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REVIEW ARTICLE

Nutritional Interventions for Elderly and Considerations for the Development of Geriatric Foods

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Abstract: The process of aging is characterized by numerous changes in the body which has an overall negative effect on the health and lifestyle of elderly. Nutrition deserves special attention as an individual reaches old age. It plays a vital role in affecting the quality of life, including physical, mental and social health. The physiological decline in food intake is very common among older age and this result in nutritional deficiencies. These increased nutritional deficiencies are the major risk factors for certain chronic diseases and deteriorated age related health. Thus, the adoption of nutritional intervention can be a measure to tackle the current situation of nutritional deficiencies and promote a healthy lifestyle.

Keywords: Aging, anorexia, nutritional deficiencies, nutritional interventions, supplementation, geriatric foods.

1. INTRODUCTION

According to gerontologist, aging is regarded as biological phenomena marked by 'temporal continuity, heterogeneity on cellular, somatic and molecular level, and, the ability of being modulated' [1]. Aging is a multidimensional process characterized by several physical, social and physiological alterations occurring in humans during the course of life. 'National Policy on Older Persons' defines 'elderly' as those people aged 60 years or above, but this age of senior citizens varies globally. If the proportion of people aged above 65 years reaches 7%, a country is said to be aging. Demographically, aging is an increase in the number of elderly (60+ years) in relation to the total population of the country over a specific period of time [2].

There has been an increase in proportion of older adults in virtually all the countries of the world. According to the data from World Population Prospects: the 2015 Revision [3], there has been a substantial increase in population of elderly people in recent years and this growth is going to accelerate in the coming decade. The people aged 60 years and above worldwide are expected to rise by 56%, from 901 million to 1.4 billion between 2015-2030. By 2050, the global aged population is expected to be more than double, reaching nearly 2.1 billion. The data from World Population Prospects: the 2017 Revision [4] show that Europe is currently having 25% of its population aged 60 years and above and this number is estimated to be 35% in 2050 and 36% in 2100. The global increase in the aged population is likely to be 65% in Asia, 14% in Africa and 11% in Latin America and Caribbean from 2017 to 2050. The current global scenario projects that people aged above 80 years are going to increase from 137 million in 2017 to 425 million in 2050, reaching nearly to 909 million in 2100.

There are various theories at molecular, biological, system and cellular level that explains the process of aging. They are categorized as programmed and damage or error theories. These theories are responsible for alterations in gene expression and cumulative damage to cells at various levels that precede aging [5].

Aging is marked by various physical, physiological and cognitive changes in the human body. For successful aging, proper nutrition is a major determinant. Incorrect dietary habits among elderly results in the progression of some communicable but chronic diseases like type II diabetes, atherosclerosis, coronary heart disease and malnutrition. This impairs the quality of life resulting in physical function and cognitive decline. The decrease in food intake is associated with nutrient deficiencies, resulting in impaired health status and common problems associated with aging. Loss of bone density is common among aged population, increasing the risk of osteoporosis. Sarcopenia, loss of muscle mass, and malnutrition are some other age related problems which results in loss of strength, endurance, resistance to diseases and functional decline [2, 6]. Various factors like physical, social, physiological contribute to re-

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duced food intake among the elderly population, resulting in the nutrient deficiencies which indirectly contributes to their poor health status.

2. FACTORS CONTRIBUTING TO A REDUCED FOOD INTAKE

The process of aging is marked by loss of appetite which results in decreased food intake. With aging, there is a decline in the ability to ingest adequate amount of food and as a consequence, elderly are not able to meet their recommended nutrient requirements. This unintentional physiologic reduction in food intake with advancing age is referred to as 'anorexia'. Nearly 20-30% of elderly individuals suffer from anorexia which is a major contributor of frailty among people [7]. Study by Theou *et al.* [8] found that 12-28% elderly people are frail, with the highest prevalence among women than men, whereas Campitelli *et al.* [9] found frailty to be prevalent among 19-44% of the elderly population. The decline in calorie intake is associated with numerous factors which aggravate the geriatric syndrome of anorexia.

The physiological factors which heighten the process of anorexia include sensory impairment, hormones, changes in the gastrointestinal tract and oral health. The decline in sensory functioning affects the food intake among elderly both in terms of quality and quantity. The impairment in gustatory and olfactory function alters the perception of food among the aged population. Anosmia or reduced sense of smell is common in this age group which is due to changes in olfactory epithelial cells. Similarly, hypogeusia or reduced sense of taste is also prevalent among elderly and this may be due to decreased number and sensitivity of papillae, taste buds or taste bud density on the tongue [7]. It is shown that more than 60% of people aged 65-80 years and 80% of people aged above 80 years have reduced sense of taste. Also, the changes in the oral cavity like increased dryness, reduced thickness of mucous membrane, reduced acini and increased fibrous adipose tissue in salivary gland contributes to a reduced sense of taste [10]. Review by Doets and Kremer [11] also reported the effect of sensory impairment on food intake among elderly. Besides sensory impairment, hormones like Cholecystokinin (CCK), grehlin, leptin, insulin, glucagon-like peptide-1 and Peptide YY (PYY) also contributes to decreased food intake. Older people are known to have impaired response to CCK, the hormone involved in providing satiety. With aging, plasma concentration of CCK increases and this results in early satiation and hence food intake decreases. GLP-1 and PYY sends negative feedback to the stomach and thus suppresses appetite. Ghrelin or the hunger hormone regulates food intake by enhancing gastric emptying. Aging is associated with low ghrelin plasma levels, delaying gastric emptying and contributing to decreased food intake. Increased circulating leptin levels and low insulin level are also associated with anorexia in the elderly. Furthermore, increased levels of proinflammatory cytokines like Interleukin (IL) 1, IL6 and Tumor Necrosis Factor alpha (TNK-α) delays gastric emptying and increases leptin level, which in turn reduces food intake [10, 12-14]. Abnormalities in gastric motility, chronic gastritis, slow bowel motility, decreased gastric secretions and impaired gall bladder contraction results in delayed gastric emptying and contribute to reduced food intake [1, 7]. Xerostomia or dry mouth or hyposalivation is also a contributor to this condition [15]. Ill-fitting dentures and poor dentition limit the food consumption in elderly as these are related to chewing problems and contribute to their poor nutritional status [13]. Apart from age related physiological factors, psychological and social factors also influence food intake among elderly. Depression, mood, apathy, social isolation, poverty, widowhood and environmental changes are known to increase stress level, which influences the dietary pattern and act as a risk factor for anorexia [12].

