

**EFFECT OF SUNLIGHT ON VITAMIN D STATUS AMONG
COLLEGE GOING GIRLS**

ANNU FRANCIS

(16PFN002)

A THESIS SUBMITTED TO THE
AVINASHILINGAM INSTITUTE FOR HOME SCIENCE AND HIGHER EDUCATION
FOR WOMEN, COIMBATORE- 641043

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE IN FOOD SCIENCE AND NUTRITION

APRIL 2018

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By

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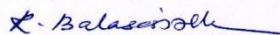
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Certified as a Bonafide Research Work



Signature of the Supervisor



Signature of the Head of the Department

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I.INTRODUCTION

If you think of it evolutionarily, it's the oldest hormone on this Earth. I don't think that this is going to be a flash in the pan.

~ Dr. Michael F. Holick

Vitamin D is a fat-soluble vitamin essential for metabolism, bone mineralization and immune function. This vitamin is provided through dietary intake as well as synthesized through the skin exposing to the ultraviolet rays from sunlight. The major circulating form of vitamin D in blood is 25(OH)D, the level of serum 25(OH)D is currently accepted as the best biochemical indicator to evaluate vitamin D status (Yao *etal.*, 2017).

In skin 7-dehydrocholesterol is converted to previtamin D₃ after absorbing solar ultraviolet B radiation and then sequentially hydroxylated into 25(OH)D and 1,25-dihydroxyvitamin D₃ by hydroxylases in the liver and kidney. It is also ingested in the diet or by oral supplements. It is involved in lipid metabolism such as the synthesis of bile acid in the liver, suggesting that may affect the regulation of lipids directly. Vitamin D deficiency is associated with the increased risk of dyslipidemias. The relationship of vitamin D status and serum lipids differ by genders (Zhao *et al.*, 2016).

Vitamin D (calciferol) comprises a group of fat soluble seco-sterols found naturally only in few foods, such as fish-liver oils, fatty fish, mushroom, egg yolk, and liver. Vitamin D is unique because it can be made in the skin by exposure to sunlight (http://www.nal.usda.gov/fnic/DRI//DRI_Calcium/250%E2%80%93287.pdf). The two major physiologically relevant forms of vitamin D are D₂ (ergocalciferol) and D₃ (cholecalciferol). Vitamin D₂ can be obtained from UV irradiation of ergosterol and it is a plant source. The ultra violet light from the sun strikes the skin and humans synthesize vitamin D₃ and it is the most "natural" form. Human beings do not make vitamin D₂ and most oil-rich fish such as salmon, mackerel, and herring contain vitamin D₃. Vitamin D that is ingested is incorporated into chylomicrons, which are absorbed into the lymphatic system and enter the venous blood. Vitamin D that comes from the skin or diet is biologically inert and its first hydroxylation takes place in the liver by the vitamin D-25-

hydroxylase (25-OHase) to 25(OH)D (Lips *et al.*, 2006). Absorption of calcium takes place mainly in the proximal part of the small intestine, highest in the duodenum, jejunum and ileum absorbing in the descending order. Various dietary factors influence calcium absorption, in addition to the physico-chemical factors such as the concentration of calcium in the gut and the intestinal pH.

Vitamin D3 is photosynthesized in the skin of vertebrates by the action of solar ultraviolet UV B radiation on 7-dehydrocholesterol. Vitamin D2 is produced by UV irradiation of ergosterol, which occurs in molds, yeast, and higher-order plants. Under conditions of regular sun exposure, dietary vitamin D intake is of minor importance. However, latitude, season, aging, sunscreen use and skin pigmentation influence the production of vitamin D3 by the skin. Most of the dietary intake of vitamin D comes from fortified milk products and other fortified foods such as breakfast cereals and orange juice (Institute of Medicine,1997). Both vitamin D2 and D3 are used as non-prescription vitamin D supplements, but vitamin D2 is the form available by prescription in the United States (Holick, 2007). Vitamin D without a subscript represents either D2 or D3 or both and is biologically inert. Vitamin D from the skin or diet is only short-lived in circulation (with a half-life of 1–2 days), as it is either stored in fat cells or metabolized in the liver (Maweret *al.*, 1972).

In circulation, vitamin D is bound to vitamin D-binding protein and transported to the liver, where it is converted to 25-hydroxyvitamin D [25(OH)D] (DeLuca,1984). This major circulating form of vitamin D is a good reflection of cumulative effects of exposure to sunlight and dietary intake of vitamin D (Haddad, 1973 and Holick, 1995) and is therefore used by clinicians to determine vitamin D status. To be biologically activated at physiologic concentrations, 25(OH)D must be converted in the kidneys to 1,25-dihydroxyvitamin D [1,25(OH)₂D], which is thought to be responsible for most, if not all, of the biologic functions of vitamin D. The production of 25(OH)D in the liver and of 1,25(OH)₂D in the kidney is tightly regulated. In the liver, vitamin D-25-hydroxylase is down-regulated by vitamin D and its metabolites, thereby limiting its increase in the circulating concentration of 25(OH)D following intakes or following production of vitamin D after exposure to sunlight. In the kidney, in response to serum calcium and

phosphorus concentrations, the production of 1,25(OH)₂D is regulated through the action of parathyroid hormone (PTH) (DeLuca, 1988; Reichel, 1989).

25(OH)D requires further hydroxylation in the kidneys by the 25(OH)D-1-OHase (CYP27B1) to form the biologically active form of vitamin D 1,25(OH)₂D (<http://www.nlm.nih.gov/medlineplus/ency/article/003569.htm>). 1,25(OH)₂D stimulates intestinal calcium absorption (Moyad, 2010). Without vitamin D, only 10–15% of dietary calcium and about 60% of phosphorus are absorbed. Vitamin D sufficiency enhances calcium and phosphorus absorption by 30–40% and 80%, respectively (Lappe, 2007).

Amongst the inorganic elements occurring in the body, calcium forms the largest amount. Ninety nine per cent of the body calcium is present in the skeleton, the remaining one per cent being distributed in the soft tissues and body fluid. Although the body contains large amounts of this metal, but is obtained from the foodstuffs in relatively small amounts. There is a wide variation in the calcium intake in different parts of the world. There are people whose daily calcium intake amounts to 300 to 400 mg per day and there are others whose daily calcium intake is of the order of 1,000 mg per day, or more.

According to the Dietary Guidelines for Americans (U.S. Department of Health and Human Services and U.S. Department of Agriculture 2005) older adults, people with dark skin, and people exposed to insufficient UV B radiation should consume extra vitamin D from vitamin D-fortified foods or supplements. The American Cancer Society Guidelines on Nutrition and Physical Activity for Cancer Prevention echo this recommendation (Kushi, 2006). Some says that optimal amounts for all adults are closer to 800–1000 IU (20–25 µg) daily (Vieth, 2007; Bischoff-Ferrari, 2006; Dawson-Hughes, 2005). The tolerable upper intake level for vitamin D is 2000 IU (50 µg) per day in North America and in Europe; however, some scientists are calling for an upward revision (Hathcock, 2007 and Vieth, 2007).

Absorption of calcium takes place mainly in the proximal part of the small intestine, highest in the duodenum, jejunum and ileum absorbing in the descending

order. Various dietary factors influence calcium absorption, in addition to the physico-chemical factors such as the concentration of calcium in the gut and in the intestinal pH.

Vitamin D Receptor (VDR) is present in most tissues and cells in the body (Chlebowski *et al.*, 2008). 1,25(OH)₂D has a wide range of biological actions, such as inhibition of cellular proliferation and inducing terminal differentiation, inhibiting angiogenesis, stimulating insulin production, inhibiting renin production and stimulating macrophage cathelicidin production.

Vitamin D Deficiency (VDD) has been historically defined and recently recommended by the Institute of Medicine (IOM) as a 25(OH)D of less than 0.8 IU. Vitamin D insufficiency has been defined as a 25(OH)D of 21–29 ng/mL (Holick, 2007). Children, young- and middle-aged adults are at equally high risk for vitamin D deficiency and insufficiency worldwide. Pregnant and lactating women who take a prenatal vitamin and calcium supplement with vitamin D remain at high risk for vitamin D deficiency (Hollis *et al.*, 2004).

Vitamin D is photosynthesized in the skin on exposure to UVB rays. Sun exposure alone ought to suffice for vitamin D sufficiency. However, vitamin D deficiency is widely prevalent despite plentiful sunshine even in tropical countries like India. Vitamin D deficiency in India significantly contributes to enormous burden on the healthcare system of India. Cultural and social taboos often dictate lifestyle patterns such as clothing, that may limit sun exposure and vegetarianism, which certainly limits vitamin D rich dietary options (Ritu, 2014).

During exposure to sunlight, it penetrates into the skin and is absorbed by proteins, DNA and RNA as well as 7-dehydrocholesterol (Holick, 2003). Most of this UVB radiation is absorbed in the epidermis and as a result when exposed to sunlight most of the vitamin D₃ that is produced in the skin is made in the living cells in the epidermis. This is the reason why after exposure to sunlight vitamin D₃ remains in the skin even when the skin is washed with soap and water immediately after the exposure to sunlight. When epidermal 7-dehydrocholesterol absorbs solar radiation, it causes an activation of the double bonds causing them to rearrange and open up the B ring to

form the seco-steroid (split steroid) previtamin D₃ which then is converted to vitamin D₃ (Tian, 1999).

The major source of vitamin D for children and adults is exposure to natural sunlight (Moan *et al.*, 2008). Thus, the major cause of VDD is inadequate exposure to sunlight (Maeda *et al.*, 2007). Wearing a sunscreen with a sun protection factor of 30 reduces vitamin D synthesis in the skin by more than 95% (Matsuoka *et.al*, 2007). People with a naturally dark skin tone have natural sun protection and require at least three to five times longer exposure to make the same amount of vitamin D as a person with a white skin tone (Clemens *et al.*, 1982). There is an inverse association of serum 25(OH)D and Body Mass Index (BMI) greater than 30 kg/m², and thus, obesity is associated with vitamin D deficiency (Wortsman *et al.*, 2000). Vitamin D Deficiency results in abnormalities in calcium, phosphorus, and bone metabolism. Vitamin D Deficiency causes a decrease in the absorption of dietary calcium and phosphorus, resulting in an increase in PTH levels (Holick, 2005).

No common definition exists for adequate vitamin D status measured as 25(OH)D serum concentrations (Dawson-Hughes, 2005). The criteria used to define adequate status should be revised upwards; serum 25(OH)D concentrations between 20 ng/mL (50 nmol/L) and 32 ng/mL (80 nmol/L) have been defined as sufficient (Hollis, 2005; Dawson-Hughes, 2005; Bischoff-Ferrari, 2006; Norman *et al.*, 2007). The Institute of Medicine 1997 used serum calcium concentrations greater than 11 milligrams per deciliter (mg/dL) for assessing the potential for increased risk of harm associated with high vitamin D intakes.

The classic effect of vitamin D is to facilitate the intestinal absorption of calcium by mediating active calcium transport across the intestinal mucosa. Vitamin D acts in system by genomic and non- genomic mechanisms (Norman, 1990). One of the mechanism involved is synthesis of a calcium transport protein (calbindin), which shuttles calcium from the brush border across to the basolateral side of the mucosal cell. An average person needs both calcium and vitamin D to ensure sufficient net absorption of calcium for meeting various body needs from commonly available food sources. Canonical function, facilitation of calcium absorption is difficult to dissect apart

from their respective roles of calcium and vitamin D. Sufficient calcium cannot be absorbed from diets unless there is reasonably normal vitamin D status, and, at the same time, cannot absorb sufficient calcium, no matter what the vitamin D status, if calcium intake itself is absolutely low (Robert, 2008).

Various nutritional and non-nutritional factors affect calcium absorption. Vitamin D is one of the most essential nutrients required for adequate calcium absorption. Certain carbohydrates like lactose, glucose, fructose and proteins like whey protein have been shown to promote calcium absorption (Guéguenet *al.*, 2000).

Even though combination of calcium and vitamin D supplementation is associated with higher bone mineral density and decreased incidence of hip fractures, the evidence for vitamin D supplementation alone is less clear. Vitamin D supplementation at doses of more than 700 IU daily (plus calcium) prevented bone loss compared with placebo. However, vitamin D supplementation (300 to 400 IU daily) without calcium did not affect fractures (Rodriguez-Martinez, 2002).

Cow's milk has good bioavailability of calcium (about 30 to 35%). It is estimated that without milk and milk products in the diet, less than half of the calcium requirements would not be met. Plant foods contain many vitamins and minerals that are important for a balanced diet and can be a source of calcium. However, generally speaking, plant foods contain a considerable amount of inhibitory substances, such as oxalates and phytates. These bind to calcium and form insoluble salt complexes, thus decreasing calcium absorption. For example, cooked spinach contains 115 mg calcium per serving (125 mL or ½ cup), but only an estimated 5% (6 mg in absolute value) of it is actually absorbed. This is very little compared to the 32% (i.e. 101 mg) of milk's calcium absorbed. Consumption of about 8 cups of spinach is needed to obtain the same amount of available calcium present in 1 cup of milk (Weaver, 2009).

The calcium bioavailability of some fortified foods is comparable with that of milk, but these foods do not always provide the same total calcium content per serving. Fortified beverages, including soy beverages and orange juice, tend to settle to the

bottom of the carton and that even vigorous shaking may not be enough to re-suspend the calcium salts (Rafferty, 2007).

Vitamin D deficiency prevails in epidemic proportions all over the Indian subcontinent, with a prevalence of 70-100% in the general population. Though in India, dairy products are rarely fortified with vitamin D rich foods, deficiency is still prevalent because of low exposure to sunlight. Indian socio-religious and cultural practices do not facilitate adequate sun exposure, thereby negating potential benefits of plentiful sunshine. The clinical vitamin D deficiency is highly prevalent in both urban and rural settings, and across all socioeconomic and geographic strata. Vitamin D deficiency is likely to play an important role in the very high prevalence of rickets, osteoporosis, cardiovascular diseases, diabetes, cancer and infections such as tuberculosis in India. Fortification of staple foods with vitamin D is the most viable population based strategy to achieve vitamin D sufficiency (Rituand Gupta, 2014).

People are worried about vitamin D deficiency and its related problems only at later stages of life. But early diagnosis helps to prevent vitamin D deficiency quickly with little life style modification. Adoption to exposure to sunlight is one of the best remedies for the absorption and utilization of calcium and vitamin D by humans. As there is more prevalence of vitamin D among people particularly among college girls the topic assumes significance and is need of the hour. As there are only very little Indian studies available, the present study aims at evaluating the effect of sunlight on vitamin D status among college going girls with the following objectives: To

- assess the vitamin D and calcium status of college girls
- educate the students on the importance of vitamin D and calcium
- give calcium rich food and expose the participants to sunlight
- evaluate the effect of sunlight on vitamin D and calcium status among the study participants

II. REVIEW OF LITERATURE

The Review of Literature pertaining to the study entitled “**Effect of sunlight on vitamin D status among college going girls**” is reviewed under the following headings:

- A. Importance of vitamin D in human nutrition
- B. Importance of calcium in human nutrition
- C. Association of vitamin D and calcium
- D. Role of sunlight in the synthesis of vitamin D and calcium

A. Importance of vitamin D in human nutrition

Vitamin D, often called the “sunshine vitamin,” is a very important nutrient for women’s health. Vitamin D is a steroid prohormone, synthesized in skin under ultra-violet light exposure. Under situations of minimal exposure to sunlight, a specific recommendation of a daily supplement of 400 IU is required for the Indian population. A serum concentration of 25-hydroxyvitamin D is the best indicator of vitamin D status as it is the major circulating form of the vitamin in the body (Satish, 2013).

