ages. It’s a quiet

condition until it develops fractures, which can lead to serious secondary health issues and even death (Cosman *et al.*, 2014). Muscle and bone are both hormonally sensitive organs. The absence of oestrogen during menopause has a far higher impact on women's bone health than on males of similar age.

Osteoporosis affects an estimated 200 million women globally. This diagnosis affects one-tenth of women aged 60, one-fifth of women aged 70, two-fifths of women aged 80 and two-thirds of women aged 90 (Kanis *et al.*, 2012). After the age of 50, one out of every three women will have an osteoporotic fracture (Sozen *et al.*, 2017).

India is the world's second most populous country, with nearly 10 percent of the population (more than 100 million) over the age of 50 (General, 2011). Fifty million Indians are either osteoporotic (T-score less than 2.5) or have poor bone mass (T-score between -1.0 and -2.5) (Mithal *et al.*, 2012).

According to various studies, osteoporosis and osteopenia, or decreased bone mass, can arise at a younger age in the Indian population (Sridhar *et al.*, 2011 and Khanna *et al.*, 2011). The research conducted in Delhi concluded that, 24.6 percent of males and 42.5 percent suffer from osteoporosis of women over the age of 50 (Thulkar *et al.*, 2015). Despite the fact that osteoporosis in male is a prevalent cause of morbidity and mortality, there are scant data on the condition in India.

Osteoporosis may be divided into two categories based on the variables that impact bone metabolism: primary (Type I) and secondary (Type II) osteoporosis. Type I osteoporosis, also known as postmenopausal osteoporosis, is caused by a lack of oestrogen and primarily affects the trabecular bone; therefore, women are more susceptible to osteoporosis than men, as evidenced by a men or women ratio of 4/5 (Tuzun *et al.*, 2012). Type II osteoporosis, commonly known as senile osteoporosis, is characterised by the loss of bone mass as cortical and trabecular bones age (Hannan *et al.*, 2000 and Cosman *et al.*, 2014).

Osteoblast activity appears to decline with age in both men and women thereby exacerbating bone loss caused by increased resorption associated with ageing

(Demontiero *et al.*, 2012). In males, androgens play a significant role in determining peak bone mass. Bone mass is directly linked to sexual development and males who have atypical or delayed puberty having lower bone mass.

Male osteoporosis is usually undiagnosed and untreated, with symptoms appearing only after a fracture. Despite the fact that osteoporotic fractures in males are more prevalent than myocardial infarction and prostate cancer, the majority of osteoporosis research focuses on women, particularly postmenopausal women, with little data on men (Agrawal *et al.*, 2013).

Bone mass in women rises fast from adolescence until the mid-20s to mid-30s, when maximal bone mass is attained (Marwaha *et al.*, 2009 and Henry *et al.*, 2010). After reaching peak bone mass, women experience a period of stability followed by a steady rate of bone loss that begins well before menopause (Teitelbaum, 2007). As a result of oestrogen deprivation, the rate of bone loss after menopause is fairly rapid-as much as 7 percent per year-for up to 7 years. Bone loss continues in later life, but at a slower rate of 1 to 2 percent per year; nevertheless, some elderly women may lose bone density at a faster pace (Karsenty *et al.*, 2009). Osteoporosis in women has a complicated aetiology. A variety of factors that act locally on bone may cause increased bone resorption after menopause and with oestrogen deficiency. Therefore in women menopause plays a major role in maintaining proper bone health (Seeman *et al.*, 2009).

Weiss *et al.*, (2004) opines that menopause is the termination of reproductive capacity and the permanent cessation of menstruation. The period shortly before menopause (when endocrinologic, biologic and clinical signs of impending menopause appear) is referred as peri menopause and the first year after menopause are referred to as postmenopause (Johnson *et al.*, 2004), regardless of whether the menopause was forced or natural (Gracia *et al.*, 2005).

The elderly and postmenopausal face the most significant risk of osteoporosis. Osteoporosis is linked positively to premature menopause (before the age of 40) and early menopause (between the ages of 40 and 50). The earlier one reaches menopause, the lesser ones bone density would be in later years. Women who had their ovaries surgically removed before the age of 45 are more likely to develop osteoporosis.