The combination of physiological and non-physiological factors lead to reduced food intake among the elderly, which aggravate the conditions of frailty, sarcopenia and cachexia among them and hence results in their poor health status.

3. NUTRITIONAL CONSIDERATION FOR ELDERLY

Old age is characterized by changes in health and physiology which affects the nutrient needs of the older population. The diet in elderly fails to provide them with adequate nutrients needed to maintain optimum health and results in nutrient deficiencies and leads to the development of degenerative diseases [16]. The elderly are usually at high risk of developing nutritional deficiencies that is either due to low dietary intake or impairment in the mechanism of absorption or failure to conversion to active forms [17-33] (Table **1**). Although energy needs decline with age, however the need for protein and certain nutrients increases in the normal functioning of the body. The deficiency of certain nutrients is known to affect cognitive functioning that is very common among the older population (Fig. **1**). There are certain recommendations of nutrients for older people, which are described below:

3.1. Protein

The reduced daily food intake among elderly fails to provide them with recommended levels of protein. This insufficiency of protein intake results in loss of muscle mass which is defined as sarcopenia. About 30% of individuals aged 60 years and above are sarcopenic, while more than 50% individuals aged 80 years and older are estimated to be sarcopenic [20]. This impaired protein turnover and inability of elderly to make balance between protein requirement and intake is known to adversely affect their health. Lower protein levels are not only associated with chronic muscle wasting, but also affects the bone health leading to functional loss and frailty. The elderly are recommended to ingest equal proportion of protein throughout the day, *i.e*. equal amounts during breakfast, lunch and dinner [34]. Due to metabolic alterations during aging, the ability to produce muscle protein decreases drastically. Adequate intake of essential amino acids or protein is known to stimulate the synthesis of skeletal muscle protein rates. Study by Volpi *et al.* [35] suggested that essential amino acid; particularly leucine has a stimulatory effect on the synthesis of muscle protein. However, this synthesis is impaired in elderly when the dietary intake of leucine is less than 3g. The threshold of 3g is achieved when approximately 25-30g of high quality protein is ingested.

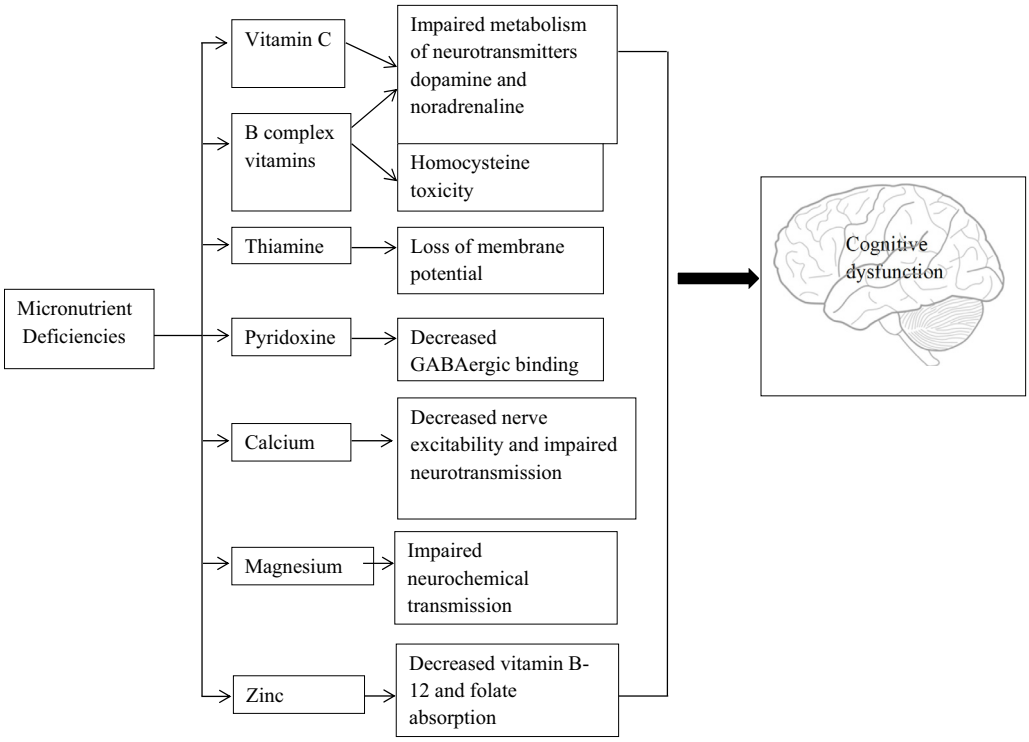

Fig. (1). Effect of micronutrients on cognitive performance [25].

Table 1. Strategies to enhance the absorption of various nutrients in the body.