Vitamin D is unique because it can be made in the skin from exposure to sunlight (Lips, 2006). Vitamin D exists in two forms. Vitamin D₂ is obtained from the UV irradiation of the yeast sterol ergosterol and is found naturally in sun-exposed mushrooms. UVB light from the sun strikes the skin, and humans synthesize vitamin D₃, so it is the most “natural” form. Human beings do not make vitamin D₂, and most oil-rich fish such as salmon, mackerel, and herring contain vitamin D₃. Vitamin D (D represents D₂, or D₃, or both) that is ingested is incorporated into chylomicrons, which are absorbed into the lymphatic system and enter the venous blood (Lappe *et al.*, 2007).

In skin 7-dehydrocholesterol can be converted to previtamin D₃ after absorbing solar ultraviolet B radiation and then sequentially hydroxylated into 25(OH)D and 1,25-dihydroxyvitamin D₃ by hydroxylases in the liver and kidney. It can also be ingested in the diet or by oral supplements. (Wang *et al.*, 2016). Vitamin D is normally produced in skin through a robust photolytic process acting on a derivative of cholesterol i.e., 7-

dehydrocholesterol to produce previtamin D, which is then slowly isomerized to vitamin D3. Vitamin D3 is the natural form of vitamin D produced in the skin, and vitamin D2 is derived from irradiation of ergosterol, which occurs to some degree in plankton under natural conditions and is used to produce vitamin D2 from the mold ergot and contains as much as 2% ergosterol (Hector, 2004).

Vitamin D2 is produced by UV irradiation of ergosterol, which occurs in molds, yeast and higher-order plants. Under conditions of regular sun exposure, dietary vitamin D intake is of minor importance. However, latitude, season, ageing, use of sunscreen and skin pigmentation influence the production of vitamin D3 by the skin (Institute of Medicine, 1997). Vitamin D3 is synthesized from 7-dehydrocholesterol in the skin. The vitamin D binding protein transports the vitamin D3 to the liver where it undergoes hydroxylation to 25(OH) D, the inactive form of vitamin D and then to the kidneys where it is hydroxylated by the enzyme hydroxylase to 1,25(OH)D, its active form. This enzyme is also present in a variety of extra renal sites, including osteoclasts, skin, colon, brain, and macrophages, which may be the cause of its broad ranging effects. The half-life of vitamin D in the liver is approximately three weeks, which underscores the need for frequent replenishment of the body's supply (Brannon *et al.*, 2008).

Vitamin D3 is a prohormone produced in skin through ultraviolet irradiation of 7-dehydrocholesterol. It is biologically inert and must be metabolized to 25-hydroxyvitamin D3 in the liver and then to 1,25-dihydroxyvitamin D3 in the kidney before function. The hormonal form of vitamin D3, i.e., 1,25-dihydroxyvitamin D3, acts through a nuclear receptor to carry out its many functions, including calcium absorption, phosphate absorption in the intestine, calcium mobilization in bone, and calcium reabsorption in the kidney. It also has several non-calcemic functions in the body. It also provides information on new selective analogs of 1,25-dihydroxyvitamin D3 for therapy (Hector, 2004).

In addition to cutaneous synthesis, vitamin D can be obtained from the diet in the form of vitamin D3 as cholecalciferol or occasionally as vitamin D2, ergocalciferol. Vitamin D3 is obtained from animal source, vitamin D2 is present in fungi and mushrooms irradiated with UVB (Battault *et al.*, 2012). Vitamin D deficiency (VDD) is

more likely to occur in women and elderly. Vitamin D deficiency is particularly seen in post-menopausal women owing to the loss of estrogen and age-related changes in the vitamin D receptor and vitamin D synthesis. Prevalence of vitamin D deficiency ranges from 50% to 90% in post-menopausal women in western world (Mitra *et al.*, 2016).

Vitamin D deficiency is characterized by inadequate mineralization or by demineralization of skeleton. Among children, vitamin D deficiency is a common cause of bone deformities known as rickets. Vitamin D deficiency in adults leads to a mineralization defect in the skeleton, causing osteomalacia and induces secondary hyperparathyroidism with consequent bone loss and osteoporosis. Potential roles for vitamin D beyond bone health, such as effects on muscle strength, the risk for cancer and for type 2 diabetes, are currently being studied. (Cranney *et al.*, 2007). A low vitamin D level is an established risk factor for osteoporosis. Inadequate serum vitamin D levels will decrease the active transcellular absorption of calcium. Although combination calcium and vitamin D supplementation is associated with higher bone mineral density and decreased incidence of hip fractures (Rodriguez *et al.*, 2002).

Serum 25(OH)D levels in adolescents are greatly affected by ethnicity, gender, stages of puberty, parathyroid hormone level, dietary vitamin D intake, and sun exposure. It is noted that there was no consensus on the concentration of serum 25(OH)D that would yield the most benefit for bone health for adolescents (Holick, 2005). Thus, dietary contributions are now emphasized. The dietary vitamin D intake correlates poorly with 25(OH)D concentrations and that 25(OH)D concentrations can hover around what is considered to be marginal deficiency (38 nmol/L) despite consumption of the recommended amount of vitamin D. Ultraviolet exposure and time spent outdoors are better predictors of 25(OH)D concentration than is dietary vitamin D intake (Thomas *et al.*, 1998). Most of the dietary intake of vitamin D comes from fortified milk products and other fortified foods such as breakfast cereals and orange juice. Both vitamin D₂ and D₃ are used in nonprescription vitamin D supplements, but vitamin D₂ is the form available by prescription in the United States. As cholecalciferol is synthesized in the skin by the action of ultraviolet light on 7-dehydrocholesterol, a cholesterol derivative, and vitamin D does not fit the classical definition of a vitamin. Nevertheless,

because of the numerous factors that influence its synthesis, such as latitude, season, air pollution, area of skin exposed, pigmentation, age, etc., vitamin D is recognized as an essential dietary nutrient (Holick, 2005).

The vitamin D hormone functions to increase serum calcium concentrations through 3 separate activities. First, it is the only hormone known to induce the proteins involved in active intestinal calcium absorption. It also stimulates active intestinal absorption of phosphate. Second, blood calcium concentrations remain in the normal range even when an animal is placed on a no-calcium diet. Therefore, an animal must possess the ability to mobilize calcium in the absence of calcium coming from the environment, i.e., through enterocytes (Hector, 2004). Vitamin D deficiency can cause various other health problems since its deficiency is often associated with obesity. Variety of psychological to physiological changes are experienced by women in different stages of their life include depression, irritability, mood swings, anxiety, weight gain, fatigue, insomnia, etc. Peri-menopausal age along with estrogen deficiency due to lesser ovarian function is more at risk (Rani, 2017). Vitamin D deficiency is epidemic, not only in the elderly, but is also commonly seen in pre pubertal children, adolescents, and young and middle-aged adults. Vitamin D deficiency has insidious consequences for the skeleton. It prevents the accrual of maximum amount of calcium that is genetically preprogrammed for the skeleton. Once peak bone mass is attained, both young and middle-aged adults who are vitamin D deficient will lose, on average, 0.25 to 0.5% of their skeletal mass per year if they do not have adequate calcium and vitamin D. Vitamin D deficiency results in secondary hyperparathyroidism, which increases the production of osteoclasts, which, in turn, dissolve bone releasing calcium into the blood stream. This results in osteopenia and can progress to osteoporosis. In addition, vitamin D deficiency causes a mineralization defect of the collagen matrix resulting in osteomalacia(Holick, 2005).

Vitamin D status is traditionally measured through assays of 25(OH)D, the major circulating form of vitamin D. Although 25(OH)D levels below 25nmol/l have been associated with disorders of bone metabolism, they are used to indicate severe vitamin D deficiency. The Institute of Medicine has suggested, for example, that approximately

97.5% of the population across all age groups meet their requirements for vitamin D, having serum vitamin D values higher than 50nmol/l. However, 25(OH)D values of 75nmol/l or higher is considered to be adequate (Hilgeret *al.*, 2014). Vitamin D status is assessed by measuring the prohormone 25(OH) D, which is an indicator of supply rather than function. The most stable and plentiful metabolite of vitamin D in human serum, 25(OH)D has a half-life of about 3 weeks, making it the most suitable indicator of vitamin D status. Liquid chromatography–tandem mass spectrometry, identifies 25-hydroxylated forms of both vitamin D₂ and D₃. The total 25(OH)D, is the sum of vitamin D₂(25(OH)D₂) and vitamin D₃ 25(OH)D₃ and is used to evaluate vitamin D status (Thacheret *al.*, 2011).

B. Importance of calcium in human nutrition

Nutrition is an important modifiable factor in the development and maintenance of bone mass. Calcium, phosphorus, proteins, vitamin D, magnesium, zinc, copper, iron, fluoride, and vitamins D, A, C, and K are some of the most essential nutrients required for adequate bone health. Of these, calcium is the most vital nutrient required for adequate bone growth and mineralization. Calcium is the most abundant mineral in the human body and makes up about 1.5-2% of the body weight and 39% of the total body minerals. Ninety-nine percentage of the body calcium exists in the bones and teeth and the remaining 1% of calcium is in the blood, extra-cellular fluids and in the tissues (Heaney, 2008).

Calcium is a building block of bone and deficiency of calcium is associated with low mineralization and increased risk of fracture. The higher velocity of bone mineral accumulation during puberty especially requires a greater intake of calcium compared to childhood and young adulthood (Institute of medicine, 1997). When there is an increase of calcium during growing years, there is an increase in the plasma levels of 1,25(OH)₂D that stimulates the renal tubular reabsorption of calcium and inorganic phosphate (Bonjour *et al.*, 2003). Calcium is essential for various functions in the body. The most important role of calcium is mineralization of bones. Adequate intake of calcium is necessary for optimum mineralization of bones especially during the pre-pubertal and adolescent years. Peak calcium retention during prepubertal and pubertal

years lays the foundation for strong bones thereby reducing the risk of osteoporotic fractures in old age. Various nutritional and non-nutritional factors affect calcium absorption. Vitamin D is one of the most essential nutrients required for adequate calcium absorption. Certain carbohydrates like lactose, glucose, fructose and proteins like whey protein have been shown to promote calcium absorption (Guéguen *et al.* 2000).

Teegarden *et al.*, (1999) says that the choice of source or combination of sources to meet the calcium needs of an individual depends on many factors and has implications for overall health. Some individuals do not consume sufficient milk to meet their calcium needs because of health reasons such as milk protein allergies or perceived milk intolerance, taste preferences, or philosophies. Others simply never acquired a habit of drinking milk as the beverage of choice. Milk-drinking habits track from early age and are related to milk-drinking habits of the mother. Nicklas, 2009 pointed out that it is possible to achieve adequate calcium intake and meet calcium requirements with a Western plant-based diet, it is easier and more practical to meet calcium balance when milk and milk products are present in the diet. The contribution of milk and milk products to calcium intake is important and advantageous nutritionally. The replacement of milk and milk products with calcium-equivalent foods has been shown to be detrimental to the overall nutritional profile, including the intake of other essential nutrients such as protein, magnesium, phosphorus, and vitamins A, D, B₂ (riboflavin) and B₁₂. (Fulgoni *et al.*, 2011).

C. Association of vitamin D and calcium

Vitamin D, in addition to its effects on calcium homeostasis, binds to specific receptors on skeletal muscle for 1,25-dihydroxyvitamin D (Simpson *et al.*, 1985). An average person needs both calcium and vitamin D to ensure sufficient net absorption of calcium for meeting various body needs from commonly available food sources. An inescapable conclusion of these quantitative relations is that, both nutrients are of dietary importance in daily life (Heaney, 2008). The main effect of vitamin D is to facilitate the intestinal absorption of calcium by mediating active calcium transport across the intestinal mucosa. Vitamin D acts in the system by both genomic and non-

genomic mechanisms. These mechanisms involve synthesis of a calcium transport protein (calbindin), which shuttles calcium from the brush border across to the basolateral side of the mucosal cell. (Norman, 2006)

The vitamin D is a hormone that functions to increase serum calcium concentrations through 3 separate activities. Primarily, it is the only hormone known to induce the proteins involved in active intestinal calcium absorption. Furthermore, it stimulates active intestinal absorption of phosphate. Secondly blood calcium concentrations remain in the normal range even when on a no-calcium diet. Therefore, it must possess the ability to mobilize calcium in the absence of calcium coming from the environment, i.e., through enterocytes. Both mechanisms play a role in increasing blood calcium concentrations, especially in the absence of intestinal calcium absorption. Vitamin D hormone stimulates osteoblasts to produce Receptor Activator Nuclear Factor- κ B Ligand (RANKL). RANKL then stimulates osteoclast genesis and activates resting osteoclasts for bone resorption (Suda *et al.*, 2002). Garabedian *et al.*, (1974) states that, the vitamin D hormone plays an important role in allowing individuals to mobilize calcium from bone when it is absent from the diet. It is very important to note, however, that *in vivo* both vitamin D and parathyroid hormone are required for this mobilization event. Rodriguez-Martinez (2002) concludes that even though combination calcium and vitamin D supplementation is associated with higher bone mineral density and decreased incidence of hip fractures, the evidence for vitamin D supplementation alone is less clear. Recent evidence found that vitamin D supplementation at doses of more than 700 IU daily (plus calcium) prevented bone loss compared with placebo. However, vitamin D supplementation (300 to 400 IU daily) without calcium did not affect fractures.

Weaver, (2009) explained that cow's milk has good bioavailability of calcium (about 30 to 35%). It is estimated that without milk and milk products in the diet, less than half of the calcium requirements would be met. In fact, adolescents in Canada who have a Western type of diet are unlikely to meet their recommendations for calcium if they do not consume milk or milk products. Plant foods contain many vitamins and minerals that are important for a balanced diet and can be a source of calcium.

However, generally speaking, plant foods contain a considerable amount of inhibitory substances, such as oxalates and phytates. These bind to calcium and form insoluble salt complexes, thus decreasing calcium absorption. Cooked spinach contains 115 mg calcium per serving (125 mL or ½ cup), but only an estimated 5% (6 mg in absolute value) of it is actually absorbed. This is very little compared to the 32% (i.e. 101 mg) of milk's calcium absorbed. Therefore, one would have to consume about 8 cups of spinach to obtain the same amount of available calcium found in 1 cup of milk.

The calcium bioavailability of some fortified foods is comparable with that of milk, but these foods do not always provide the same total calcium content per serving. Studies on fortified beverages, including soy beverages and orange juice, have shown that the fortificant tends to settle to the bottom of the carton and that even vigorous shaking may not be enough to re-suspend the calcium salts (Rafferty *et al.*, 2007).

Autajay (2003) stated that there are many foods to choose from, that provide calcium. Milk and milk products—such as low-fat or fat-free cheese and yogurt—are excellent sources because they are high in calcium. Most types of milk have approximately 300 milligrams of calcium per 8 fluid ounces (1 cup), or about 25 percent of the calcium that twins and teens need every day. The better choices are low fat or fat-free milk and milk products. Because these items contain little or no fat, it's easy to get enough calcium without adding extra fat to the diet. Flavored milk has just as much calcium as plain milk, but is higher in sugar and calories than plain milk. Young generation may choose to drink chocolate or other flavored milk if they prefer the taste, but they should remember to factor in the additional calories into their overall daily needs. Whether plain or flavored, remember to choose low-fat or fat-free milk and milk products must be chosen. Individuals, who do not consume adequate amount of milk or dairy products, must take supplements.

D. Role of sunlight in the synthesis of vitamin D and calcium

Casual exposure to solar radiation of wavelengths 290–315 nm results in the cutaneous production of previtamin D3. Dress code, skin pigmentation and application of Sun Protection Factor (SPF) of 15 reduce the UVB penetration into epidermis by

>95%, thereby limiting the production of previtamin D3 by the skin (Harinarayanan *et al.*, 2013). Surprisingly on sunscreen use, even those with a high sun protection factor (SPF), did not significantly affect vitamin D status; however, self-reported use does not necessarily imply total skin coverage. There have been numerous studies looking at skin pigmentation as a predominant factor for reducing vitamin D synthesis (Hall, 2010).

Exposure of arms and legs to sunlight for an average of 10 minutes, depending on the time of day, season of year and latitude can provide around 3,000 International Units (IU) of vitamin D3. In comparison, an eight ounce glass of vitamin D fortified milk provides around 100 IU and a 3.5 ounce portion of wild salmon contains approximately 600-1,000 IU of vitamin D3 (Holick, 2007).