Apart from menopause, there are furthermore risk factors causing osteoporosis. (Marjoribanks *et al.*, 2012).

Three groups of non modifiable risk factors for osteoporosis have been identified as old age, feminine gender, genetic predisposition and ethnicity. These are uncontrollable characteristics (Caucasian and Asian). Leanness, low body mass, oestrogen deficiency, early menopause (before the age of 45), hyperthyroidism, type 1 diabetes, rheumatic diseases (including ankylosing arthritis and ankylosing spondylitis), treatment with corticosteroid therapies or other chronic disease drugs, anti-leptic drugs, stomach-protecting drugs containing tranquillizers, heparin, oral anticoagulants, anti-tuberculosis drugs and lifestyle are the modifiable type of osteoporosis risk factors (fully-controllable variables) and the most prevalent ones are sedentary lifestyle, insufficient vitamin D intake or lack of sunlight exposure, a calcium-deficient diet, cigarette smoking, excessive coffee and alcohol use and protein intake in the diet (Burckhardt *et al.*, 2001 and Reventlow *et al.*, 2007).

Identification of risk factor causing osteoporosis is not always an easy task. As a first step, bone mineral density is tested to examine the bone health status and then preventive measures can be done based on the BMD and risk factor causing osteoporosis in order to attain optimal bone health. Bone mineral density can be easily evaluated to identify bone density, but the degree of degeneration of bone tissue with the exception of biochemical indicators of bone tissue, cannot be detected in clinical settings (Seeman *et al.*, 2006).

Bone strength can be determined using bone mineral density for 70 percent and quality of the bone. BMD measurement is the incidence of a fragility fracture of the hip or vertebra which is all used to diagnose osteoporosis. (Watts *et al.*, 2010).

The real expression of the bone in absolute terms of grams of mineral (mainly, as g/cm of calcium) per square centimetre of the scanned bone is assessed using dual X-ray absorptiometry (DXA). BMD measurements of the hip and spine are used to diagnose or confirm osteoporosis, estimate future fracture risk and track patients' progress (Tuzun *et al.*, 2012).

Osteoporosis is diagnosed when BMD falls below 2.5 SD, the typical value for young healthy women (a T-score of 2.5 SD), according to the World Health Organization (WHO). A second, higher criterion assigns a T-score between 1 and 2.5 SD to “poor bone mass” or osteopenia. The term “severe” or “established” osteoporosis refers to the condition of having one or more verified fragility fractures (Kanis *et al.*, 2007).

The greatest and best indicators of hip fracture risks are Dual Energy X-Ray Absorptiometry (DEXA) readings. The preferred measuring locations are the entire hip, femoral neck, or total lumbar spine (or a combination of these sites). Fracture risk is directly proportional to bone strength and rises exponentially as BMD falls hence apart from various diagnosis methods consequences caused due to osteoporosis can also define the bone health status (Moyer *et al.*, 2013).

The clinical consequences of osteoporosis are fractures and associated comorbidities. Until a patient has a fracture, osteoporosis is a quiet condition. A recent fracture in an adult older than 50 years at any major skeletal site, such as the vertebrae (spine), proximal femur (hip), distal forearm (wrist), or shoulder, with or without trauma, should indicate that the diagnosis of osteoporosis requires further urgent assessment involving diagnosis and treatment (Compston *et al.*, 2013 and Cooper *et al.*, 2002).

Siminoski *et al.*, (2006) stated that the patient’s first complaint may be a loss of height owing to spinal compression induced by fractures, which is more noticeable in the presence of numerous fractures; this anomaly may be objectively identified by increased occiput-to-wall distance caused by dorsal kyphosis (dowager’s hump). Restrictive lung disease and consequent cardiac difficulties may develop from many vertebral thoracic fractures. Back pain (acute and chronic), prolonged disability, poor self-image, social isolation, depression and positional restriction are among problems caused by compression fractures.

Dorsal kyphosis can be found in elderly adults without fractures, thus it’s not a reliable indicator of osteoporosis. Other variables, irrespective of bone mineral density (BMD), can enhance fracture risk and osteoporosis (Kanis *et al.*, 2007). The patient’s age (D’Amelio *et al.*, 2015), a low BMI (less than 21 kg/m) is a major

risk factor for hip fracture (De Laet *et al.*, 2005), Another major indicator for subsequent fracture risk is a history of past osteoporotic fractures, which virtually doubles the risk of spinal fractures (Kanis *et al.*, 2004). After the diagnosis, understanding the severity of osteoporosis and by considering the consequences caused by its preventive measures and treatment should be done for proper bone health.