Nutrients	Role in Body	Impaired Utilization or Absorption	Strategies to Enhance Availability	References
Protein	Muscle and bone development, Fracture reduction.	Insulin resistance. Protein anabolic resistance .	Increased aerobic exercise can have positive effect on protein anabolism and reduce insulin resistance by increasing microvascular supply of amino acid.	[17-20]
Iron	Oxygen transport, Hormone synthesis, Component of enzymes and cytochrome and plays role in electron transport, Thyroid metabolism.	Increased non-heme iron levels in body organs (brain, heart, liver, kidney) Increased hepcidin levels Regular usage of aspirin	Iron chelation therapy in case of excess iron accumulation Dietary intake of heme and non-heme sources of iron like meat and meat products, fish (tuna, sardine), egg, fortified breakfast cereals, dry fruits, dark green vegetables, soyabean, chickpea, tofu, kidney beans, lentil *etc*.	[21, 22]
Calcium	Osteoporotic fracture prevention, Maintenance of bone health, Regulation of neurotransmitters and nerve excitability.	High sodium diet increases urinary calcium loss. Oxalates in spinach, walnuts and sorrel, tannins in tea and phytate in bran, nuts, seeds and most cereals reduces intestinal calcium absorption. Inadequate Vitamin D3 levels.	Diet rich in calcium and supplementation of calcium and vitamin D3 in case of severe hypocalcemia.	[23-25]
Zinc	Normal functioning of immune system, Anti-inflammatory properties, Prevention of apoptosis, Taste acuity, Cognitive functioning.	Altered zinc transporter expression due to epigenetic dysregulation affects zinc homeostasis. Degenerative alterations in intestine with age.	Intake of zinc supplementation.	[16, 26]

(Table 1) Contd…

Nutrients	Role in Body	Impaired Utilization or Absorption	Strategies to Enhance Availability	References
Magnesium	Neuromuscular excitability, Co-factor for protein synthesis and nucleic acid synthesis.	Altered vitamin D3 metabolism decreases intestinal absorption. Use of excessive diuretics reduces Mg reabsorption.	Adequate dietary intake of magnesium rich foods like whole grains, green leafy vegetables, beans, nuts and fruits.	[27]
Vitamin D3	Intestinal calcium absorption, Maintenance of muscular strength, Prevention of osteoporosis and osteomalacia.	Lower cutaneous Vitamin D3 synthesis.	Supplementation of vitamin D3.	[24, 28, 29]
Vitamin B12	Improve cognitive performance, Breakdown of homocysteine (risk factor for cardiovascular diseases).	Malabsorption due to gastrointestinal disorders. Excess use of drugs that interfere with B_{12} absorption. Food-cobalaminmalabsorption syndrome Intestinal malabsorption.	Consumption of B-complex or multivitamin supplements containing 1000 mcg cobalamin daily.	[29-31]
Vitamin B9	Improve cognitive performance, Metabolism of homocysteine (risk factor for cardiovascular diseases), Formation of nerve tissues and blood cells, Synthesis of nucleic acid.	Intestinal malabsorption due to atrophic gastritis. Long term intake of high doses of gastric acid secretion suppressor drugs.	Vitamin B supplementation.	[25, 29, 31, 32]
Vitamin B6	Improve cognitive performance, Breakdown of homocysteine (risk factor for cardiovascular diseases), Co-factor for enzymes involved in synthesis, catabolism, decarboxylation, transformation of amino acid and metabolism of nucleic acid and lipids.	Altered protein metabolism and inflammation by chronic diseases.	Vitamin B supplementation.	[25, 29, 31, 33]

Survey data from the National Health and Nutrition Examination III shows that average protein intake of elderly people is 0.9g/kg body weight per day, with 50% of daily protein consumption occurring during dinner [36]. Such consumption pattern concludes that an average 70 kg elderly consumes enough protein in dinner than during the entire day to stimulate muscle protein synthesis. This results in the synthesis of protein using dietary amino acids from other pathways like lipogenesis and oxidation. Thus, equal distribution of 30g of protein throughout the day is suggested for proper protein turnover, which can be a measure to enhance protein synthesis and prevent lean protein loss [35]. The current dietary recommendations for protein are not adequate to fulfil the demands of elderly. Earlier dietary protein intake of 0.8g/kg/day was advised for all age groups regardless of age and sex. These recommendations were made taking into consideration only the nitrogen balance studies, while loss of muscle mass, changes in food intake, reduced physical activity and increased fat mass were neglected in the current RDA (recommended dietary allowances). However, new evidence has shown that this amount of protein intake is insufficient to maintain the health of the elderly. Older adults having acute or chronic diseases have higher demands for protein, which ranges between 1.2-1.5g/kg body weight/day. This higher demand for dietary protein than younger is due to impaired anabolic response to protein. Some longitudinal studies suggest 1g/kg per day protein intake is beneficial for maintaining positive protein status in the elderly population, whereas other studies suggest that people with protein intake of 1.3-1.73g/kg/ day has better health status as compared with those consuming 0.8g/kg/day. According to PROT-AGE study group, the diet of older individuals should contain approximately 25-30g protein per meal, out of which 2.5-2.8g should be contributed by leucine so as to maintain optimum protein anabolism. Thus, on an average total protein intake should be in the range of 1.0-1.2g/kg/day [17, 20].

Health, Aging and Body Composition study data demonstrates better preservation of muscle mass is associated with consumption of animal protein (with more essential amino acid content) than plant protein [37]. It has also been suggested by research that proper protein source (high quality protein), timing of protein intake and amino acid supplemen-

tation or content are known to enhance protein absorption among elderly [17].