Most human depends on sun exposure to satisfy their requirement for Vitamin D3. When solar ultraviolet – B radiation (UV – B: 290-315 nm) penetrates the skin, cells absorb it, resulting in the ring opening of 7- dehydrocholesterol to form previtamin D3. Previtamin D3 is thermodynamically unstable and is rapidly converted to vitamin D3. Once formed ejected out of the plasma membrane into the extracellular space where finds its way into dermal capillary bed, and is bound to the vitamin D binding protein (Holick *et al.*, 2004). Regular exposure to sunlight is required during summer to build up sufficient stores to ensure adequate vitamin D status and also during winter and spring, even in younger persons. Uses of artificial sun-beds have the same predictive effect on serum 25(OH)D as vitamin supplementation, although sun-beds contribute marginally to endogenous production of vitamin D, they transmit small amounts of ultraviolet B radiation. In elder people, the development of vitamin D deficiency has often been attributed to the lack of sunlight, rather than to the effects of ageing (Brot *et al.*, 2001).

Anything that influences the number of UVB photons penetrating into the skin will affect the synthesis of Vitamin D3. (Holick *et al.*, 1994; 2004) The role of UVB photons for the synthesis of Vitamin D3 is the most important in human health. Ultraviolet exposure beyond the minimal erythemal dose does not increase vitamin D production further. The ultraviolet induced production of vitamin D precursors is counter balanced by degradation of vitamin D and its precursors. The concentration of previtamin D in the skin reaches equilibrium in white skin within 20 min of ultraviolet

exposure. Ultraviolet exposure pigmented skin take 3–6 times longer to reach the equilibrium concentration of dermal pre vitamin D, skin pigmentation does not affect the amount of vitamin D that can be obtained through sunshine exposure (Holick,1995). Ageing does lower the amount of 7-dehydrocholesterol in the skin and lowers substantially the capacity for vitamin D production (Need, 1993). Skin synthesis is limited by various determinants, including pigmentation, age, zenith angle of the sun, poor air quality and percentage of the skin surface area available for exposure. A recent study of sun-protective behaviour in USA showed that wearing long sleeves or staying in the shade reduced vitamin D status (Linouset *al.*, 2003).

III. METHODOLOGY

The methodology followed for the present study entitled “**Effect of sunlight on vitamin D status among college going girls**” is presented under the following heads:

- A. Selection of area and screening of sample
- B. Formulation of questionnaire
- C. Conduct of the supplementation study
 - i. Selection and grouping of participants
 - ii. Assessment of anthropometric measurements and biochemical parameters
- D. Statistical analysis and interpretation of data

A. Selection of area and screening of sample

The area selected for the study was Coimbatore. Coimbatore is a district in the state of Tamil Nadu (Manchester of South India, 2015). It is one of the most industrialized district and a major textile, industrial, commercial, educational, information technology, healthcare and manufacturing hub of Tamil Nadu (Indian Government Press Release, 2013).

The participants for the study are selected among the students of Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore. A sample design is a definite plan for obtaining a sample from a given population. It refers to the technique or procedure the researcher would adopt in selecting items for the sample (Kothari and Garg, 2014). The sampling method used for the current study is random sampling. Girls aged between 18 – 22 years doing under graduation are selected for the study. All the selected respondents are participants of the same Institute. The initial data on demographic profile, dietary and food consumption pattern, nutritional knowledge was collected from 150 participants, of which sub samples of 45 participants are selected for the further supplementation study.

B. Formulation of questionnaire

To collect information of the demographic data, dietary pattern and nutritional knowledge of 150 participants, a questionnaire was formulated. Primary data was collected through questionnaire.

A questionnaire is a form prepared and distributed to secure responses to certain questions. It is a systematic compilation of questions that are submitted to a sampling of population from which desired information is collected (Saravanvel, 1997). The questionnaire of the present study had 31 questions, with 25 multiple choice questions, 2 fill ups and 8 open ended question. The questionnaire consisted of questions with details on demographic data, dietary and food consumption pattern and nutritional knowledge of the study participants. Demographic analysis can cover whole societies or groups defined by criteria such as education, nationality, religion and ethnicity. In this survey, the demographic data included details on name, age, place, educational qualification, occupation and marital status. The dietary pattern of the participants was assessed through dietary and food consumption pattern. The dietary pattern included type of diet, type of meal pattern whether 2 meal, 3 meal, 4 meal and also details regarding skipping meals. The nutritional knowledge of the participants is to check about the participants' knowledge for better nutrition education.

The questionnaire consisted of both closed ended questions and open ended questions. The questions that can be answered by "yes" or "no" or a specific piece of information is closed ended questions. Open ended questions are usually referred as a statement which requires response.

Initially the nutrition knowledge of the participants was evaluated by giving a questionnaire prior to nutrition education. The evaluation of nutrition knowledge of the participants helps to give more appropriate nutrition education to the participants. The questionnaire used in the study is appended in Appendix I.

C. Conduct of supplementation study

The supplementation study was conducted as per the following steps:

i. Selection and grouping of participants

A total of 150 samples was selected for the study of which 45 sub – samples were selected for the conduct of the experimental study, they were further divided into 3 groups. All the participants were aged between 18 – 22 years. The participants were further divided into three groups namely Experimental I, Experimental II and Control group each group consisting of 15 participants. Grouping of participants was done to identify the effect of sunlight on vitamin D. There was no specific criterion for grouping of the participants as all the participants had low vitamin D status as per their biochemical assessment. Based on the willingness and co-operation of the participants and serum vitamin D values, the participants were grouped into 3 groups. The inclusion and exclusion criteria of the study are:

Inclusion criteria

- College going girls between the age of 18 – 25 years
- College going girls who are physically fit with no other illness/ complications
- Self-interested and willing participants with low vitamin D levels

Exclusion criteria

- College going girls less than 18 years and more than 25 years
- Girls who have any other complications
- Girls with normal vitamin D level
- Girls who are not interested to participate in the study

A total of 45 college going girls of age 18 – 25 years was selected, who are physically fit and willing to for the co-operate study. A written consent was obtained from all the participants of the study expressing their willingness for participation in the supplementation and to exposure to sunlight.

Experimental group I A total of 15 participants comprised of experimental group I. The participants were exposed to sunlight, calcium rich curd was given along with nutrition education. This was to evaluate the calcium and vitamin D status among the participants and also to find the absorption rate of calcium with the exposure of sunlight among the participants. Sunlight exposure helps to evaluate the effect of sunlight on vitamin D status in the body.

The sunlight exposure of the participants was during their lunch break between 12:45 pm to 1:30 pm. The duration of sunlight exposure was about 45 minutes and they were asked to expose to sunlight in the morning also. The participants were asked to wear light clothing for the entire period of the study. So the absorption of sunlight would be maximum. They were also asked not to use any cream or sunscreen lotions for the entire period of exposure to sunlight (Plate 1).

Autajay (2003) stated that there are many foods to choose from that provide calcium. Milk and milk products—such as low-fat or fat-free cheese and yogurt—are excellent sources because they are high in calcium. Most types of milk have approximately 300 milligrams of calcium per 8 fluid ounces (1 cup), or about 25% of the calcium that teens need every day. So curd, a rich source of calcium which had 149 mg of calcium per 100 g was chosen to be given daily for the participants. The RDA for calcium for women is about 600 mg/ day. Hence 200 g of curd provided about 50% of the daily requirements.

200 g of the curd contain about 298 mg of calcium which is higher than that of milk. That is 100 ml of milk contains about 120 mg of calcium and a same amount of curd contains 149 mg of calcium, the absorption rate of milk is about 30 – 45 % (www.dairynutrition.com). Thus curd was given for the participants as the calcium supplementation. 200 g of curd was supplemented to the participants for a time period of 50 days. The supplementation of curd was given a period of 50 days. Before the sunlight exposure the participants collected their curd cups (Plate 2).

Nutrition education was given to participants fortnightly that is once in 15 days for a period of 50 days to impart knowledge on the topic “Importance of calcium and vitamin

D and the effect of sunlight on vitamin D". It included information on vitamin D, calcium, importance of sunlight, which is the best source of vitamin D and correlation of vitamin D and calcium. The participants were asked to assemble in a class or open space where the presentation was done. The presentation was interactive and the participants actively participated in the sessions. The education was given as PowerPoint presentation which is one of the best methods of education as it also included pictures which was attractive. This helped the participants to gain knowledge and awareness on what the study is and the importance of vitamin D and calcium in the body. Once in every 15 days, nutrition education with power point presentation was given. The power point was exclusively on vitamin D, calcium and the effect of sunlight. Also daily messages on WhatsApp was sent to the group for a period of 50 days. WhatsApp group was created and a message was sent every day to the group. The messages were sent between 8-10 am. The messages included notes on vitamin D and calcium, images, video links of the same. The message on WhatsApp was to revamp the knowledge of the participants (Plate 3 and Appendix II).

Experimental group II comprised of 15 participants. The participants were given nutrition education and they were exposed to sunlight for a period of about 45 minutes. No curd was supplemented to this group of participants.

The nutrition education was given to the participants once in every 15 days and WhatsApp messages were sent daily to the participants. The nutrition education was related to the topic and it included vitamin D, calcium, association of vitamin D and calcium.

The third category was **control group** of 15 participants who received neither curd supplementation nor exposed to sunlight or nutrition education.

ii. Assessment of anthropometric measurements and biochemical parameters

Assessment of anthropometric measurements

Anthropometry refers to the human measurements. It is used to assess either growth or change in body composition of the individual. Anthropometric measurements are body measurements and provide information on body muscle mass and fat reserves (Srilakshmi, 2012).

Growth assessment includes measurements like height, weight and waist and hip circumference, head circumference, mid upper arm circumference and body mass index, while change in body composition measures fat mass and fat free mass.

In the present study growth measurements like

- Height
- Weight
- BMI
- Waist circumference
- Hip circumference
- Waist Hip Ratio
- Weight to Height Ratio was measured

It reflects both health and nutritional status and predicts performance, health and survival. Basic anthropometric measurements such as height, weight, BMI, waist hip ratio, waist circumference, hip circumference, waist to height ratio measurements were assessed using standard methods(Plate 4).

Height - Height was measured using a stadiometer. The study participants was made to stand erect on levelled surface, without shoes, looking straight with heels together and toes apart. An anthropometer rod was placed behind the participant in the centre of the heels perpendicular to the ground with the investigator standing on the left side of the participant. The moving head piece of the anthropometer was placed in the sagittal plane over the head of the participant applying a slight pressure to reduce the thickness

of the hair. The reading was taken when the anthropometric rod is still in position. An average of three successive measurements is taken as the final measurement. Height was measured in cm to the nearest millimeter (Bamji, 2004).

Weight - Body weight is a time honored and most widely used anthropometric measurement for the evaluation of nutritional status. It indices body mass and is a composite of all body constituents like water, minerals, fat, protein, bone, etc. (Bamji, 2004). Body weight of all study participants was measured using a weighing balance with accuracy of 0.1 kg. The weighing balance was placed on a firm and flat ground and zero-error was adjusted. The participant was made to stand on the platform of the balance without foot wear and with minimal clothing and weight was recorded by the investigator (NIN, 2011). Care was taken to keep the feet parallel, hands straight and head looking straight ahead and was measured.

BMI - Body Mass Index (BMI) is a simple index of weight-for-height and it is commonly used to classify underweight, overweight and obesity in adults. It is defined as the weight in kilograms divided by the square of the height in meters (kg/m^2) (WHO, 2012). BMI is a key index for relating weight to height. Abbreviated BMI is a person's weight in kilograms (kg) divided by his or her height in meters squared. The National Institutes of Health (NIH) defines normal weight, overweight, and obesity according to BMI rather than the traditional height/weight charts. Overweight is a BMI of 27.3 or more for women and 27.8 or more for men. Obesity is a BMI of 30 or more for either sex (about 30 pounds overweight).

From the measured heights and weights BMI was calculated using the standard formula.

$$\text{Body Mass Index} = \frac{\text{Weight (Kg)}}{\text{Height (m}^2\text{)}}$$

Waist circumference - Waist circumference may be a better indicator of obesity-related diseases than body mass index(BMI) (Cawley, 2006). Waist circumference is measured by first locating the upper hipbone and lowest rib, followed by placing the end of a non-stretchable fiber glass measuring tape between these two points and wrapping horizontally around the abdomen. Waist circumference is obtained by

measuring the distance around the smallest area below the rib cage and above the umbilicus with the use of non-stretchable tape. Waist circumference measures abdominal fat content.

A measurement of >40 inches (102cm) for men and 35 inches (88cm) for women are independent risk factors for diseases when out of proportion to total body fat (Center for Disease Control and Prevention, 2002).

Hip circumference - Hip circumference is measured around the widest part of the hip bones. The participant was made to stand erect in front of the investigator (who was comfortably seated on a chair) with feet together, the tape was positioned around the hips at the level of the symphysis pubis and the greatest gluteal protuberance (CSTF, 1986) and the circumference was measured using a non-stretchable fiber glass tape (to the millimetre). Hips are measured at the widest point of buttocks.

For women the reference values are:

- Below 0.8 is very low risk.
- 0.8 - 0.89 is moderate risk.
- 0.9 and above are high risk category

Waist Hip ratio - The Waist Hip Ratio (WHR) is the ratio of waist circumference to hip circumference. Waist to Hip Ratio assesses body fat distribution as an indicator of health risk. Obese persons with a greater proportion of fat in the upper body, especially in the abdomen have android obesity, obese persons with most of their fat in the hips and thighs have gynecoid obesity.

The ratio is the indicator of central obesity. Adult men with waist hip ratio of ≥ 0.95 and women with ≥ 0.80 are considered having central obesity (Bamji *et al*, 2009).

According to the standard defined by World Health Organization (WHO) in 1999 about metabolic syndrome, in which type 2 diabetes mellitus, glucose tolerance, and insulin resistance are required items, obesity is defined as WHR >0.9 in men and WHR >0.85 in women (World Health Organization, 2008).

Waist to Hip Ratio is calculated by the formula,

$$\text{Waist Hip Ratio} = \frac{\text{Waist Circumference}}{\text{Hip Circumference}}$$

Waist to Height Ratio - A person's Waist-To-Height Ratio (WHtR), also called Waist-To-Stature Ratio (WSR), is defined as their waist circumference divided by their height, both measured in the same units. The WHtR is a measure of the distribution of body fat. Higher values of WHtR indicate higher risk of obesity-related cardiovascular diseases; it is correlated with abdominal obesity (Lee *et.al*, 2008). Waist to height ratio is calculated by dividing waist size by height. If the waist measurement is less than half the height, the person is likely not at risk for obesity-related disease.

24 hour diet recall method

A diet history is the best means of obtaining dietary intake information and refers to a review of an individual's usual patterns of food intake and the food selection variables that dictate the food intake (Mahan and Stump SE, 2016). A 24 hour recall is a dietary assessment tool that consists of a structured interview in which the participants are asked to recall all the foods and drinks they have consumed in the previous 24 hours. It can be self – administered (Medanth, 2017). The participants are asked to fill the questionnaire and the diet and nutritional status of participants was evaluated. Three day 24 hour recall of the study participants was noted and evaluated. This helps to identify the food consumed by of the participants and their usual food intake pattern.

From the food intake, the mean nutrient intake of the selected participants was calculated using the ICMR food composition tables and compared with the RDA suggested by ICMR (2016).

Assessment of Biochemical parameters

A blood test is a laboratory analysis performed on a blood sample that is usually extracted from a vein in the arm using a hypodermic needle, or via finger prick. Blood tests are often used in health care to determine physiological and biochemical states, such as disease, mineral content, pharmaceutical, drug effectiveness and organ function. The blood samples are collected from the participants and are biochemically estimated. The biochemical estimations included in the study are blood hemoglobin level, vitamin D and calcium. For women the normal range of hemoglobin is 12.0 to 15.5 g/dl (<https://www.mayoclinic.org/testsprocedures/haemoglobin-test/about/pac-20385075>).