Prevention begins at a young age with adequate diet and physical exercise, as well as the treatment of risk factors such as smoking (Kanis *et al.*, 2005) and the prompt management of hormonal balance problems, menstruation, and menopause, as well as the necessary replacement medication. Without a doubt, the latter is linked to the best results in terms of boosting bone density and other menopausal benefits (Ivanova and Vasileva, 2017).

Rizzoli *et al.*, (2010) found that throughout life, a regular weight-bearing exercise routine (for example, walking 30-40 minutes each session) should be recommended, as should back and posture exercises for a few minutes on most days of the week. Active children and young adults have a higher peak bone mass than inactive children and young adults.

These activities assist elderly people decrease bone loss due to inactivity, improve balance and boost muscular strength, lowering their risk of falling. Pushing, pulling, lifting and bending actions compress the spine, resulting in fractures. Patients should avoid forward flexion, side-bending exercises, and carrying heavy things (Kelley *et al.*, 2002).

Several therapies, including lifetime regular weight-bearing and muscle strengthening exercises, the cessation of tobacco use and excessive alcohol intake, and the treatment of risk factors for falling, are essential components of any osteoporosis preventive or treatment programme (Bischoff *et al.*, 2005).

Adequate exposure to sunlight is very much important to maintain peak bone mass thereby preventing osteoporosis. Sunlight being non nutritious source of vitamin D, remains as a main factor in osteoporosis prevention (Kopiczko, 2014). The sunlight converts 7-dehydrocholesterol in the skin to previtamin D3, which inturn

becomes the active form vitamin D and helps in absorption of calcium thereby maintaining healthy bones (Wacker, 2013).

Vitamin D deficiency in older persons is caused by ageing skin and decreased sunshine exposure, which reduces the conversion of 7-dehydrocholesterol to cholecalciferol (vitamin D₃) by ultraviolet radiation. Vitamin D deficiency, in turn, lowers calcium absorption. Furthermore, elderly persons are more likely to consume insufficient levels of vitamin D and calcium. Para Thyroid Hormone (PTH), which acts to maintain blood calcium levels, rises as a result of lower calcium levels, leading to accelerated bone resorption (Vesper *et al.*, 2004).

Excessive alcohol consumption is bad for the bones and should be avoided. The reasons are multifaceted and include a tendency to falls, calcium shortage, and chronic liver illness, all of which lead to Vitamin-D deficit. People who are prone to osteoporosis should avoid drinking more than 7 drinks per week, with 1 drink equaling 120 mL of wine or 30 mL of liquor, or 260 mL of beer (Kanis *et al.*, 2005).

Kadam *et al.*, (2019) stated that there is low knowledge and awareness about osteoporosis in Indian men and women; hence there is a need for implementation of osteoporosis awareness for both men and women especially targeting low economic status and poorly educated people in order to prevent osteoporosis and also peri menopause and menopausal women in order to prevent osteoporosis. Hence, awareness on osteoporosis should be integrated in comprehensive women health program. (Janiszewska *et al.*, 2015)

Antiresorptive medicines are most commonly used to prevent osteoporosis and fractures. Estrogen, BisPhosphonates (BPs) such as alendronate, risedronate, ibandronate and zoledronic acid, Selective Oestrogen Receptor Modulators (SERM) raloxifene, human monoclonal antibody against receptor activator of NF-B ligand denosumab and Strontium Ranelate (SR) are among them (Robertson *et al.*, 2002).

Calcium and calorie intake are essential for bone development, growth, overall health and it plays a major role in prevention of osteoporosis (Alan *et al.*, 2000 and Nichols *et al.*, 2007). Calcium and vitamin D supplementation reduces the incidence of non-vertebral fractures and delays bone loss in the femoral

neck, spine and overall body. Weight gain and enhanced bone mineral density have been related to high energy intake. It's likely that the effect of obesity on bone mineral density is linked to the weight-bearing pressures exerted on the bone. Similarly, a 10 percent weight loss is related with a 1 percent to percent drop in bone mass (Compston *et al.*, 2002 and Harris *et al.*, 2006).