3.2. Calcium and Vitamin D3

For optimum bone health, calcium and vitamin D3 plays a crucial role. The process of aging is characterized by several losses, of which loss of bone mineral density is most common and can lead to severe osteoporotic fractures and can limit the mobility of elderly. The elderly women are at a higher risk of bone loss which is 2-3% per year as compared to men. This greater bone loss among women occurs after menopause, which is due to estrogen deficiency resulting in decreased intestinal calcium absorption. This deficiency also leads to decreased re-absorption of calcium by the kidneys and increased secretion of parathyroid hormone and bone resorption [23]. This increased bone turnover in older adults is also due to vitamin D3 deficiency which in turn affects calcium homeostasis by decreasing intestinal calcium absorption. Deficiency of vitamin D3 among elderly is due to decreased ability of skin to synthesize it. Also, the decreased exposure to sun adds to this deficiency [24]. The failure of kidney to convert 25(OH) vitamin D3 to 1,25 (OH) vitamin D and decreased ability of intestine to receive vitamin D3 further increases vitamin D3 deficiency [38]. Lips *et al.* [24] reported that serum 25(OH)D levels below 50 nmol/l are associated with increased muscular weakness and decreased physical function among elderly, whereas levels below 25-30 nmol/l increases susceptibility to falls and fractures.

It was reported that in America, very less women (>1%) and about 25% men above 70 years were able to meet their requirement for calcium through diet. Study on free living Australian women aged 70-85 years revealed that calcium intake among them was 900-980 mg/day and about 70% of the population fails to meet estimated average requirement of 1100 mg/day [23]. In Western countries, the mean calcium intake among older subjects is 700-900 mg/day and still lower in people dwelling in Asia and Africa. Thus, on an average, older adults tend to have less calcium intake which is approximately 600mg/day and hence are more prone to osteoporotic fractures and falls. Calcium intake of 1000-1200 mg/day is advised for elderly population for the maintenance of optimum bone health [39, 40]. Dawson-Hughes *et al.* [28] suggested an average intake of 20-25µg/day, *i.e.* 800-1000 IU/day of vitamin D3 among elderly is important for maintaining serum 25(OH)D levels of 75nmol/L which will be beneficial in lowering the risk of falls and fractures. Intake of approximately 800 IU/day will be sufficient for older adults having appropriate exposure to the sun, whereas those having limited sun exposure and are obese need to have a high intake of approximately 2000 IU/day. Intestinal calcium absorption is affected by various components in the diet. The antinutrients present in food like phytates, oxalates and tannins are known to form insoluble complexes with calcium, contributing to reduced intestinal calcium absorption. High sodium diet is related to increased calcium loss in the urine, leading to decreased calcium retention [23].

Hence, to reduce the prevalence of osteoporotic fractures, both calcium and vitamin D3 levels should be maintained which can be achieved either through dietary sources or through supplementation. It was reported by Zhu and Prince [23] that the risk of falls and fractures can be reduced with intake of 1200 mg/day of calcium alone or 1200mg/day calcium and 1000 IU/day vitamin D3.

3.3. Zinc

Zinc is an essential micronutrient involved in enzymatic catabolism, transcription, signal transduction for the functioning of immune cell, DNA synthesis and various micronutrient metabolisms. The elderly have been reported to have low concentrations of serum zinc, which contributes to a weakened immune system and makes them susceptible to infections and thus increases the risk of morbidity among them. With aging T-cell mediated functioning is impaired, particularly due to zinc deficiency. The synthesis of metallothionein decreases and this cause zinc imbalance in the gut and other tissues [41]. The main factor responsible for this insufficiency is improper dietary zinc intake coupled with other intrinsic and extrinsic factors. Other factors which lead to poor zinc status in elderly includes poor mastication of food, oral problems limiting food intake, ingestion of several medications which alter the physiology of absorption and some psychosocial factors which limit the food intake [16]. Wong *et al.* [26] hypothesized that decreased levels of zinc with progressing age are due to epigenetic alterations such as DNA methylation, which contribute to zinc transporter impairment, resulting in decreased absorption of zinc and hence low zinc levels in elderly. Zinc absorption in older age is influenced by numerous factors. Altered villus shape, changes in mitochondria, elongation of crypts, alterations in collagen and increased cryptal cell replication time significantly alters the zinc absorption among elderly. Also alterations in intestinal microvilli and enterocytes in the large intestine decreases zinc absorption. The presence of antinutritional factors in the diet like phytates and some minerals like iron and calcium imposes inhibitory effect on zinc absorption [16]. However, Kim *et al.* [42] showed that phytate may not be a major determinant of decreased zinc absorption.

The recommended dietary allowances of zinc for older men is 11 mg/day and for older women is 8 mg/day with an upper tolerable limit of 25-40 mg/day which includes both the dietary zinc and supplemental zinc. It has been shown that people above 60 years are having zinc intake below 50% than what is recommended for proper functioning of body systems [16]. Third Health and Nutrition Survey data showed that in the United States, only 42.5% of the older population (> 71 years) were having an adequate zinc intake and a majority was suffering from zinc deficiency [43].

Zinc deficiency also affects the functioning of other nutrients through its interaction. Synthesis of Retinol-Binding Protein (RBP) is dependent upon zinc, which is required to transport vitamin A to plasma and for mobilization of retinol from the liver. With less serum zinc concentration, this transportation of retinol is impaired. Low zinc status increases vitamin E requirement due to decreased intestinal absorption. Whereas this low or marginal zinc status also decreases folate absorption from food [44]. The decreased gustatory sense which strongly affects the food intake among the elderly is also due to zinc deficiencies [16]. To meet the upper tolerable limit of 40mg of zinc per day, zinc intake

from both dietary sources and supplementation must be taken into account and this will help in normalizing serum zinc concentration, in the case of zinc deficient elderly subjects. Various dietary sources of zinc like seafood, poultry, red meat, beans, fortified breakfast cereals, whole grains, nuts and dairy products can help in maintaining adequate zinc status. However, zinc absorption is more from animal protein sources as compared to plant protein sources [40].