Vitamin D - The normal range of vitamin D is 30-100 ng/ml. Vitamin D total test is analyzed on Siemens ADVIA Centaur, standardized against ID-LC/MS/MS, as per vitamin D. Standardization Program (VDSP) is by Fully Automated Chemi Luminescent Immuno Assay.

The Diasorin (formerly Incstar) 25-OH-D assay consists of a two-step procedure. The first procedure involves a rapid extraction of 25-OH-D and other hydroxylated metabolites from serum or plasma with acetonitrile. Following extraction, the treated sample is assayed by using an equilibrium RIA procedure. The RIA method is based on an antibody with specificity to 25-OH-D. The sample, antibody, and tracer are incubated for 90 min at 20-25 °C. Phase separation is accomplished after a 20-minute incubation at 20-25 °C with a second antibody-precipitating complex. An NSB/Addition buffer is added after this incubation prior to centrifugation to aid in reducing non-specific binding (Gunter 1996).

Calcium - Calcium-Arsenazo III method was used for calcium estimation. The DxC800 system uses indirect (or diluted) I.S.E. (ion selective electrode) methodology to measure calcium concentration in serum, plasma, or urine.

At a neutral pH, the Ca²⁺ forms with arsenazo III a complex, the color intensity of which is directly proportional to the concentration of calcium in the sample. Reference values Serum is 2.2-2.55 mmol/l (8,80-10,2 mg/dl) . A calcium ion selective electrode

measures un-bound free calcium ions in solution. The system determines calcium concentration by measuring calcium ion activity in solution. When the sample buffer mixture contacts the electrode, calcium ions complex with the ionophore at the electrode surface. Changes in potential develop at the electrode surface as the reaction occurs. These changes in potential are referenced to a sodium reference electrode. The reference signal is used in calculating the analyte concentrations based on the Nernst equation (Dong *et al.*, 1994)

Hemoglobin - Fully automated bidirectional analyzer (6 Part Differential SYSMEX XN-1000) was used. (This device performs hematology analyses according to the Hydrodynamic Focussing (DC method), Flow Cytometry is a method using a semiconductor laser and SLS- hemoglobin method. Hemoglobin is a routine diagnostic parameter in each blood count. The method recommended by the ICSH (International Committee for Standardization in Hematology) for measuring hemoglobin concentration is the cyan-methaemoglobin method. SLS hemoglobin detection method uses cyanide-free sodium lauryl sulphate (SLS). The reagent lyses red blood cells and white blood cells in the sample. The chemical reaction begins by altering the globin and then oxidising the heme group. Now the SLS' hydrophilic groups can bind to the heme group and form a stable, coloured complex (SLS-HGB), which is analyzed using a photometric method. (<https://www.sysmex-europe.com/academy/knowledge-centre/measurement-technologies/sls-detection-method.html>).

A well trained biochemical technician from a reputed lab took the blood samples of 45 participants in total. The participants were asked to come in the morning on empty stomach. The biochemical assay of vitamin D, calcium and hemoglobin was taken twice before supplementation and after supplementation so that the pre and post supplementation effect can be evaluated. Three milliliter of blood was collected from participants for the estimation (Plate 5).

E. Statistical analysis and interpretation of data

The data obtained in the present study was tabulated and statistically analyzed for correlation and test of significance. The application form explaining the design and the protocol used in the research study was submitted to the Institutional Human Ethical Committee of Avinashilingam Institute for Home Science and Higher Education for Women and Ethical Clearance was obtained. The approval number is AUW/IHEC/17-18/FSN/XPD/22 (Appendix III).



Plate 1
Exposing to sunlight



Curd supplementation Consumption of curd

Plate 2
Curd supplementation



Plate 3

Nutrition education



Height measurement



Weight measurement



Waist circumference measurement



Hip circumference measurement

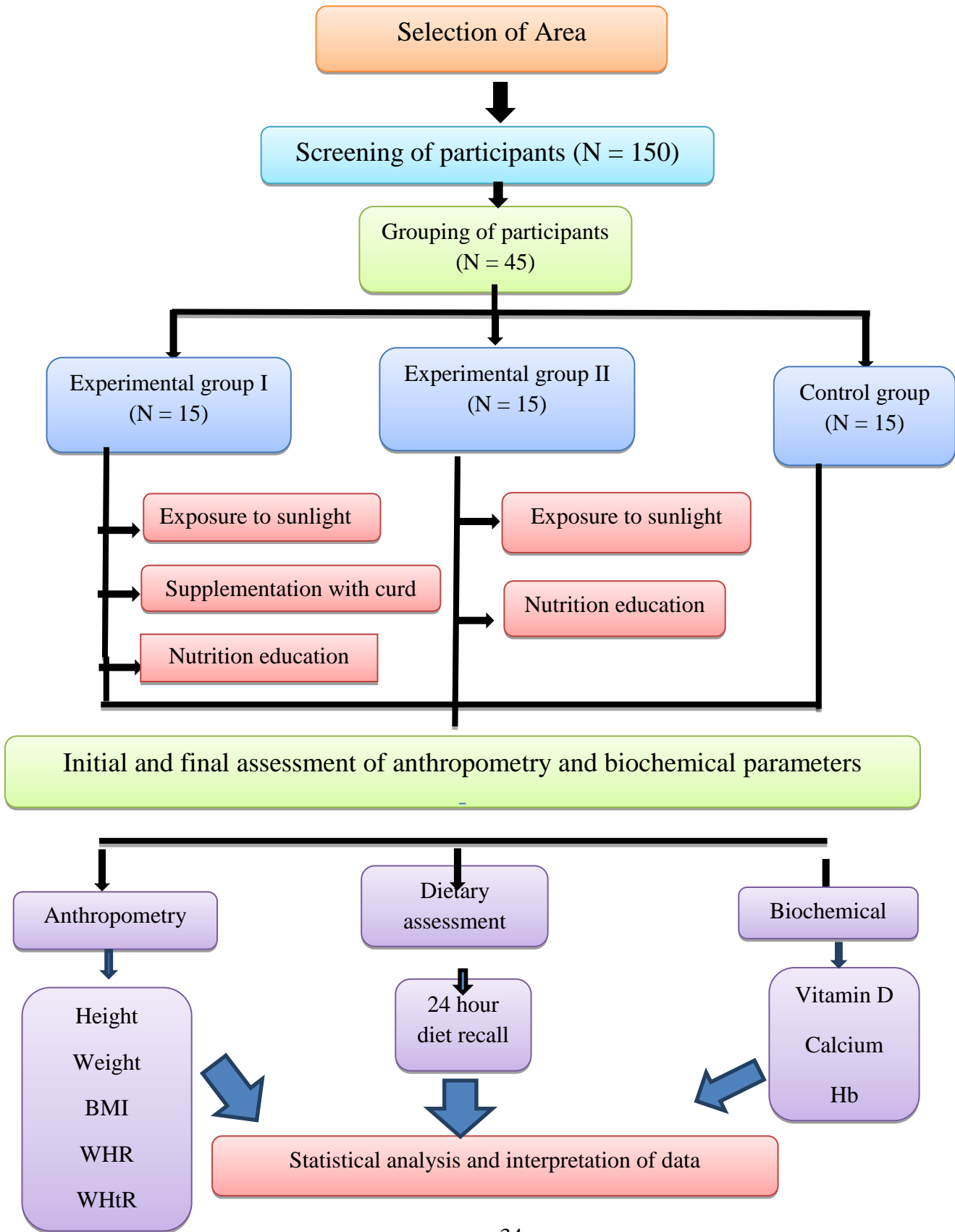
Plate 4

Anthropometric measurements



Plate 5

Biochemical test



FIGURE

Figure 1 - Research Design

IV. RESULTS AND DISCUSSION

The results of the study entitled, “**Effect of sunlight on vitamin D status among college going girls**” is presented and discussed under the following headings:

- A. Background information of the participants
- B. Impact of supplementation of sunlight on vitamin D status
 - i. Mean nutrient intake
 - ii. Anthropometric measurements and biochemical assessment

A. Background information of the participants

Table I reveals the details pertaining to the socio-economic background of the participants.

TABLE I
SOCIO-ECONOMIC BACKGROUND OF THE PARTICIPANTS
N = 150

Characteristics	Number	Percentage
Age (years)		
18- 20	145	96.6
21- 22	5	3.4
Total	150	100
Religion		
Hindu	126	84.0
Muslim	15	10.0
Christian	9	6.0
Total	150	100
Residence		
Home	80	53.4
Hostel	60	40.0
Others	10	6.6
Total	150	100

Among 150 participants, 96.6 per cent belonged to the age group between 18 – 20 years, 3.4 per cent belonged to the age group between 21 - 22 years. All the participants of the study were college going girls doing under graduation in Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore. Of the 150 participants, 84 per cent of the participants were Hindus, 10 per cent were Muslims and 6 per cent were Christians. 53.4 per cent were day scholars *ie.* they came from home, 40 per cent were residing in hostel and the rest 6.6 per cent were staying as paying guests.

Dietary and food consumption pattern

Table II reveals the dietary and food consumption pattern of the participants.

TABLE II
TYPE OF DIET

N = 150

Type of food	Number	Percentage
Vegetarian	14	9.3
Non Vegetarian	114	76
Ovo Vegetarian	22	14.7
Total	150	100
Eating episode per day	Number	Percentage
2	15	1
3	110	73.4
4	25	16.6
Total	150	100

It is evident from the Table II that 76 per cent of the respondents were non-vegetarians. Pure vegetarians accounted for 9.3 per cent. Ova vegetarians – a group which consumed egg only in addition to vegetarian diet constituted 14.7 per cent. Out of 150 participants, majority (73.4%) followed 3 eating episode and 16.6 per cent followed a four eating episode. Eating episodes or routine has been shaped by the environment and cultural context (Gallimore and Lopez, 2002).

Habit of skipping meals

Details regarding skipping of meals are presented in Table III.

TABLE III
SKIPPING MEALS

N = 150

	Number	Percentage
Skipping meals		
Yes	110	73.3
No	40	26.7
Total	150	100
Skipped meal		
Breakfast	70	63.6
Lunch	10	9.1
Dinner	30	27.3
Total	110	100
Frequency of skipping meal		
Regularly	20	18.2
Once a week	23	20.9
Occasionally	67	60.9
Total	110	100

It is evident from the table that out of the 150 participants about 73.3 per cent skipped their meals and the remaining participants were maintaining regular meals. Of the 110 participants who skipped their meals, 63.6 per cent skipped their breakfast, 9.1 per cent skipped their lunch and 27.3 per cent skipped their dinner. 18.2 per cent had a regular routine of skipping their meals, 20.9 per cent of participants skipped their meals once in a week and 60.9 per cent of the participants skipped their meals occasionally.

Habit of eating outside

Table IV reveals details regarding participant's habit of eating outside.

TABLE IV
HABIT OF EATING OUTSIDE

N = 150

Characteristics	Number	Percentage
Eating outside		
Yes	120	80
No	30	20
Total	150	100
Place		
Restaurants	33	28.3
Cafeteria	44	36.7
Fast food shops	30	25
Street Vendors	13	11
Total	120	100

About three fourth i.e. 80% of the participants had the habit of eating outside food. Among them 28.3 per cent preferred eating out in restaurants. Majority of the respondents (36.7 per cent) prefer to eat in cafeteria and 25 per cent of the respondents had a habit of eating in fast food shops. Only 11 per cent of the respondents ate from street vendors.

Nutritional knowledge

Nutritional knowledge of the respondents was determined using a questionnaire and the responses were noted. Table V reveals the knowledge of the participants on calcium as a food supplement and the best sources of calcium.

TABLE V
CALCIUM AS A FOOD SUPPLEMENT

N = 150

Characteristics	Number*
Calcium as food supplement	
Yes	150
No	-
Total	150
Best source of calcium	
Milk and milk products	80
Green leafy vegetable	60
Paneer	10
Cheese	15
Ragi	15

***Multiple responses**

All the respondents(100 per cent) answered that they are aware about the importance of calcium as a food supplement. Among the participants majority of them said that milk, milk products and green leafy vegetables are the best source of calcium.

Details regarding awareness of vitamin D and its food source are presented in Table VI.

TABLE VI
AWARENESS OF VITAMIN D AND ITS SOURCE
N = 150

Characteristics	Number*	Percentage
Aware of vitamin D		
Yes	140	93.3
No	10	6.7
Total	150	100
Source of vitamin D		
Egg yolk	90	-
Organ meat	40	-
Fish	60	-
Soya	10	-

***Multiple responses**

Among the participants it was observed that 93.3 per cent of the participants were aware about the importance of vitamin D and 6.7 per cent had little knowledge on vitamin D and organ meats. They also mentioned fish, soya are good sources of vitamin D. The participants responded that the best sources of vitamin D are egg yolk.

Frequency of drinking milk and the quantity of milk consumed

Table VII reveals the frequency of drinking milk and the quantity of milk consumed.

TABLE VII
FREQUENCY OF DRINKING MILK
N = 150

Characteristics	Number	Percentage
Daily	70	46.6
Weekly	37	24.6
Monthly	43	28.6
Never	-	-
Total	150	100
Quantity		
100 – 200	82	54.6
200 – 300	41	27.4
300 – 400	27	18
Total	150	100

Majority of the participants (46 per cent) had the habit of drinking milk daily. About 28.6 per cent drink milk rarely any day of the month and 24.6 per cent drink milk weekly. It is evident from the table that out of 150 participants, about 54.6 per cent drink about 100 – 200 ml of milk. 27.4 per cent participants drink about 200-300 ml of milk and the rest of participants drink 300 – 400 ml of milk per day.

Duration of sunlight exposure

Details regarding the duration of sunlight exposure is presented in VIII.

TABLE VIII
DURATION OF SUNLIGHT EXPOSURE

N = 150

Duration	Number	Percentage
Less than 10 min	32	21.33
For 15 min	61	40.66
For 20 min	27	18.00
For 30 min	20	13.33
For 40 min	7	4.66
More than 40 min	3	2
Total	150	100

Of the 150 samples, most of the participants (40.66 per cent) exposed themselves to sunlight for about 15 minutes. 21.33 per cent of the participants get exposed to sunlight for less than 15 minutes. About 18 per cent of the participants get exposed for 20 minutes and 13.3 per cent get about 30 minute exposure. 4.66 per cent participants get sun exposure for about 40 minutes. Only 2 per cent get sun exposure for more than 40 minutes. This sunlight exposure is while they go to from home and back, or during the lunch time or during games period.

Awareness on osteoporosis

Table IX reveals the knowledge of the participants on osteoporosis

TABLE IX
KNOWLEDGE ON OSTEOPOROSIS
N = 150

Characteristics	Number	Percentage
Yes	110	73.3
No	40	26.7
Total	150	100

Majority of the participants (73.3 per cent) had knowledge on osteoporosis and the rest of the participants (26.7 per cent) had little or no knowledge on osteoporosis.

Prescription of calcium and vitamin D supplement by a physician

Table X reveals the details on prescription of calcium and vitamin D supplement by physician for the participants.

TABLE X
PRESCRIPTION OF CALCIUM AND VITAMIN D SUPPLEMENT BY A PHYSICIAN
N = 150

Characteristics	Number	Percentage
Calcium supplement		
Yes	-	-
No	150	100
Total	150	100
Vitamin D supplement		
Yes	7	4.7
No	143	94.3
Total	150	100

Of the 150 participants none of them have got prescription of calcium supplement by physician. In case of vitamin D about 94.3 per cent of the participants have not got any vitamin D prescription and the rest 4.7 per cent have got prescription of vitamin D supplementation by a physician because they had a very low serum vitamin D and some students who had menstrual problems also had been given vitamin D supplements.

Source of information about vitamin D and Calcium

Table XI shows the sources which helped to know about vitamin D and calcium.