In several controlled intervention studies, increasing calcium intake resulted in enhanced calcium balance, greater bone acquisition during growth, reduced bone loss in later years, or reduced fracture incidence. A long-term calcium deficiency can lead to dental changes, cataracts, alterations in the brain and osteoporosis, which causes the bones to become brittle (Hochburg, 2003).

Calcium absorption, bone health, muscular function and balance all require vitamin D. Adults should take 600 IU/day until they reach 70 years of age, then 800 IU/day beyond that vitamin D is found in fortified milk, juices, and cereals, as well as saltwater fish and liver. vitamin D (ergocalciferol) or vitamin D (cholecalciferol) supplementation may be employed (Bischoff *et al.*, 2005).

Calcium is a vital component in bone mineralization and anti-demineralization methods (Dawson *et al.*, 2000; Compston *et al.*, 2005 and Dawson *et al.*, 2006). An external source of enough calcium is required to keep blood calcium at a steady level; otherwise, low serum calcium levels induce bone resorption to bring calcium levels below normal. Calcium needs rise as people age, making the elderly particularly vulnerable to calcium insufficiency. The Institute of Medicine (IOM) recommends a daily calcium intake of 1000 mg for males 50-70 years old and 1200 mg for women over 50 and men over 70 years old (Rosset *et al.*, 2011).

Several calcium sources are available for food fortification to accommodate increasing needs or to overcome inadequate intakes. Purified calcium carbonate (Dawson *et al.*, 2000; Chevalley *et al.*, 2004 and Reid *et al.*, 2013), calcium citrate (Dawson *et al.*, 2005), osseino-mineral complex (Chevalley *et al.*, 2004), oyster shell electrolysate (Fujita *et al.*, 2010), calcium lactate gluconate (Reid *et al.*, 2013; Prince *et al.*, 2015; Reid *et al.*, 2015 and Thamsborg *et al.*, 2016) and milk-calcium (Nelson *et al.*, 2011) have all been examined for their effects on BMD in postmenopausal women and the elderly. The effects were similar in most cases,

generating a slight, possibly temporary increase in BMD or a reduction in bone loss (Reid *et al.*, 2015).

Jang *et al.*, (2007) stated that synthetic calcium supplements like calcium carbonate, calcium lactate and calcium citrate are available, as are natural calcium supplements such as whey calcium and seaweed powder.

Calcium lactate and citrate are water soluble, much like milk, but calcium carbonate is not, which makes it difficult to absorb (Szeleszczuk *et al.*, 2015). In comparison to commercial supplements like Calcivit®, Calcigran® and Coral Calcium®, calcium acquired from eggshell is easily diffused in gastric secretions (Bradauskiene *et al.*, 2017).

Calcium citrate is more costly and it takes more tablets to get the appropriate amount; nevertheless, it does not require stomach acid for absorption and it does not cause GI problems. Some foods contain too much oxalate, which binds to calcium and inhibits it from being absorbed. Consumption of over 1200-1500 mg per day may raise the risk of kidney stones, cardiovascular disease and stroke (Moyer *et al.*, 2013).

When calcium supplements are taken with meals, they are more readily absorbed, especially when stomach acid is absent. Calcium doses should not exceed 500-600 mg per dose for optimum absorption. Calcium carbonate is the least costly and requires the least amount of pills, although it can induce Gastro Intestinal (GI) issues (Vasikaran *et al.*, 2011).

Calcium supplements, which are given by doctors for impoverished individuals to heal ailments or satisfy nutritional needs, are expensive (Silva and Nabavi, 2019). Chicken Eggshell Powder (CESP) is an alternate source of calcium for human consumption, according to Ray *et al.*, (2017) and Bradauskiene *et al.*, (2017).

Chicken eggshell is a low-cost calcium source that may be found at home. It's made up of 94 percent calcium carbonate, 1 percent magnesium carbonate and 1percent calcium phosphate. It is a potential and effective source of dietary calcium, with 39 percent elemental calcium (Murakami *et al.*, 2007 and Milbradt *et al.*, 2015) claim that half an eggshell (2.7 g) can deliver enough calcium to fulfil an adult's daily needs.