3.4. Iron

Iron deficiency is very common among elderly population and contributes to anemia amongst them. The inability of the body with advancing age to maintain a balance between iron store and iron supply amplify the condition of anemia. This iron deficiency is multifactorial, which means that there are numerous factors responsible for this condition. With advancing age, the decreased food intake, frequent medications, gastrointestinal malabsorption and occult bleeding are the common causes that results in this deficiency. Iron malabsorption is also one of the factors contributing to iron deficiency and this result in excessive iron accumulation in elderly [45]. This age related anemia can also be due to increased hepicidin levels, a regulatory hormone, which decrease iron absorption in the intestine and results in low iron levels [21].

The recommended daily allowance of iron for both the sexes is 8 mg/day with the upper tolerable limit of 45 mg/day. According to World Health Organization (WHO), the women having hemoglobin levels <12g/dl and men having hemoglobin levels <13mg/dl are categorized as anemic [45]. The third US National Health and Nutrition Examination Survey (NHANES III) data reported the prevalence of anemia among people aged above 65 to be 10.2% in women and 11% in men [46]. With increasing age, the prevalence rate of anemia was also known to increase. Studies have reported that in people aged 75 years and above, the prevalence rates were 14.9-15% in men and 7.1-12.7% in women. People 85 years and above showed more prevalence rates of 29.6-30.7% in men 16.5-17.7% in women. Studies conducted in the United States and Europe on older adults indicated that the prevalence of anemia among these populations ranges from 8-25% [47]. The low levels of iron not only affects the quality of life, but are also known to be associated with other factors like depression, fatigue, impairment of cognitive functioning and loss of muscle strength [45].

The various constituents present in diet play a pivotal role by affecting the bioavailability of iron. The tannins and polyphenols present in tea and coffee exhibit an inhibitory role in iron absorption, whereas vitamin C rich food components are known to enhance iron absorption [48]. However, iron and vitamin C interaction is known to generate free radicals. The conversion of ferrous ions to ferric ions generates *OH free radicals. These ferric ions are converted back to ferrous ions by vitamin C and this results in another cycle of free radicals from newly formed ferrous ions. However, this generation of free radicals occurs only in case of iron overload in the body. In case of iron deficiency, vitamin C helps in enhancing iron absorption [49]. The intake of aspirin in elderly to treat CVDs is associated with low concentrations of serum ferritin [22]. Iron deficiency can be corrected by consumption of diet adequate in iron. Besides this, iron supplementation can be an alternate for treatment of severe iron deficiency anemia. Oral iron therapy with 300mg of ferrous sulfate tablets having 60 mg elemental iron can also be a measure of recovery from severe iron deficiency. The people who fail to respond to oral treatment, an intravenous iron replacement can be an option [48]. Also iron chelation therapy can be adopted in case of age-related iron overload among elderly [21].

3.5. B-Vitamin Complex

B-vitamin complex consist a group of eight water soluble vitamins, which have interrelated functions in maintaining the cellular function and brain atrophy. Among elderly, deficiency of vitamin B12, B6 and folate are known to affect cognitive functioning and is accompanied with depressive symptoms prevalent among older adults [50, 51]. The Recommended Dietary Allowance (RDA) for this vitamin is 0.9-2.4 µg/day, but the estimated average requirement in the United States and Canada is 0.7-2µg/day throughout the life span. Elderly with plasma vitamin B12 levels below 148pmol/L are considered to be severely deficient in this vitamin, whereas those with levels in the range of 148-221pmol/L are marginally deficient [52]. The deficiency of B-complex vitamins, particularly B6, B12 and folate is associated with increased serum homocysteine levels. This elevated level increases the risk of diseases like Alzheimer's disease and dementia, which is very common among this age group. Increasing the intake of these vitamins can lower the risk of developing these disorders by reducing the levels of plasma homocysteine. The frequent use of laxatives to treat constipation in elderly disturbs the gut metabolism and affects the absorption of vitamin B complex in the digestive tract [31].

National Health and Nutrition Examination Survey (1999-2002) have shown that among US population, about 6% of elderly (age > 70 years) are severely deficient in vitamin B12 and more than 20% elderly (age > 60 years) are mildly deficient [53]. According to recent studies, more than 20% of the elderly population are at risk of vitamin B12 deficiency [31]. The prevalence of this deficiency is due to insufficient food intake and malabsorption of vitamin B12 due to degenerative digestive conditions. Data from Framingham Offspring Study on elderly people revealed the elevated plasma gastrin levels in 24% of those aged 60-69 years and 37% in those aged above 80 years. The altered digestive function elevates the gastrin levels, which in turn causes malabsorption of vitamin [31, 52]. The prevalence of vitamin B6 deficiency among European institutionalized elderly population is below 1-75% [33].

These vitamins are found mainly in animal food sources. Therefore, its deficiency is more prevalent due to low consumption of animal food sources owing to cultural or religious limitations and also due to the high cost of these foods. Adoption of dietary fiber therapy to treat constipation, reduces the use of laxatives and enhances vitamin B12 absorption. As vitamin B12 is found in animal food sources, thus fortified foods can be an alternative for vegetarians to normalize their serum vitamin B12 levels [31, 52, 54].

4. NUTRITION IN PREVENTION OF AGE RELATED PROBLEMS

The aging is marked by increase prevalence of some common age related problems due to disturbed metabolism. However, the improper dietary habits are major contributors of these diseases. Nutrition intervention helps in enlightening the role of nutrition in the prevention of diseases and in increasing the life expectancy by promoting healthy lifestyle [38]. Table **2** shows some common age related problems, their reason of occurrence, effect and effective preventive measures to stop its further progression.