TABLE XI
SOURCE OF INFORMATION ABOUT VITAMIN D AND CALCIUM
N = 150

Characteristics	Number*
Relatives	50
Teacher	60
Physician	5
Books	80
Interest	10
Others	9

***Multiple responses**

The participants were asked about the source of their knowledge and information about calcium and vitamin D. Eighty per cent of the participants had information on calcium and vitamin D through books followed by teachers' (60), relatives (50) and their personal interest (10)

B. Impact of supplementation of sunlight on vitamin D status

i. Mean nutrient intake

Details pertaining to the mean nutrient intake of the adolescent girls are shown in Table XII and Figures 2 and 3.

TABLE XII
MEAN NUTRIENT INTAKE OF THE PARTICIPANTS OF THE
SUPPLEMENTATION STUDY

N = 45

Nutrients	ICMR RDA (2010)	Experimental group I (N = 15)		Experimental group II (N = 15)		Control group (N = 15)	
		Actual intake	% deficit or excess	Actual intake	% deficit or excess	Actual intake	% deficit or excess
Energy (kcal)	1900	2163.16	+13.84	2206.11	+16.10	2064.59	+8.66
Carbohydrate (g)	230	257.38	+12.1	258.08	+12.1	233.74	+1.6
Protein (g)	55	59.41	+8.01	58.45	+6.27	58.64	+6.61
Fat (g)	20	36.65	+83.25	37.68	+88.4	37.08	+85.4
Calcium (mg)	600	590.15	- 1.64	533.66	-9.39	564.37	-5.9
Iron (mg)	21	13.65	-35	13.07	-37.76	13.31	-36.61
Fiber (g)	30	11.82	-60.6	16.27	-45.7	13.58	-54.73

Table XII gives the mean nutrient intake of the participants of the supplementation study namely experimental group I, experimental group II and control group.

Energy- The mean energy value of the experimental group I was 2163 kcal and the recommended dietary guide line is 1900 kcal and that was 263 kcal in excess. For experimental group II the mean energy value was 2206.16 kcal and there was an excess of 306.11 kcal than the recommended value. The mean energy value of control group 2064.59 kcal and there was an excess of 164.59 kcal than the recommended value.

Carbohydrate - The actual intake of carbohydrate was 257.38g and it was 27.38g excess than the normal value, the normal value was 230g. For the experimental group II the actual carbohydrate intake was 258.08g and there was an excess intake of 28.08g than the normal value. For control group the actual mean intake was 233.74 g and there was an excess intake of carbohydrate 3.74 g.

Protein - The protein intake of the experimental group I was 59.41g which is 4.41 g excess than the normal value, 55g. For the experimental group II the actual protein intake was 58.45g and there was an excess intake of 3.45g than the normal value. For control group the actual mean intake was 58.64 g and there was an excess intake of protein 3.64 g.

Fat - The mean fat intake of the experimental group I was 36.65g and the normal value is 20 and the difference is 16.65g, which is excess than the recommended intake. For the experimental group II the actual intake was 37.68g and there was an excess intake of 17.68g than the normal value. For control group the actual mean intake was 37.08g and there was an excess intake of fat 17.08g.

Calcium – The mean calcium intake of the experimental group I was 590.15 mg and the normal value is 600mg and the difference is 9.85 mg, which is deficit than the recommended intake. For the experimental group II the actual intake was 533.66 mg and there was a deficit intake of 66.34 mg than the normal value. For control group the actual mean intake was 564.37 mg and there was a deficit intake of calcium 35.63 mg.

Iron - The mean iron intake of the experimental group I was 13.65 mg and the normal value is 21 mg and the difference is 7.35 mg, which is deficit than the recommended intake. For the experimental group II the actual intake was 13.07 mg and there was a deficit intake of 7.93 mg than the normal value. For control group the actual mean intake was 13.31 mg and there was a deficit intake of iron 7.69 mg.

Fiber - The mean fiber intake of the experimental group I was 11.82 g and the normal value is 30 g and the difference is 18.18 mg, which is deficit than the recommended intake. For the experimental group II the actual intake was 16.27 g and there was a deficit intake of 13.73 mg than the normal value. For control group the actual mean intake was 13.58 g and there was a deficit intake of fiber 16.42 g (Figure 2 and 3).

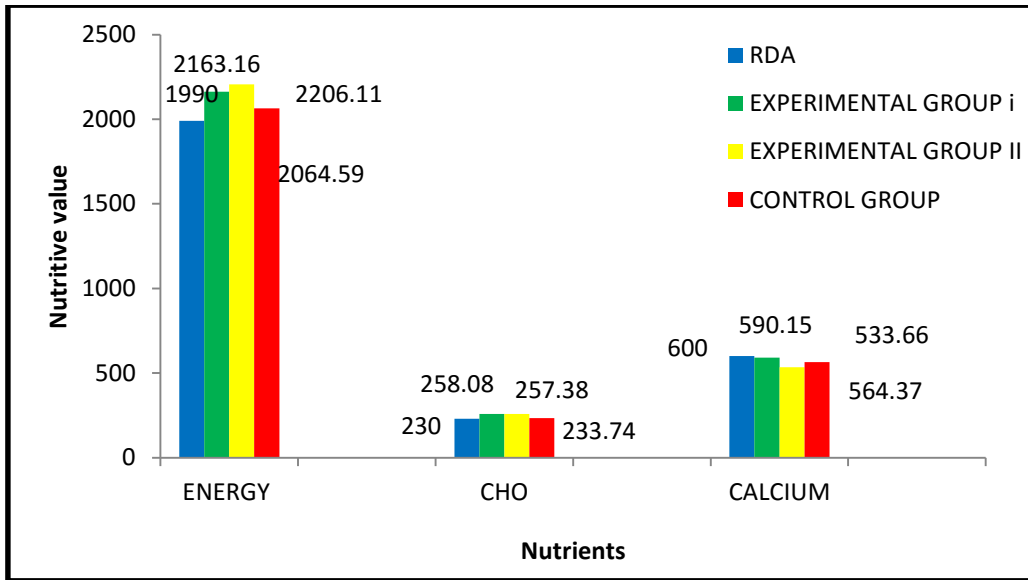


Figure 2

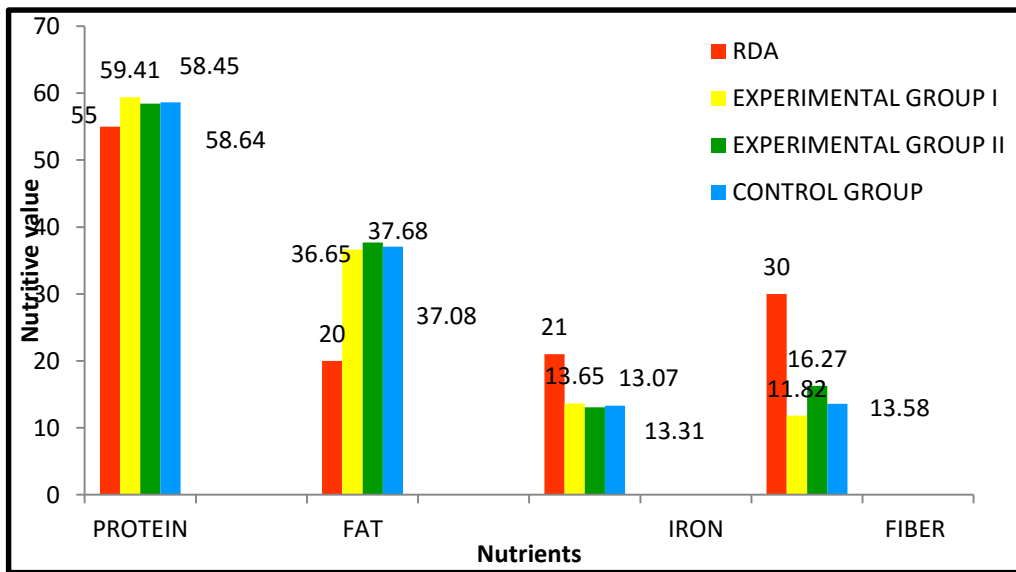


Figure 3

Mean nutrient intake of the participants

ii. Anthropometric measurements

Table XII revealed the anthropometric measurements of the participants of experimental group I, experimental group II and control group.

**TABLE XIII
ANTHROPOMETRIC MEASUREMENTS**

N = 45

Parameters	Standard Values	Experimental group I (N = 15)		Experimental group II (N = 15)		Control group (N = 15)	
		Mean ± SD	Mean diff	Mean ± SD	Mean diff	Mean ± SD	Mean diff
Height (cm)	152	159.21 ± 4.42	+7.21	158.88 ± 5.23	+6.88	157.45 ± 4.47	+5.45
Weight (kg)	52	52.06 ± 11.14	+0.04	54.93 ± 10.83	+2.83	56.30 ± 10.16	+4.2
BMI	22.90	20.47 ± 4.02	-2.43	21.69 ± 3.70	-1.21	22.74 ± 4.06	-0.16
WHR	0.8	0.79 ± 0.057	-0.01	0.79 ± 0.04	- 0.01	0.84 ± 0.15	+0.04
WHtR	0.5	0.45 ± 0.06	-0.05	0.47 ± 0.043	- 0.03	0.48 ± 0.07	-0.02

*(WHO 2010)

Experimental group I - The mean height of the participants of the experimental group I who were exposed to sunlight, given curd supplementation and nutrition education was 159.21 cm and the standard height is 152 cm and its difference was 7.2 cm. The mean weight of the participants was 52.06 kg and the standard weight was 52.10 kg and its difference was 0.04 kg. The BMI of the adolescent girls was 20.47 and the standard BMI was 22.90 and the difference was 2.43. Likewise the waist hip ratio of the participants was 0.79 and the standard value is 0.8 and its difference was 0.01. The waist to height ratio was also measured and the mean waist to height ratio of participants was 0.45 and the standard waist to height ratio 0.5.

Experimental group II - The mean height of experimental group II who were exposed to sunlight and given nutrition education was 158.88 cm and the standard height is 152 cm and its difference was 6.88 cm. The mean weight of the participants was 54.93 kg and the standard weight was 52.10 kg and its difference was 2.83 kg. The BMI of the adolescent girls was 20.47 and the standard BMI was 21.69 and the difference was 1.21. Likewise the waist hip ratio of the participants was 0.79 and the standard value is 0.8 and its difference was 0.01. The waist to height ratio was also determined and the mean waist to height ratio of participants was 0.47 and the standard waist to height ratio 0.5 and the difference was 0.03.

Control group - The mean height of the control group was 157.45 cm and the standard height is 152 cm and its difference was 5.45 cm. The mean weight of the participants was 56.03 kg and the standard weight was 52.10 kg and its difference was 4.2 kg. The BMI of the adolescent girls was 22.74 and the standard BMI was 22.90 and the difference was 0.16. Likewise the waist hip ratio of the participants was 0.84 and the standard value is 0.8 and its difference was 0.04. The waist to height ratio was also checked and the mean waist to height ratio of participants was 0.48 and the standard waist to height ratio is 0.5 and the mean difference was 0.02.

Biochemical assessment

Changes in hemoglobin levels before and after supplementation

Table XIV indicates the biochemical assessment vitamin D of the participants before and after supplementation.

TABLE XIV
CHANGES IN HEMOGLOBIN LEVELS BEFORE AND AFTER SUPPLEMENTATION

N = 45

Groups	Hemoglobin (g/dl)		Mean Difference	't' value
	Before	After		
Experimental Group I (N = 15)	12.2 ± 1.32	12.36 ± 1.14	+ 0.16	1.253 ^{NS}
Experimental Group II (N = 15)	12.31 ± 1.30	12.40 ± 1.14	+ 0.09	0.348 ^{NS}
Control Group (N = 15)	12.48 ± 1.64	12.46 ± 1.43	- 0.02	0.222 ^{NS}

^{NS} – Not Significant

The mean initial hemoglobin value of the participants of experimental group I was 12.2 g/dl and the mean final value was 12.36 g/dl there was slight increase with a mean difference of 0.16. For the experimental group II the mean initial value was 12.31g/dl and the mean final value 12.40 g/dl with a mean difference of 0.09. The initial mean hemoglobin of control group was 12.48 g/dl and the final mean value was 12.46 g/dl. There was a difference of 0.02 before and after supplementation. There was no significance in the initial and final value of hemoglobin test of the participants before and after supplementation.

Changes in serum vitamin D levels before and after supplementation

Table XV and Figure 4 indicate the changes in serum vitamin D before and after supplementation.

TABLE XV
CHANGES IN SERUM VITAMIN D BEFORE AND AFTER SUPPLEMENTATION

N = 45

Groups	Vitamin D (ng/ml)		Mean Difference	't' value
	Before	After		
Experimental Group I (N = 15)	9.81 ±2.68	13.03 ±1.09	+ 3.22	4.461**
Experimental Group II (N = 15)	9.95 ±1.53	10.98 ±1.82	+ 1.03	2.497*
Control Group (N = 15)	16.57 ±8.28	15.00 ±9.19	- 1.57	3.783**

** - Significant at 1% level; * - significant at 5% level; ^{NS} – Not significant

The mean initial vitamin D status of the participants of the experimental group I who were exposed to sunlight, given curd supplementation and nutrition education was 9.81ng/ml and the mean final value was 13.03 ng/ml having a mean increase of 3.22 ng/ml. For the experimental group II who were exposed to sunlight and given nutrition education the mean initial value of vitamin D was 9.95 ng/ml and the mean final value was 10.98 ng/ml. There was a mean increase of 1.03 ng/ml after the supplementation period. The mean initial value of vitamin D of control group was 16.57 ng/ml and the final mean value was 15.00 ng/ml. There was a mean difference of 1.57 ng/ml in the control group before and after the supplementation period.

For experiment group I, it was observed that the mean initial and final values for vitamin D showed a statistical significant difference at 1% level with a 't' value of 4.461.

For experimental group II, the vitamin D had a significant difference at 5% level with a 't' value of 2.497 before and after a supplementation period of 50 days. The 't' value of the control group showed a significant difference at 1% level with the value 3.783** on the negative side. The mean increase in experimental group I may be because the participants were exposed to sunlight with curd supplementation along with nutrition education.

Changes inserum calcium levels before and after supplementation

Table XVI and Figure 5 indicate the changes inserum calcium levels before and after supplementation.

TABLE XVI
CHANGES IN SERUM CALCIUM BEFORE AND AFTER SUPPLEMENTATION

N = 45

Groups	Calcium (mg/dl)		Mean Diff	't' value
	Before	After		
Experimental Group I (N = 15)	9.33±0.30	9.67 ±0.43	+ 0.34	4.432**
Experimental Group II (N = 15)	9.36 ±0.29	9.56±0.41	+ 0.20	2.732*
Control Group (N = 15)	9.44 ±0.26	9.39±0.28	- 0.05	1.524 ^{NS}

** - Significant at 1% level; * - significant at 5% level; ^{NS} – Not significant

The mean initial calcium level of the participants of the experimental group, i.e. before supplementation who were exposed to sunlight, given curd supplementation and nutrition education was 9.33 mg/dl and the final value is 9.67 mg/dl with a mean difference of 0.34 mg/dl. The experimental group II who were exposed to sunlight and given nutrition education was 9.36 mg/dl and the final mean value is 9.56 mg/dl. The mean decrease of 0.20 mg/dl was seen before and after supplementation. The initial mean calcium of control group was 9.44 mg/dl and the final mean value was 9.39 mg/dl.

The mean difference of 0.05 mg/dl was noted before and after supplementation in the control group.

For experiment group I, it was observed that the mean initial and final values for calcium showed a statistical significant difference at 1% level with a 't' value of 4.432. For experimental group II, the calcium had a significant difference at 5% level with a 't' value of 2.732 before and after a supplementation period of 50 days. The 't' value of the control group showed no significance with the value of 1.524.