Calcium carbonate accounts for around 98 percent of the weight of egg shell powder, while other minerals important for bone metabolism, such as strontium and fluoride, are present in trace levels. Furthermore, Slovakian experts believe that egg shell powder includes beneficial elements. When calcium is combined with vitamin D (Chevalley *et al.*, 2004; Dawson *et al.*, 2005 and Nelson *et al.*, 2011) and magnesium (Abraham *et al.*, 2001), the benefits of calcium on BMD in postmenopausal women are enhanced.

In humans, eating eggshell powder has a favourable influence on bone mass growth (Schaafsma and Pakan, 1999). It boosts the density of the femoral neck bone Schaafsma *et al.*, (2002) and Sakai *et al.*, (2017) discovered that eggshell calcium was more effective than calcium carbonate in increasing bone mass in women, indicating that it might be used as a calcium supplement in human nutrition. Eggshell powder has been used to augment calcium in a variety of diets.

Salem *et al.*, (2012) investigated the practicality of employing eggshell powder in butter cake and indicated that a 10 percent eggshell powder inclusion level in bakery products might be recommended. Hassan (2015) found that supplementing biscuits with eggshell powder up to 6 percent did not result in any noticeable changes in flavour. Another study found that white bread can be fortified with eggshell powder and is satisfactory for fortification up to a level of 2 percent (Platon *et al.*, 2020).

According to a Slovakian study (2011) with osteoporotic patients, chicken egg shell powder, which is not typically utilised as a calcium source for humans, may have a greater influence on BMD (Makai *et al.*, 2011).

In certain industrialised nations, eggshell powder is already highly appreciated as a rich source of calcium (Schaafsma *et al.*, 2000 and Rovensky *et al.*, 2003). According to the study, there was no difference in calcium absorption between pure calcium carbonate and eggshell powder (Schaafsma *et al.*, 2009). Postmenopausal women with osteoporosis who took eggshell powder with vitamin D3 and magnesium supplementation had higher calcium content in their bones (Czernichow *et al.*, 2010). Every day, millions of eggs are devoured, and the eggshells are usually thrown (Sreenivasa *et al.*, 2014).

Food manufacturers and egg-based product enterprises, chicken farms, hatcheries, restaurants and houses generate a tonne of eggshell trash, causing environmental difficulties (Amu *et al.*, 2005; Phil and Zhihong, 2009). The shell membrane and eggshell are non-edible by-products that also serve as a source of beneficial substances to enhance bone health (Abdulrahman *et al.*, 2014). The food processing sector generates roughly 2,50,000 tonnes of eggshell trash each year due to the use of egg in various products (Verma *et al.*, 2012). The United States alone produces 1.5 lakh tonnes of garbage each year (Abdullah *et al.*, 2018).

Waste eggshells, on the other hand, may be a valuable and inexpensive source of calcium and other minerals. People in impoverished nations like Bangladesh might get enough calcium via eggshell enhanced meals and drinks. It would lower the cost and make calcium supplements more accessible to everyone (Olgun *et al.*, 2015).

With a calcium concentration of roughly 38 percent, chicken eggshell powder is a promising but little-known source of calcium for human nutrition. The usage of chicken eggshell powder might help people with osteoporosis by increasing bone density and reducing discomfort. The finest natural supply of calcium is eggshell calcium, which is approximately 90 percent absorbable.

The prevention of osteoporosis and its complications has become a goal for many health care practitioners. Health education is one of the most effective strategies for disease prevention and health promotion (Nutti *et al.*, 2019). Healthcare providers, especially community and geriatric nurses can communicate with older people to adopt osteoporosis preventing behaviours (Phelan *et al.*, 2015).

Considering all the above mentioned facts and emerging necessity, the study was coined based on the following objectives:

- To assess the risk factors associated with osteoporosis among selected adult women,
- To formulate egg shell calcite powder and determine its characteristics,
- To develop calcite incorporated recipes,
- To create awareness on calcite and its role in the prevention and management of osteoporosis.

The following Hypothesis are tested:

1. H0 - There is no significant association between calcium intake and BMD value of selected subjects.
2. H0 - There is no significant difference between pre and post awareness knowledge on calcite of the selected subjects.