The improper and inadequate nutrition intake through diet have put the elderly at a marked risk of PEM (Protein Energy Malnutrition), affecting about 23-60% elderly. In community dwelling older adults, the prevalence rates were 5-30%, whereas in residential aged care setting, this rate

Table 2. Common age related problems and its preventive measures.

Age Related Problems in Elderly People	Reasons	Effects	Preventive Measures
Hypertension	↑salt in diet ↓ Ca intake ↓K and Mg [38]	↓Na excretion ↑ Arterial pressure ↑ Blood pressure [38]	Low sodium diet [38] 3.7 g Fish oil consumption reduces blood pressure [38] 1-1.5g Calcium intake per day ameliorate systolic hypertension [38] Dietary sources of potassium [40] Dietary sources of magnesium [40]
Osteopenia	Ca intake < 400mg/day Elderly with lactose intolerance and malabsorption syndrome Vitamin D deficiency due to ↓ dietary intake ↓sun exposure Impairment of ability of UV light to produce cholecalciferol in older skin ↓intestinal reception of vitamin D ↓conversion of 25(OH) vitamin D to 1,25 (OH) vitamin D by kidney [38]	↑ Risk of osteoporosis and hip fracture [38]	1-1.5g Calcium intake per day [38] Calcium and vitamin D supplementation Daily intake of 800 IU vitamin D [38] Fortified milk [40] Fish liver oil [40] Saltwater fish [40]
Cancer	Iron deficiency Iodine deficiency ↓ Selenium levels ↓Selenium and vitamin E levels [38]	Hypopharyngeal cancer in women Thyroid cancer ↑ Cancer risk ↑ Gastrointestinal cancer [38]	325mg of ferrous sulfate providing 150-200 mg iron per day [40] Adequate dietary intake of iron Selenium rich foods [40]
Type II diabetes	↑ Adiposity ↓Insulin secretion [55]	↑ Zn loss in urine Leg ulcers Urinary tract infections Delayed healing [38]	Adequate dietary intake of zinc [40]
Decreased nutrient bioavailability	Diuretics Tuberculosis therapy with isoniazid Epileptic treatment with phenytonin or phenobarbitone Laxative abuse with mineral oil [38]	Magnesium, potassium and Zinc deficiency Vitamin B6 deficiency Folate deficiency Vitamin D, A and K deficiency [38]	Adequate dietary intake of minerals Vitamin A rich food [40] Dietary source of vitamin B6 [40] Folate rich foods [40]
Protein energy malnutrition	Anorexia Cachexia Sarcopenia [56]	Involuntary weight loss [56]	Nutritional supplements [56] Orexigenic drugs to stimulate appepite [56]

ranged from 16-70% [57]. Hypertension is known to affect the majority of the older population and about 70% of elderly aged above 65 years are hypertensive [58]. According to National Health and Nutrition Survey (NHANES) data, 44% of whites and 60% of blacks aged 65-74 years have elevated blood pressure of 160/95 mmHg. This untreated hypertension causes risk of stroke and CVDs as revealed by the studies of Framingham Study and Chicago Stroke Study. Osteopenia is also very prevalent among elderly and is most common in older with vitamin D3 deficiency and calcium intake of less than 400mg. Type II diabetes is also affecting the elderly population with 20% of people already suffering from it. Cancer also significantly affects the health of elderly subjects. Individuals above 65 years of age are found to be suffering from particularly prostate, gastrointestinal and breast cancer. Improper dietary habits like consuming high fat diet increases the risk of breast and colon cancer. High consumption of red meat is associated with a 15% increase in colon cancer and 30% increase in prostate cancer. Also, deficiencies like iron deficiency is associated with hypopharyngeal cancer in women and iodine deficiency causes thyroid cancer. Although with advancing age, incidence of cancer rises, however, it decreases in those aged 85-90 years [38].

The aging process can be drastically affected by environmental factors and the formation of free radicals during normal metabolic process. Incorporation of dietary antioxidants like flavonoids and carotenoids, as well as antioxidants, vitamins and minerals into daily diet help fight the oxidative stress and delays the progression of diseases like Alzheimer disease, cataract and Age – related Macular Degeneration (AMD) [59]. Constipation is commonly seen in almost every older adult and the daily consumption of 25-30g fiber proves beneficial in relieving constipation. Besides this, incorporation of good fats, particularly omega-3 fatty acids, low glycemic index foods, high biological protein sources and vitamin rich foods in the daily diet is associated with lowering cholesterol levels and thus helps to maintain a healthy lifestyle [2]. Various dietary components are known to affect blood pressure. Low sodium intake in the diet is associated with lower blood pressure in hypertensive subjects. Reduction of 78meq/day in sodium intake for 4 weeks or more resulted in blood pressure reduction of 5.0/2.47 mmHg in subjects with hypertension. However, only moderate sodium restriction (80-100meq/day) is recommended as high salt restriction is associated with increased total and low density lipoprotein cholesterol levels. Thus including natural food items in the diet is effective in reducing sodium consumption. Potassium also exerts antihypertensive effect in people with salt sensitive hypertension. Calcium is also known to affect blood pressure in salt sensitive hypertensive subjects by increasing sodium excretion by the kidneys [58]. Component of diet like whole grains, fruits, legumes and vegetables significantly decreases postprandial serum glucose levels as these are good sources of water soluble dietary fiber. Also including polyunsaturated fat sources in the diet reduces the hypertriglyceridemia which is commonly associated with type II diabetes [55]. High intake of fruits, vegetables, whole meal bread and fresh milk helps in decreasing the incidence of cancer. Dietary fiber intake has a protective effect against colon cancer. Intake of sufficient selenium and vitamin E rich foods in the diet decreases the risk of developing cancer. Sources of selenium include milk and dairy products, eggs, spinach, lentils, fish, chicken, meat and selenium fortified foods [38]. Thus, nutritional interventions can be an effective measure of preventing these problems which are responsible for depleted health status among elderly.