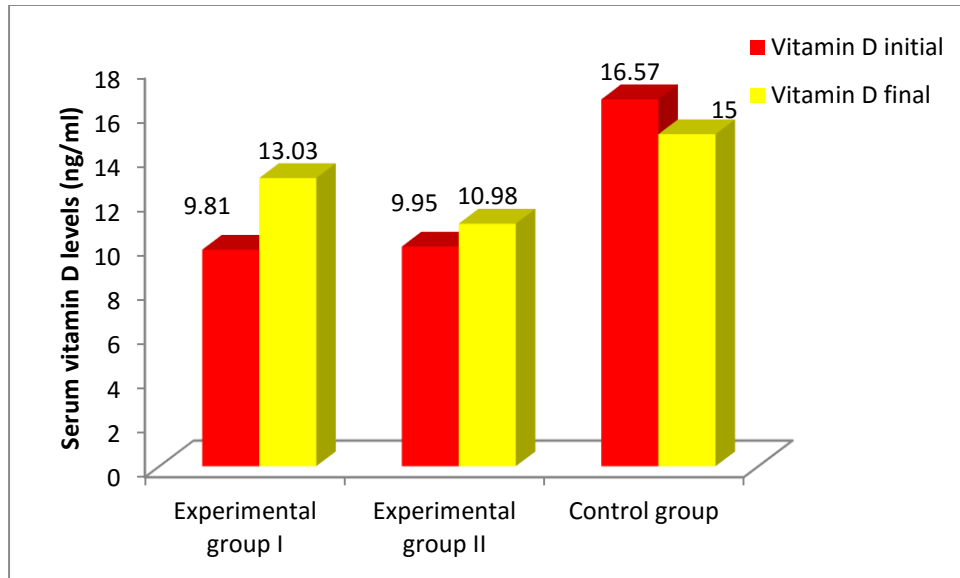


Figure 4
Changes in vitamin D before and after supplementation

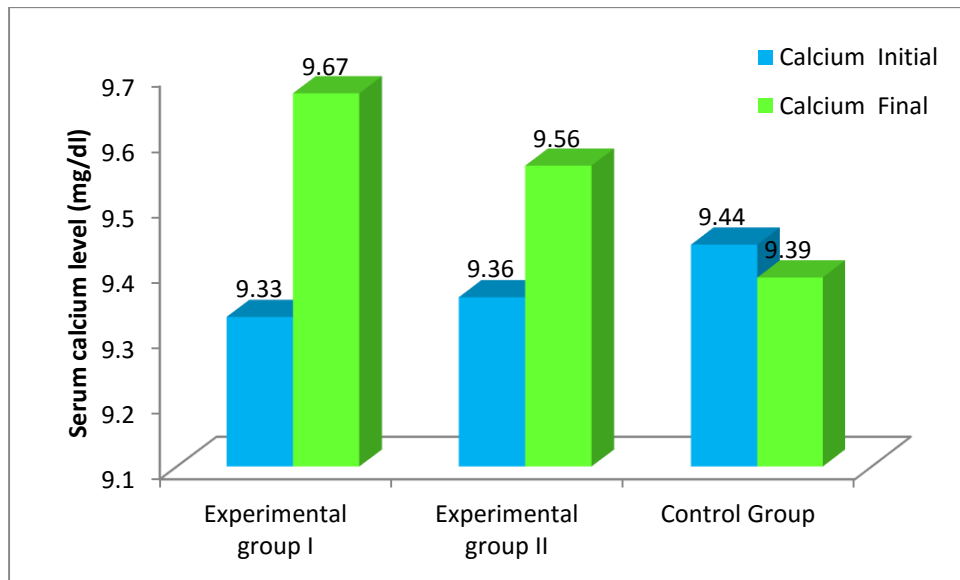


Figure 5
Changes in calcium levels before and after supplementation

Relation between vitamin D and sunlight

Table XVII reveals the details on the relation between sunlight with vitamin D and calcium absorption of experimental group I, experimental group II and control group.

TABLE XVII
RELATION BETWEEN VITAMIN D AND SUNLIGHT

Groups	Correlation value
Experimental group I and sunlight	0.035
Experimental group II and sunlight	-0.045
Control group and sunlight	0.072

The correlation between vitamin D and sunlight was estimated statistically for experimental group I, experimental group II and control group. For experimental group I who were exposed to sunlight, supplemented with curd and nutrition education showed a positive correlation with a value of 0.035. For experimental group II there was a negative correlation with a value of 0.045. The control group showed a strongly negative correlation with a value 0.072. The positive correlation of vitamin D and calcium for experimental group I may be due to the sunlight exposure, curd supplementation and nutrition education. For experimental group II, the negative correlation may be due to the reason that they were exposed to sunlight only and there was no curd supplementation. The strong negative correlation may be attributed that they were neither exposed to sunlight nor given curd supplementation and nutrition education.

V.SUMMARY AND CONCLUSION

Vitamin D is a fat-soluble vitamin essential for metabolism, bone mineralization and immune function. This vitamin is provided through dietary intake as well as synthesized through the skin exposing to the ultraviolet rays from sunlight. The major circulating form of vitamin D in blood is 25(OH)D, the level of serum 25(OH)D is currently accepted as the best biochemical indicator to evaluate vitamin D status. The two major physiologically relevant forms of vitamin D are D₂ (ergocalciferol) and D₃ (cholecalciferol). Vitamin D₂ can be obtained from UV irradiation of ergosterol and it is a plant source. The ultra violet light from the sun strikes the skin and humans synthesize vitamin D₃ and it is the most “natural” form. Human beings do not make vitamin D₂ and most oil-rich fish such as salmon, mackerel, and herring contain vitamin D₃. Vitamin D that is ingested is incorporated into chylomicrons, which are absorbed into the lymphatic system and enter the venous blood. Vitamin D that comes from the skin or diet is biologically inert and its first hydroxylation takes place in the liver by the vitamin D-25-hydroxylase (25-OHase) to 25(OH)D. Absorption of calcium takes place mainly in the proximal part of the small intestine, highest in the duodenum, jejunum and ileum absorbing in the descending order. Various dietary factors influence calcium absorption, in addition to the physico-chemical factors such as the concentration of calcium in the gut and the intestinal pH.

The present study entitled “**Effect of sunlight on vitamin D status among college going girls**” was aimed at evaluating effect of sunlight in vitamin D status among college going girls by assessing serum vitamin D and calcium of the same. Hence the objectives of the study are to assess the vitamin D and calcium status of college girls, educate the students on the importance of vitamin D and calcium, give calcium rich food and expose the participants to sunlight, evaluate the effect of sunlight on vitamin D and calcium status among the study participants. The methodology of the study included selection of girls aged between 18 – 22 years doing under graduation at Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore. The initial data on demographic profile, dietary and food consumption pattern, nutritional knowledge was collected from 150 participants, of which sub

samples of 45 participants are selected for further supplementation study using a questionnaire. Among this, a total of 45 college going girls of age 18 – 25 years was selected, who are physically fit and willing to for the co-operate study. **Experimental group I** comprised of 15 participants. The participants were exposed to sunlight, calcium rich curd was given along with nutrition education. This was to evaluate the calcium and vitamin D status among the participants and also to find the absorption rate of calcium with the exposure of sunlight among the participants. Sunlight exposure helps to evaluate the effect of sunlight on vitamin D status in the body. The sunlight exposure of the participants was during their lunch break between 12:45 pm to 1:30 pm. The duration of sunlight exposure was about 45 minutes and they were asked to expose to sunlight in the morning also. The participants were asked to wear light clothing for the entire period of the study. So the absorption of sunlight would be maximum. They were also asked not to use any cream or sunscreen lotions for the entire period of exposure to sunlight. 200 g of curd was supplemented to the participants for a time period of 50 days. Nutrition education was given to participants fortnightly that is once in 15 days for a period of 50 days to impart knowledge on the topic “Importance of calcium and vitamin D and the effect of sunlight on vitamin D”. It included information on vitamin D, calcium, importance of sunlight, which is the best source of vitamin D and correlation of vitamin D and calcium. **Experimental group II** comprised of 15 participants. The participants were given nutrition education and they were exposed to sunlight for a period of about 45 minutes. No curd was supplemented to this group of participants. The third category was **control group** of 15 participants who received neither curd supplementation nor exposed to sunlight or nutrition education. The 24 hour diet recall survey was carried out for all the 45 participants. Anthropometric measurements namely height, weight, waist circumference, hip circumference and biochemical assessment namely Hb, calcium and vitamin D was done for all the participants of the supplementation study before and after supplementation for a period of 50 days.

The study protocol was approved by Institutional Ethical Committee of Avinashilingam Institute for Home Science and Higher Education for Women and Ethical Clearance was obtained. The approval number is AUW/IHEC/17-

18/FSN/XPD/22. The data obtained in the present study was tabulated and statistically analyzed for correlation and test of significance.

The salient findings of the study are summarized below:

Background information about the participants:

- The total number of participants was 150. Of 150 participants, 96.6 per cent belonged to the age group between 18 – 20 years, 3.4 per cent belonged to the age group between 21 - 22 years. All the participants were from the Avinashilingam Institute for Home Science and Higher Education, Coimbatore. Of the 150 participants, 84 per cent of the participants were Hindus, 10 per cent were Muslims and 6 per cent were Christians. 53.4 per cent were day scholars i.e. they came from home, 40 per cent were residing in hostel and the rest 6.6 per cent were stayed as paying guests etc..
- The dietary and food consumption pattern of the participants showed that 76 per cent of the respondents were non-vegetarians. Pure vegetarians accounted for 9.3 per cent. Ova vegetarians – a group which consumed egg only in addition to vegetarian diet constituted 14.7 per cent. Out of 150 participants, majority (73.4%) followed 3 eating episode and 16.6 per cent followed a four eating episode.
- From the total participants 73.3 per cent skipped their meals and the remaining participants were maintaining regular meals. Of the 110 participants who skipped their meals, 63.6 per cent skipped their breakfast, 9.1 per cent skipped their lunch and 27.3 per cent skipped their dinner. 18.2 per cent had a regular routine of skipping their meals, 20.9 per cent of participants skipped their meals once in a week and 60.9 per cent of the participants skipped their meals occasionally.
- About three fourth i.e. 80% of the participants had the habit of eating outside food. Among them 28.3 per cent preferred eating out in restaurants. Majority of the respondents (36.7 per cent) prefer to eat in cafeteria and 25 per cent of the respondents had a habit of eating in fast food shops. Only 11 per cent of the respondents ate from street vendors.

- About three fourth i.e. 80% of the participants had the habit of eating outside food. Among them 28.3 per cent preferred eating out in restaurants. Majority of the respondents (36.7 per cent) prefer to eat in cafeteria and 25 per cent of the respondents had a habit of eating in fast food shops. Only 11 per cent of the respondents ate from street vendors.
- From the nutrition knowledge evaluation it was found that almost all the students were aware about the importance calcium and also mentioned the calcium rich source. Majority of them said that milk, milk products and green leafy vegetables are the best source of calcium. Like wise 93.3 per cent of the participants were aware of importance of vitamin D and 6.7 per cent had little knowledge on vitamin D and organ meats. They also mentioned fish, soya are good sources of vitamin D. The participants responded that the best sources of vitamin D are egg yolk.
- The frequency of drinking milk and the quantity of milk consumed was evaluated. It was found that majority of the participants (46 per cent) had the habit of drinking milk daily. About 28.6 per cent drink milk monthly and 24.6 per cent drink milk monthly. It is evident from the table that out of 150 participants, about 54.6 per cent drink about 100 – 200 ml of milk. 27.4 per cent participants drink about 200-300 ml of milk and the rest of participants drink 300 – 400 ml of milk per day.
- As sunlight exposure was an important factor of the study. The sunlight exposure of the participants was studied Of the 150 samples, most of the participants (40.66 per cent) exposed themselves to sunlight for about 15 minutes. 21.33 per cent of the participants get exposed to sunlight for less than 15 minutes. About 18 per cent of the participants get exposed for 20 minutes and 13.3 per cent get about 30 minute exposure. 4.66 per cent participants get sun exposure for about 40 minutes. Only 2 per cent get sun exposure for more than 40 minutes. This sunlight exposure is while they go to from home and back, or during the lunch time or during games period.
- Majority of the participants (73.3 per cent) had knowledge on osteoporosis and the rest of the participants (26.7 per cent) had little or no knowledge on osteoporosis.

- Of the 150 participants none of them have got prescription of calcium supplement by physician. In case of vitamin D about 94.3 per cent of the participants have not got any vitamin D prescription and the rest 4.7 per cent have got prescription of vitamin D supplementation by a physician because they had a very low serum vitamin D and some students who had menstrual problems also had be given vitamin D supplements.
- There was multiple responses for the resource which helped to know about vitamin D and calcium. The participants were asked about the source of their knowledge and information they know about calcium and vitamin D. Eighty per cent of the participants had information on calcium and vitamin D through books followed by teachers (60) relatives (50) and their personal interest (10).
- The mean food intake of the participants of the supplementation study namely experimental group I, experimental group II and control group.
- **Energy**- The mean energy value of the experimental group I was 2163 kcal and the recommended dietary guide line is 1900 kcal and that was 263 kcal in excess. For experimental group II the mean energy value was 2206.16 kcal and there was an excess of 306.11 kcal than the recommended value. The mean energy value of control group 2064.59 kcal and there was an excess of 164.59 kcal than the recommended value.
- **Carbohydrate** - The actual intake of carbohydrate was 257.38 g and it was 27.38 g excess than the normal value, the normal value was 230 g. For the experimental group II the actual carbohydrate intake was 258.08 g and there was an excess intake of 28.08g than the normal value. For control group the actual mean intake was 233.74 g and there was an excess intake of carbohydrate 3.74 g.
- **Protein** - The protein intake of the experimental group I was 59.41g which is 4.41 g excess than the normal value, 55g. For the experimental group II the actual protein intake was 58.45g and there was an excess intake of 3.45g than the normal value. For control group the actual mean intake was 58.64 g and there was an excess intake of protein 3.64 g.

- **Fat** - The mean fat intake of the experimental group I was 36.65g and the normal value is 20 and the difference is 16.65g, which is excess than the recommended intake. For the experimental group II the actual intake was 37.68g and there was an excess intake of 17.68g than the normal value. For control group the actual mean intake was 37.08g and there was an excess intake of fat 17.08g.
- **Calcium** – The mean calcium intake of the experimental group I was 590.15 mg and the normal value is 600mg and the difference is 9.85 mg, which is deficit than the recommended intake. For the experimental group II the actual intake was 533.66 mg and there was a deficit intake of 66.34 mg than the normal value. For control group the actual mean intake was 564.37 mg and there was a deficit intake of calcium 35.63 mg.
- **Iron** - The mean iron intake of the experimental group I was 13.65 mg and the normal value is 21 mg and the difference is 7.35 mg, which is deficit than the recommended intake. For the experimental group II the actual intake was 13.07 mg and there was a deficit intake of 7.93 mg than the normal value. For control group the actual mean intake was 13.31 mg and there was a deficit intake of iron 7.69 mg.
- **Fiber** - The mean fiber intake of the experimental group I was 11.82 g and the normal value is 30 g and the difference is 18.18 g, which is deficit than the recommended intake. For the experimental group II the actual intake was 16.27 g and there was a deficit intake of 13.73 g than the normal value. For control group the actual mean intake was 13.58 g and there was a deficit intake of fiber 16.42 g.

Anthropometric measurements

- **Experimental group I** - The mean height of the participants of the experimental group I who were exposed to sunlight, given curd supplementation and nutrition education was 159.21 cm and the standard height is 152 cm and its difference was 7.2 cm. The mean weight of the participants was 52.06 kg and the standard weight was 52.10 kg and its difference was 0.04 kg. The BMI of the adolescent girls was 20.47 and the standard BMI was 22.90 and the difference was 2.43. Likewise the waist hip ratio of the participants was 0.79 and the standard value is

0.8 and its difference was 0.01. The waist to height ratio was also measured and the mean waist to height ratio of participants was 0.45 and the standard waist to height ratio 0.5.

- **Experimental group II** - The mean height of experimental group II who were exposed to sunlight and given nutrition education was 158.88 cm and the standard height is 152 cm and its difference was 6.88 cm. The mean weight of the participants was 54.93 kg and the standard weight was 52.10 kg and its difference was 2.83 kg. The BMI of the adolescent girls was 20.47 and the standard BMI was 21.69 and the difference was 1.21. Likewise the waist hip ratio of the participants was 0.79 and the standard value is 0.8 and its difference was 0.01. The waist to height ratio was also determined and the mean waist to height ratio of participants was 0.47 and the standard waist to height ratio 0.5 and the difference was 0.03.
- **Control group** - The mean height of the control group was 157.45 cm and the standard height is 152 cm and its difference was 5.45 cm. The mean weight of the participants was 56.03 kg and the standard weight was 52.10 kg and its difference was 4.2 kg. The BMI of the adolescent girls was 22.74 and the standard BMI was 22.90 and the difference was 0.16. Likewise the waist hip ratio of the participants was 0.84 and the standard value is 0.8 and its difference was 0.04. The waist to height ratio was also checked and the mean waist to height ratio of participants was 0.48 and the standard waist to height ratio is 0.5 and the mean difference was 0.02.

Biochemical assessment

- **Hemoglobin** - The mean initial hemoglobin value of the participants of experimental group I was 12.2 g/dl and the mean final value was 12.36 g/dl there was slight increase with a mean difference of 0.16. For the experimental group II the mean initial value was 12.31 g/dl and the mean final value 12.40 g/dl with a mean difference of 0.09. The initial mean hemoglobin of control group was 12.48 g/dl and the final mean value was 12.46 g/dl. There was a difference of 0.02 before and after supplementation. There was no significance in the initial and

final value of hemoglobin test of the participants before and after supplementation.

- **Vitamin D** - The mean initial vitamin D status of the participants of the experimental group I who were exposed to sunlight, given curd supplementation and nutrition education was 9.81ng/ml and the mean final value was 13.03 ng/ml having a mean increase of 3.22 ng/ml. For the experimental group II who were exposed to sunlight and given nutrition education the mean initial value of vitamin D was 9.95 ng/ml and the mean final value was 10.98 ng/ml. There was a mean increase of 1.03 ng/ml after the supplementation period. The mean initial value of vitamin D of control group was 16.57 ng/ml and the final mean value was 15.00 ng/ml. There was a mean difference of 1.57 ng/ml in the control group before and after the supplementation period. For experiment group I, it was observed that the mean initial and final values for vitamin D showed a statistical significant difference at 1% level with a 't' value of 4.461. For experimental group II, the vitamin D had a significant difference at 5% level with a 't' value of 2.497 before and after a supplementation period of 50 days. The 't' value of the control group showed a significant difference at 1% level with the value 3.783** on the negative side. The mean increase in experimental group I may be because the participants were exposed to sunlight with curd supplementation along with nutrition education.

- **Calcium** -The mean initial calcium level of the participants of the experimental group, i.e. before supplementation who were exposed to sunlight, given curd supplementation and nutrition education was 9.33 mg/dl and the final value is 9.67 mg/dl with a mean difference of 0.34 mg/dl. The experimental group II who were exposed to sunlight and given nutrition education was 9.36 mg/dl and the final mean value is 9.56 mg/dl. The mean decrease of 0.20 mg/dl was seen before and after supplementation. The initial mean calcium of control group was 9.44 mg/dl and the final mean value was 9.39 mg/dl. The mean difference of 0.05 mg/dl was noted before and after supplementation in the control group. For experiment group I, it was observed that the mean initial and final values for

calcium showed a statistical significant difference at 1% level with a 't' value of 4.432. For experimental group II, the calcium had a significant difference at 5% level with a 't' value of 2.732 before and after a supplementation period of 50 days. The 't' value of the control group showed no significance with the value of 1.524.

Relation between vitamin D and sunlight

- The correlation between vitamin D and sunlight was estimated statistically for experimental group I, experimental group II and control group. For experimental group I who were exposed to sunlight, supplemented with curd and nutrition education showed a positive correlation with a value of 0.035. For experimental group II there was a negative correlation with a value of 0.045. The control group showed a strongly negative correlation with a value 0.072. The positive correlation of vitamin D and calcium for experimental group I may be due to the sunlight exposure, curd supplementation and nutrition education. For experimental group II, the negative correlation may be due to the reason that they were exposed to sunlight only and there was no curd supplementation. The strong negative correlation may be attributed that they were neither exposed to sunlight nor given curd supplementation and nutrition education.

From the study, it was concluded that, there is an effect of sunlight on vitamin D status and also improved the calcium level of the participants. Sunlight exposure is an effective method of improving the vitamin D status. It also helped to increase the serum calcium along with the supplementation of curd, which is one of the richest sources of calcium. A normal vitamin D status helps to increase the absorption of calcium and thus prevents the bone and bone related disorders. Hence sunlight exposure is an effective source of vitamin D for all the age groups and can be effectively used as an effective strategy for bone related problems like rickets, osteoporosis, osteoarthritis etc. Also, it can be recommended for school going children to compulsorily expose the students to

sunlight atleast during their games hour which would in turn reflect their vitamin D and calcium status in their future reproductive and elderly stage.

Recommendations for further research:

- Vitamin D studies in osteoporotic patients/ people with related problems
- Study on the influence of skin colour on vitamin D absorption
- Study the relation between obesity and vitamin D
- Explore the calcium rich foods and identify the active principle component
- Relation between vitamin D and other nutrients which would increase the absorption of the same

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Webography

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- http://www.nal.usda.gov/fnic/DRI//DRI_Calcium/250%E2%80%93287.pdf
- <http://www.nlm.nih.gov/medlineplus/ency/article/003569.htm>.
- www.dairynutrition.com

APPENDIX I

Questionnaire to

Evaluate the effect of sunlight on vitamin D status among college going girls

Demographic Data

1. Name:
2. Age:
3. Date of birth:
4. Class:
5. Place of residence
 - a) Home
 - b) Hostel
 - c) othersSpecify
6. Address for communication:
Mobile number:
7. Religion:
8. Type of Family:
 - a) Nuclear
 - b) Joint
9. Designation :
10. Marital status
 - a) Married
 - b) Unmarried

Anthropometric measurements

1. Height:
2. Weight:
3. BMI:
4. Waist Hip ratio:
5. Waist Height Ratio:

11. If yes, for what

12. Has any physician prescribed vitamin D supplement for you ever?

Yes	No
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13. If yes for what

14. Which source helped you to know about Calcium and Vitamin D

	Relatives				Teacher
	Books				Interest

APPENDIX II
NUTRITION EDUCATION

Date	WhatsApp messages
18/01/2018	<p>What is Vitamin D</p> <ul style="list-style-type: none"> • Vitamin D is important for good overall health and strong and healthy bones. • It's also an important factor in making sure your muscles, heart, lungs and brain work well and that your body can fight infection. Your body can make its own vitamin D when you expose your skin to the sun. You can also get vitamin D from supplements and a very small amount comes from a few foods you eat.
19/01/2018	<ul style="list-style-type: none"> • The vitamin D that you make in your skin from sunlight and the vitamin D you get from supplements or food have to be changed by your body a number of times before it can be used. • Once it's ready, your body uses it to manage the amount of calcium in your blood, bones and gut. It's also used to help cells all over your body to communicate properly.
20/01/2018	<p>What does vitamin D do?</p> <ul style="list-style-type: none"> • Vitamin D isn't like most other vitamins. Your body can make its own vitamin D when you expose your skin to sunlight. • Also what makes vitamin D unique compared to other vitamins, is that when your body gets its vitamin D, it turns vitamin D into a hormone. This hormone is sometimes called "activated vitamin D" or "calcitriol." Getting the right amount of vitamin D doesn't depend on the foods you eat. • To get enough vitamin D you need to expose your skin to sunlight regularly.
21/01/2018	<p>"Getting the right amount of vitamin D doesn't depend on the foods you eat. To get enough vitamin D you need to expose your skin to sunlight regularly and you may also need to take supplements. This makes getting the right amount a</p>

	little more complex compared to other vitamins and minerals “
22/01/2018	<ul style="list-style-type: none"> • Vitamin D is very important for strong bones. Calcium and phosphorus are essential for developing the structure and strength of your bones, and you need vitamin D to absorb these minerals. • Even if you eat foods that contain a lot of calcium and phosphorus, without enough vitamin D, you can't absorb them into your body.
23/01/2018	<p>Some functions that vitamin D helps:</p> <ul style="list-style-type: none"> • Immune system, which helps you to fight infection • Cardiovascular function, for a healthy heart and circulation • Respiratory system, for healthy lungs and airways • Brain development • Muscle function • Anti-cancer effects
24/01/2018	<p>How does vitamin D work?</p> <p>Part I</p> <ul style="list-style-type: none"> • Vitamin D mainly comes from your skin when it is exposed to sunlight. After that, your body changes the vitamin D so that it can be used. • When your skin is exposed to the sun, it produces vitamin D and sends it to your liver. If you take supplements or eat foods that contain vitamin D, your gut also sends the vitamin D to your liver. • From here, your liver changes it to a substance called 25(OH)D. When your doctor talks about your vitamin D levels, it is the amount of 25(OH)D you have in your blood.
25/01/2018	<p>Part II</p> <ul style="list-style-type: none"> • The chemical in the blood is sent all over your body where different tissues, including your kidney, turn it into activated vitamin D. From here, it gets a little complicated, but you can think of activated vitamin D working in two ways:

- Manages calcium in your blood, bones and gut
- Helps cells all over your body to communicate properly

As Vitamin D goes a long way from its original form from the skin, supplement or food. But without vitamin D, your body can't perform at its best

26/01/2018

Are certain people more likely to be vitamin D deficient?

- People with darker skin. The darker your skin the more sun you need to make the same amount of vitamin D as a fair-skinned person.
- People who spend a lot of time indoors during the day. For example, if you're housebound, work nights or are in a hospital for a long time.
- People who cover their skin all of the time..
- E.g. sunscreen or if your skin is covered with clothes.
- Older people. They tend to have thinner skin than younger people and this may mean that they can't produce as much vitamin D.
- People who are very overweight (obese).

27/01/2018

D₃ vitamin

The Sunshine VITAMIN

Who is at risk of Vit D Deficiency?

85%
lower-than-optimal vitamin D levels

- People With Limited Sun Exposure**
We need 10-15 minutes of UVB per day with 40% of our skin exposed.
- Overweight People**
Vitamin D is oil soluble & hides in fat.
- Pregnant Women**
Those with pregnancy-related high blood pressure or preeclampsia, have lower blood levels of D.
- The Elderly**
As you age, your skin loses the ability to generate Vitamin D.
- Dark-Skinned People**
The pigmentation of darker-skinned people blocks UVB radiation.
- Infants**
Human breast milk contains low levels of vitamin D.

Naturalhealthyconcepts.com

28/01/2018

25(OHD) GUIDELINES FROM VARIOUS ORGANIZATIONS

	Vitamin D Council	Endocrine Society	Food and Nutrition Board	Testing Laboratories
Deficient	0-30 ng/ml	0-20 ng/ml	0-11 ng/ml	0-31 ng/ml
Insufficient	3-39 ng/ml	21-29 ng/ml	12-20 ng/ml	————
Sufficient	40-80 ng/ml	30-100 ng/ml	>20 ng/ml	32-100 ng/ml
Toxic	>150 ng/ml	————	————	————

Live elsewhere? To convert these into nmol/l, multiply these numbers by 2.5. Now you're in nmol/l

29/01/2018

Sunlight - Our body is designed to get the vitamin D it needs by producing it when your bare skin is exposed to sunlight.

- The part of the sun's rays that is important is ultraviolet B (UVB). This is the most natural way to get vitamin D. Large amounts of vitamin D3 (cholecalciferol) are made in your skin when you expose all of your body to summer sun. This could be just 15 minutes for a very fair skinned person, yet a couple of 10,000 to 25,000 IU of vitamin D in just a little under the time it takes for your skin to turn pink. You make the most vitamin D when you expose a large area of your skin, such as your back, rather than a small area such as your face or arms. There are a number of factors that Human skin can make large amounts of vitamin D when lots of skin is exposed and the sun is high in the sky.

30/01/2018

Melanin is a substance that affects how light or dark your skin color is. The more melanin you have, the darker your skin color. The amount of melanin you have in your skin affects the amount of vitamin D you can produce. Melanin protects against skin damage from too much UVB exposure, so darker skins with more melanin allow less UVB to enter the skin. With less UVB getting through the skin, less vitamin D is produced each minute. This is why if you're

	dark skinned, you need more sun exposure to make vitamin D than if you're fair skinned.
31/01/2018	<p>Other factors - There are other factors which can affect the amount of vitamin D your body makes from exposure to the sun. These are:</p> <ul style="list-style-type: none"> • The amount of skin you expose. The more skin you expose, the more vitamin D you can produce. • How old you are. As you get older, your skin has a harder time producing vitamin D. Whether you're wearing sunscreen. • Sunscreen blocks a lot of vitamin D production.
31/01/2018	<ul style="list-style-type: none"> • The altitude you're at. The sun is more intense on top of a mountain than at the beach. This means you make more vitamin D the higher up you are (at higher altitudes). Whether it is cloudy. Less UVB reaches your skin on a cloudy day and your skin makes less vitamin D.
1/02/2018	<ul style="list-style-type: none"> • Air pollution. Polluted air soaks up UVB or reflects it back into space. This means that if you live somewhere where there is lots of pollution, your skin makes less vitamin D. • Being behind glass. Glass blocks all UVB, so you can't make vitamin D if you're in sunlight, but behind glass. The amount of skin you expose. The more skin you expose, the more vitamin D you can produce
2/01/2018	



VITAMIN D

What makes "the sunshine vitamin" so special?

- Essential for strong, healthy bones
- Promotes absorption of calcium
- Valuable immune-supporting nutrient

3/02/2018

Vitamin D – Recommended Daily Intakes

RECOMMENDED DAILY INTAKES

	Vitamin D Council	Endocrine Society	Food and Nutrition Board
Infants	1,000 IU/day	400-1,000 IU/day	400 IU/day
Children	1,000 IU/day per 25lbs of body weight	600-1,000 IU/day	600 IU/day
Adults	5,000 IU/day	1,500-2,000 IU/day	600 IU/day, 800 IU/day for seniors

4/02/2018

Very few foods in nature are good sources of vitamin D. This is one of the main reasons that vitamin D deficiency is so common, since it's very easy to leave these foods out of our diet.

5/02/2018

Salmon, Mackerel and Other Fatty Fish

Just 3 ounces of salmon, mackerel or other fatty fish contain over 400 IU of vitamin D. This amount alone is enough to prevent many deficiency-related issues such as rickets or depression.