5. NUTRITIONAL SUPPLEMENTS

Elderly people fail to meet their requirement for nutrients through dietary sources due to their inadequate food intake. In order to meet this requirement successfully, the use of dietary supplements like multivitamin supplements, protein supplements and mineral supplements has been in great demand. In the last few decades, the United States have experienced a rising trend of using dietary supplements in order to normalize their nutrient levels. Iowa Women Health Study conducted in 1986 showed that about 66% women at an average age of 62 years consume minimum of one dietary supplement and this has increased to 85% in the year 2004, with about 27% women consuming 4 or more supplements [60]. Various nutrition intervention studies were carried out for studying the effects of different dosage of nutrient on the health of the elderly. To overcome the cases of sarcopenia among elderly, it is suggested to incorporate high concentration of Essential Amino Acids (EAAs) particularly leucine in their daily routine. This is possible by ingestion of whey protein supplements rich in EAAs as it will boost muscle protein synthesis among elderly [61]. The intake of protein supplement alone showed a minor increase in muscle mass, but when combined with exercise, it showed an effective result in improving the muscle strength. Studies have suggested that combination of folate, vitamin B6 and B12 are effective results in lowering serum homocysteine levels and thus reduces cognitive decline [62]. But this intervention is effective for people with mild cognitive impairment, only and this supplementation showed no positive results in improving cognitive functioning when taken for shorter duration. The cases of osteoporosis and osteopenia among adults were significantly dropped after supplementation with various dosages of calcium and vitamin D3 [63]. Table **3** shows several studies conducted on the use of various dietary supplements among the older population and their respective outcomes.

The vast use of supplements among the elderly is aimed to attain a healthier lifestyle by decreasing the risk of chronic diseases occurring due to the deficiency of nutrients. However, supplement usage must be wisely monitored as the combined intake of supplement and fortified food may increase a risk of exceeding the upper tolerable limit and also increases the risk of their toxicity [60].

CONCLUSION

The accelerated decline in the health status with the growing age has made elderly home bound. The maintenance of correct nutritional status is a major challenge among the elderly population as inadequate nutrition is associated with impaired health. With aging, the increased dependency on medications is also known to affect health by antagonistic relationship with certain nutrients. Social and economic factors, metabolic changes during aging and the increased risk

Table 3. Effect of different dosage of supplements on the health of elderly.

Nutrient Supplement	Dosage	Outcome	Study [References]
Calcium and Vitamin D3	≥800 IU daily	Prevention of hip fracture and nonvertebral fracture.	Bischoff- Ferrari *et al*. 2012 [64]
	700-1000 IU daily	Reduced the risk of falling among elderly (>65 years) by 19%. Serum 25-hydroxyvitamin D3 concentration of less than 60nmol/l or supplemental vitamin D3 dosage of less than 700 IU may not reduce fall prevention.	Bischoff- Ferrari *et al*. 2009a [65]
	4000 IU daily	10% increase in muscle fiber size in older (≥ 65 years), mobility- limited, vitamin D3- deficient women	Ceglia *et al*. 2013 [66]
	800 IU/day + 1000mg/day calcium	Increased serum 25(OH)D3 levels by 49% and decreased the risk of any fracture by 17%, distal forearm fracture by 30%, nonvertebral fracture by 13%,upper extremity fracture by 25% and any osteoporotic fracture by 19%.	Salovaara *et al*. 2010 [63]
	482-770 IU/day	Reduction in nonvertebral fractures by 20% and hip fractures by 18%.	Bischoff-Ferrari *et al*.2009b [67]
	500000 IU annually	Increased risk of falls and fractures.	Sanders *et al*. 2010 [68]
	800-1000 IU daily	Positive effect on strength and balance.	Muir and Montero-Odasso 2011 [69]
	400 IU vitamin D3 + 500 mg calcium daily	Did not significantly improve mobility or strength in vitamin D3 insufficient geriatric women.	Janssen *et al*. 2010 [70]
	800 IU vitamin D3 + 1000 mg calcium	Prevention of bone loss in ambulatory postmenopausal women.	Karkkainen *et al*. 2010 [71]
Vitamin B	500µg B12+ 400 µg folic acid + 600 IU D3 daily	Vitamin B12 and folic acid supplementation showed no effect on osteoporotic fracture incidence and is thus not recommended for prevention of fractures.	van Wijngaarden *et al*. 2014 [72]
	0.8 mg folic acid+ 20 mg B6+ 0.5 mg B12	High dosage of vitamin B supplementation slowed the brain atrophy rate by nearly 40% in subjects with good serum ʊ- 3 fatty acid (>590 µmol/l).	Jerneren *et al*. 2015 [73]
	400 mcg/day folic acid + 100 mcg/day B12	B12 and folic acid supplementation showed no effect in reducing depressive symptoms.	Walker *et al*. 2010 [74]
	0.8 mg folic acid + 0.5 mg vitamin B12 + 20 mg vitamin B6 daily	Slowed down the accelerated rate of brain atrophy in elderly with mild cognitive impairement.	Smith *et al*. 2010 [75]
	400 µg folic acid+ 100 µg vitamin B12 daily	Improved cognitive functioning among elderly.	Walker *et al*. 2011 [76]
	0.4 mg folic acid+ 0.5 mg vitamin B12+ 0.15 mg vitamin D3	Slower decline in cognitive functioning.	van der Zwaluw *et al*. 2014 [77]
	0.8 mg folic acid + 0.5 mg vitamin B12 + 20 mg vitamin B6	Reduction in cognitive decline and memory decline rates and improvement in clinical dementia rating scores.	de Jager *et al*. 2012 [62]
	5 mg folic acid+ 1 mg vitamin B12	Construction cognitive function improved but no change in global cognitive decline, memory and attention.	Kwok *et al*. 2011 [78]
	2 mg folic acid+ 0.5 mg vitamin B12 + 25 mg vitamin B6 + 20-40 mg citalopram	Decrease in relapse of depressive symptoms.	Almeida *et al*. 2014 [79]
	2.5 mg folic acid + 1 mg vitamin B12 + 50 mg vitamin B 6	No reduction in depression and depressive symptoms.	Okereke *et al*. 2015 [80]