6/02/2018

Vitamin D3 Fortified Milk or Raw Milk

While the pasteurization process destroys much of milk's natural vitamin D

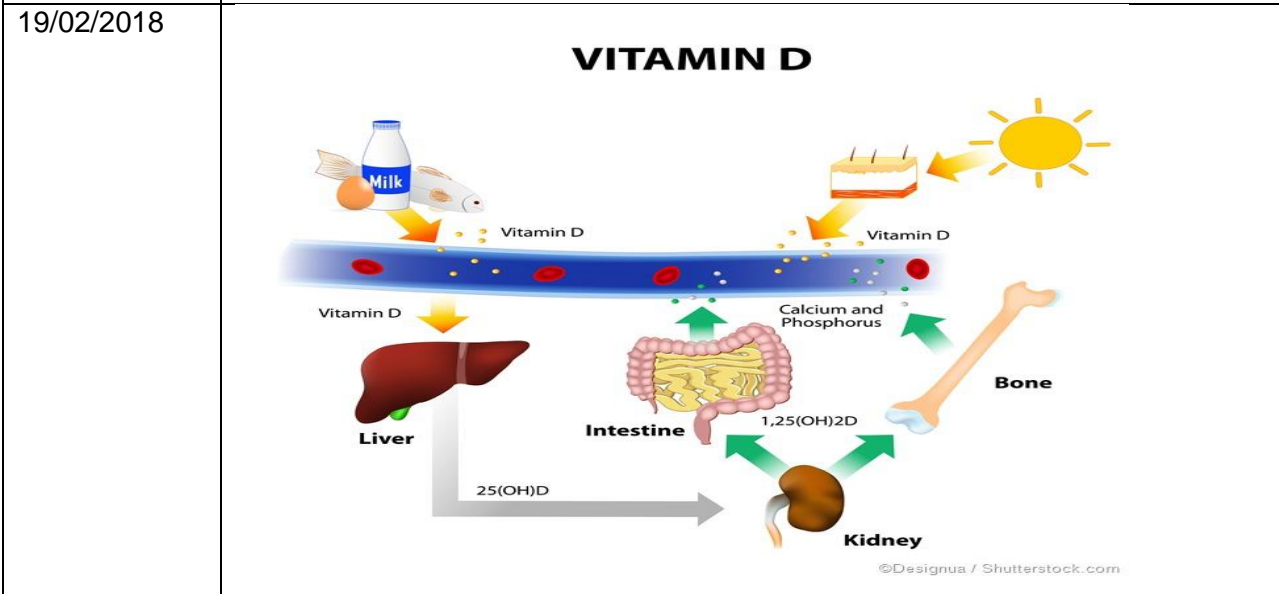
	<p>content, most pasteurized milk is fortified with vitamin D3 to compensate. Drinking a glass or two of milk each day will help, and if we have access to raw milk and can afford it, it's a great investment in our health.</p>
7/02/2018	<p>Butter, Cheese and Eggs</p> <p>Like milk, all of these products contain vitamin D but it's difficult to eat them in high enough quantities to really compensate for a lack of sun exposure. One egg, for example, only has about 40 IU of vitamin D. keep in mind though that most people get the majority of their vitamin D intake from sun exposure.</p>
8/02/2018	<p>Cod Liver Oil and Other Fish Oils</p> <p>Perhaps it is the best natural source of vitamin D. One tablespoon of cod liver oil contains 1,360 IU of vitamin D. If we're worried about deficiency, cod liver oil (and other fish oils to a lesser extent) is great sources.</p>
9/02/2018	<p>Beef Liver, Chicken Liver and Pork Liver</p> <p>These and some other organ meats contain vitamin D, but to a lesser degree than cod liver oil. Liver and other organ meats offer a host of other health benefits, so it's worth incorporating them into our diet even if you're vitamin D levels are sufficient.</p>
10/02/2018	<p>Vitamin D Deficiency</p> <p>Vitamin D deficiency is characterized by inadequate mineralization or by demineralization of the skeleton. Among children, vitamin D deficiency is a common cause of bone deformities known as rickets. Vitamin D deficiency in adults leads to a mineralization defect in the skeleton, causing osteomalacia, and induces secondary hyperparathyroidism with consequent bone loss and osteoporosis. Potential roles for vitamin D beyond bone health, such as effects on muscle strength, the risk for cancer and for type 2 diabetes, are currently being studied. The Agency for Healthcare Research and Quality recently reviewed the effectiveness and safety of vitamin D on outcomes related to bone health</p>
11/02/2018	<p>Chemistry of Calcium</p> <p>Calcium plays a pivotal role in the physiology and biochemistry of organisms and the cell. It plays an important role in signal transduction</p>

	<p>pathways, where it acts as a second messenger, in neurotransmitter release from neurons, contraction of all muscle cell types, and fertilization. Many enzymes require calcium ions as a cofactor, those of the blood-clotting cascade being notable examples. Extracellular calcium is also important for maintaining the potential difference across excitable cell membranes, as well as proper bone formation.</p>
12/02/2018	<p>Physiological Roles of calcium</p> <ul style="list-style-type: none"> • Control excitability of nerves and muscles and regulate permeability of cell membrane. • Maintain integrity of cell membrane and regulate cell adhesion. • Ca²⁺ ions are essential for excitation-contraction of all type of muscle. • Ca²⁺ ions are essential for excitation-secretion coupling in exocrine and endocrine glands.
13/02/2018	<ul style="list-style-type: none"> • Ca²⁺ ions releases of transmitter from nerve ending. • Act as intracellular messenger for hormones and autacoids. • Generate impulse in heart and determine level automatically. • Help in coagulation of blood. • Structural function of bone and teeth
13/02/2018	<p>Source of Calcium</p> <p>There are many foods to choose from that provide calcium. Milk and milk products—such as low-fat or fat-free cheese and yogurt—are excellent sources because they are high in calcium.</p> <ul style="list-style-type: none"> • Most types of milk have approximately 300 milligrams of calcium

14/02/2018	<ul style="list-style-type: none"> • per 8 fluid ounces (1 cup), or about 25 percent of the calcium that twins and teens need every day. • The best choices are low fat or fat-free milk and milk products. Because these items contain little or no fat, it's easy to get enough calcium without adding extra fat to the diet. • Flavored milk has just as much calcium as plain milk, but is higher in sugar and calories than plain milk. Young people may choose to drink chocolate or other flavored milk if they prefer the taste, but they should remember to factor in the additional calories into their overall daily needs. Whether plain or flavored, remember to choose low-fat or fat-free milk and milk products.
15/02/2018	<p>Calcium and Vitamin D</p> <ul style="list-style-type: none"> • Calcium is essential to maintaining total body health, normal growth and development, metabolizing iron, helping blood clotting & regulating blood pressure, keeping bones & teeth strong over lifetime, the action of the number of hormones, cell structure etc. • Vitamin D is required for regulation of cell growth, bone formation, immune function, muscle strength, hair growth, reducing autoimmune disease, fighting infection etc.
16/02/2018	<p>Use of Vitamin D in the Regulation of Calcium, Phosphorus, and Bone Metabolism</p> <p>Part I</p> <p>During exposure to solar ultraviolet B (UVB) radiation, 7-dehydrocholesterol in the skin is converted to previtamin D₃, which is immediately converted to vitamin D₃ in a heat-dependent process. Excessive exposure to sunlight degrades previtamin D₃ and vitamin D₃ into inactive photoproducts.</p>
17/02/2018	<p>Part II</p> <p>Vitamin D₂ and vitamin D₃ from dietary sources are incorporated into chylomicrons and transported by the lymphatic system into the venous circulation. Vitamin D (hereafter "D" represents D₂ or D₃) made in the skin or ingested in the diet can be stored in and then released from fat</p>

cells. Vitamin D in the circulation is bound to the vitamin D-binding protein, which transports it to the liver, where vitamin D is converted by vitamin D-25-hydroxylase to 25-hydroxyvitamin D. This is the major circulating form of vitamin D that is used by clinicians to determine vitamin D status

18/02/2018 Skin synthesis is limited by various determinants, including pigmentation, age, zenith angle of the sun, poor air quality and percentage of the skin surface area available for exposure. A recent study of sun-protective behaviour in USA showed that wearing long sleeves or staying in the shade reduced vitamin D status



20/02/2018

Calcium & Vitamin D


Minerals

Ca


Calcium

- Supports growth of healthy bones.*
- Found in dairy products, meats and veggies.


Kids 4-8 Should Get 800 mg of Calcium per Day, Which Equals:




3 Cups of Milk



3 Cups of Yogurt



6 Slices of Cheese



One Serving of L'il Critters® Calcium Gummy Bears Provides


Vitamin

D


Vitamin D

- Supports calcium absorption and the immune system.*
- Found in dairy products, fish, eggs and liver.


The American Academy of Pediatrics Now Recommends Kids Get 400 IU of Vitamin D Every Day, Which Equals:




3 oz. of Salmon



9.5 oz. of Beef Liver



10 Eggs



One Serving of L'il Critters® Vitamin D Gummy Bears Provides 800 IU of Vitamin D

Source: Committee to Review Dietary Reference Intakes for Vitamin D and Calcium, Food and Nutrition Board Institute of Medicine, Dietary Reference Intakes for Calcium and Vitamin D, Washington, DC: National Academy Press, 2010.

21/02/2018

Understanding vitamin D - video link
<https://www.youtube.com/watch?v=onSPZ0aBUKM&t=25s>

22/02/2018

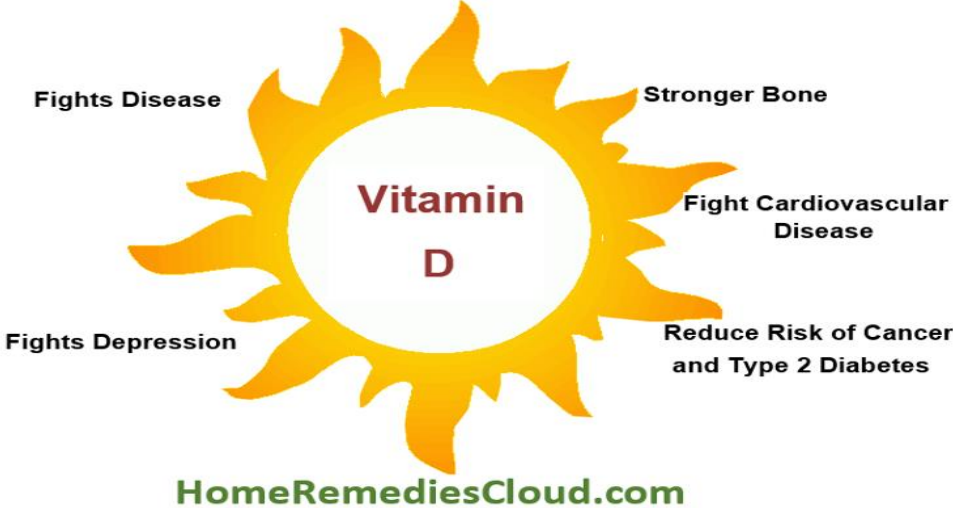
Vitamin D and Calcium Absorption - Biochemistry Lesson - JJ Medicine, <https://www.youtube.com/watch?v=YEnxruA-bsk>
 Role and importance of Vitamin D (calcitriol) in calcium absorption and why we actually need vitamin D for proper absorption and utilization of calcium

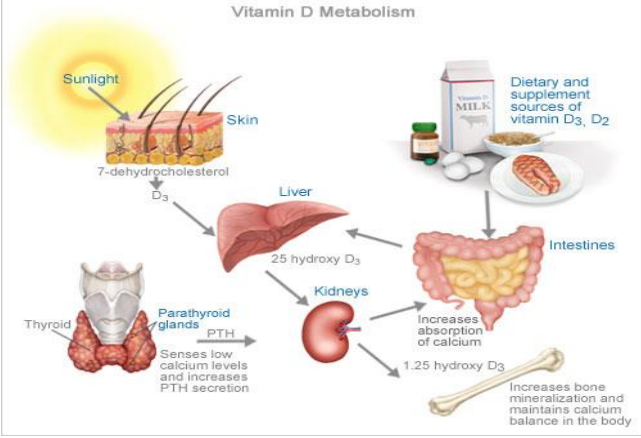
23/02/2018









24/02/2018

Vitamin D, a fat-soluble prohormone, is synthesised in response to sunlight. Vitamin D requires two metabolic conversions, 25-hydroxylation in the liver and

	<p>1alpha-hydroxylation in the kidney, to become active hormone. The active form, 1alpha,25-(OH)₂D, binds to the vitamin D receptor (VDR) to modulate gene transcription and regulate mineral ion homeostasis. Vitamin D plays several roles in the body, influencing bone health as well as serum calcium and phosphate levels. Furthermore, vitamin D may modify immune function, cell proliferation, differentiation and apoptosis.</p>
<p>25/02/2018</p>	<p style="text-align: center;">Health Benefits of Vitamin D</p>  <p style="text-align: center;">HomeRemediesCloud.com</p>
<p>26/02/2018</p>	<ul style="list-style-type: none"> ● Sunshine vitamin ● Modest exposure to sunlight is usually sufficient for most people to produce their own Vitamin D using ultraviolet light and cholesterol in skin.
<p>27/02/2018</p>	<p>Vitamin D is a group of vitamins which are produced by irradiating a precursor with UV light they are:</p> <ul style="list-style-type: none"> ● Ergosterol is the precursor in plants and gets converted to ergocalciferol (vitamin D2) ● Vitamin D3 or cholecalciferol/calcitrol occurs in animal cells.

28/02/2018	 <p style="text-align: center;">Vitamin D Metabolism</p>	
1/01/2018	<p>Vitamin D helps the body absorb calcium and phosphorous from the intestinal tract. Calcium and phosphate are two minerals that are essential for normal bone formation.</p> <p>Throughout childhood, body uses these minerals to produce bones.</p> <p>If body does not get enough calcium, or if body does not absorb enough calcium from diet, bone production and bone tissue may suffer.</p>	
2/02/2018	<p>Calcification of bone does not take place resulting in rickets (children) and osteomalacia (adults) both leading to weak bones and physical deformation.</p> <ul style="list-style-type: none"> ● Rickets ● Tetany ● Osteomalacia ● Osteoporosis 	
3/02/2018	<p>Sources - The body makes vitamin D when the skin is directly exposed to the sun using ultraviolet rays and cholesterol.</p> <ul style="list-style-type: none"> ● Fortified foods ● Excellent sources – fatty fish such as tuna, salmon and mackerel. <p>Fish liver oil – cod, halibut, shark liver oils</p>	
4/02/2018	<p>Good sources - organ meats (liver, kidney), whole milk, butter, cream, malai. Cheese, curds, whole milk powder, egg yolk.</p> <p>Fair sources - fortified fats and cereals</p> <p>Poor sources – sugars, most vegetables and fruits.</p>	

5/02/2018	<h2 style="text-align: center;">Foods High in Vitamin D</h2> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  <p>Fish</p> </div> <div style="text-align: center;">  <p>Egg yolk</p> </div> <div style="text-align: center;">  <p>Meat</p> </div> </div> <div style="display: flex; justify-content: space-around; align-items: center; margin-top: 10px;"> <div style="text-align: center;">  </div> <div style="text-align: center;">  </div> <div style="text-align: center;">  </div> </div> <p style="text-align: center;">Fortified beverages, cereals and milk</p> <p style="text-align: center; font-size: small;">© iStockphoto.com</p>
6/2/2018	<p>Casual exposure to solar radiation of wavelengths 290–315 nm results in the cutaneous production of previtamin D3. Dress code, skin pigmentation and application of Sun Protection Factor (SPF) of 15 reduce the UVB penetration into epidermis by > 95%, thereby limiting the production of previtamin D3 by the skin</p>

Thank you!

APPENDIX III
ETHICAL CLEARANCE

INSTITUTIONAL HUMAN ETHICS COMMITTEE



Avinashilingam

Institute for Home Science and Higher Education for Women

University

(Estd. u/s 3 of UGC Act 1956)

19th March 2018

Chairman

Dr. S. Ramalingam
Principal, PSG Institute
of Medical Sciences
& Research, Coimbatore

Member Secretary

Dr.S.Uma Mageshwari
Associate Professor,
Department of Food Service
Management & Dietetics

Members

Dr. S. Kowsalya
Dr.P.R.Padma
Mr. K.Arulmoli (Legal Expert)
Dr. N.S. Rohini
Dr.A. Saraswathy
Mrs. V. Mangayarkarasi
Dr.Subhashini K. Sripathi
Mrs. S. Radha Devi
Dr.G.Victoria Naomi
Dr. Judith Justin
Dr.AnithaSubash

To

Ms. Annu Francis
Department of Food Science and Nutrition
Avinashilingam Institute for Home Science and
Higher Education for Women
Coimbatore – 641 043

Dear Annu Francis,

Ref: Your proposal No. IHEC/17-18/FSN/22 "Effect of Sunlight
on Vitamin D status among College Going Girls" submitted
for approval of the IHEC on 14th December.

The Institutional Human Ethics Committee of our University hereby
grants approval to your research proposal No. IHEC/17-18/FSN/22
"Effect of Sunlight on Vitamin D status among College Going Girls"
submitted by you. The Approval number for the same is AUW/
IHEC/ FSN -17-18/XPD/22.

We wish you all the best in your research endeavours.

Regards,

S. Uma Mageshwari
Dr.S.Uma Mageshwari
Member Secretary