(Table 3) Contd…

Nutrient Supplement	Dosage	Outcome	Study [References]
Zinc	10 mg/day zinc asparate	Decrease in AGE plasma levels (Advanced glycation end products) which represent risk for atherosclerosis by stimulating reactive oxygen species Increased intracellular zinc ion availability.	Giacconi *et al*. 2014 [81]
	15or 30 mg/day as zinc gluco-nate	No increase in plasma homocysteine levels. No deficiency in vitamin B12 and folate levels.	Ducros *et al*. 2009 [82]
	30 mg/day	Increase in plasma zinc concentration. T cell function increased with increased number of T cell.	Barnett *et al*. 2016 [41]
	10 mg/day	Increase in heat induced Hsp70 and stress inductibility provided better stress tolerance.	Putics *et al*. 2008 [83]
	15 or 30 mg/day	Increase in serum Vitamin A levels. Increased serum zinc concentration. No change in serum vitamin E and erythrocyte folate levels.	Intorre *et al*. 2008 [44]
	10 mg /day (50mg DL zinc-asparate)	Reduction in spontaneous cytokine release. Improvement in immune reaction upon attack by pathogen.	Kahmann *et al*. 2008 [84]
	10 mg/day	Reduction in stress among elderly.	Marcellini *et al*. 2008 [85]
	20 mg/day	Increased serum zinc concentration. No alteration in vitamin B12, folate and homocysteine levels. Lowers DNA damage and thus improved genome stability. Increase in antioxidant activity. Enhances zinc storage and transporter gene expression.	Sharif *et al*. 2015 [86]
Protein and Amino acids	2 g two times a day oral EAA	Improved depressive symptoms. Improved physical performance. Improved muscle function.	Rondanelli *et al*. 2011 [87]
	30g Whey protein per day	No improvement in muscle mass or physical function in healthy ambulant postmenopausal women. Deterioration of upper arm and calf muscle area.	Zhu *et al*. 2015 [88]
	4g Leucine per meal and 3 meals per day	Increased muscle protein synthesis.	Casperson *et al*. 2012 [89]
	20g Whey protein and 3g leucine	Increased postprandial muscle protein synthesis.	Luiking *et al*. 2014 [90]
	15g EAA three times per day	Increase in muscle function. Increase in whole body protein synthesis.	Ferrando *et al*. 2010 [91]
	15g two times a day	No improvement in cognitive functioning, memory, information processing speed and executive functioning. Might improve reaction time.	van der Zwaluw *et al*. 2014 [76]
	10,20 or 35g whey protein	35g protein ingestion results in better amino acid absorption and stimulated muscle protein synthesis as compared to 10 or 20g protein ingestion.	Pennings *et al*. 2012 [92]
	20g Whey protein + 3g leucine + 800 IU vitamin D3	Improved muscle mass and lower extremity function in sarcopenic older adults.	Bauer *et al*. 2015 [93]
	25 g protein + 9.4 g EAA per day	Reduction in progression of functional decline.	Kim and Lee 2012 [94]

(Table 3) Contd…

Nutrient Supplement	Dosage	Outcome	Study [References]
	20g protein two times a day	Protein supplementation before and after resistance type exercise shows no further enhancement in skeletal muscle mass and strength. No changes in renal function.	Verdijk *et al*. 2008 [95]
	3g leucine enriched EAA mixture twice a day	Amino acid supplementation along with exercise resulted in increased muscle protein synthesis, muscle strength, muscle mass and walking speed.	Kim *et al*. 2012 [96]
	20 g whey protein three times a week	Supplementation along with resistance type exercise did not lead to greater enhanced physical function, lean body mass and strength.	Arnarson *et al*. 2013 [61]
	15g protein two time a day	Supplementation along with resistance type exercise enhanced physical performance, muscle mass and strength. No effect on renal function.	Tieland *et al*. 2012 [97]
	40g whey protein per day	Whey protein supplement along with resistance exercise did not significantly show additional improvement in muscle mass, strength and physical function in mobility limited older people.	Chale *et al*. 2012 [98]
	15g protein per day	Additional protein supplement along with resistance exercise shows no additional increase in muscle mass, strength and physical function.	Leender *et al*. 2013 [99]

of disease severely affect the nutritional status in multitude ways. The majority of the age related disorder can be prevented by following proper nutritional interventions and consuming food rich in nutrients and antioxidants. The literature has shown that disorders like osteopenia, fractures, type II diabetes, malnutrition and nutritional deficiencies are common among elderly. Prevention and treatment of these conditions can be done through interventions of correct dietary habits, supplements and adequate intake of nutrients as required for maintenance of proper health. The correct dietary modifications have a potential to raise the health standards of the older population globally. Thus, special emphasizes must be given to geriatric health for the maintenance of their health status and to decrease the prevalence of chronic diseases.

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