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Review article

Changes during aging and their association with malnutrition

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ABSTRACT

The aging process involves changes in physiological, pathological, social, and psychological conditions of a person. Nutrition is an important element of health among the elderly, and it affects the whole process of aging. The prevalence of malnutrition is increasing in this population and is associated with a decline in functional status, impaired muscle function, decreased bone mass, immune dysfunction, anemia, reduced cognitive function, poor wound healing, delayed recovery from surgery, higher hospital readmission rates, and mortality. Due to changing socioeconomic environment, elderly people are often left alone to fend for themselves to maintain their health, which may interfere with the maintenance of a good nutritional status. Regular diagnosis of malnutrition among older patients increases the need for more education regarding nutritional status in older patients, and the purpose of this article is to provide information with an educational overview of essential nutritional aspect associated with changes in aging.

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1. Introduction

As a population, older adults are more prone to age-related diseases, functional impairment, and physical inability that may interfere with the maintenance of a good nutritional status (Figure 1).¹ Aging refers to a multidimensional process in humans, the process of physical, psychological, and social changes.

The cutoff for old age cannot be defined exactly because the concept of old age does not have the same meaning in all societies. Government of India adopted the “National Policy on Older Persons” in January 1999. The policy defines “senior citizen” or “elderly” as a person who is 60 years of age or older; however, the age of senior citizen differs in various parts of the world.² According to the definition given by the National Policy on Older Person (Government of India), the elderly group is stratified on the basis of age (Table 1).³

Demographically, aging is the growth of the aged population (60 + years) in proportion to the total population over a period of time. A country is said to be aging if the proportion of people over 65 years of age reaches 7%.⁴ The elderly population is the fastest growing segment throughout the world. In the next 30 years, there

will be a rise in elderly population of up to 300% in Asia and Latin America (Table 2).^{2,5}

The life expectancy at birth in developed countries is over 70 years. According to the global estimation, 605 million people are older than 65 years.⁶ Aging of the world's population is the result of two factors: a decline in fertility and an increase in life expectancy.⁷ There has been a decline in fertility rates in developing countries during the preceding 30 years and in developed countries throughout the 20th century.⁷ In developed countries, the largest gain ever in life expectancy at birth occurred during the 20th century, averaging 71% for females and 66% for males.⁷ Life expectancy at birth in developed countries now ranges from 76 years to 80 years.⁷ Life expectancy has also increased in developing countries since 1950, although the amount of increase has varied. A higher life expectancy at birth for females compared with males is almost universal. Advances in medical science, improved health care, and improved standard of living have helped people to stay healthy and prolong their life. From the health perspective, the goal is to keep people alive and healthy as long as possible. Health education and health promotion play very important roles in maintaining good health, good mobility, and independent functional status in the elderly.⁸

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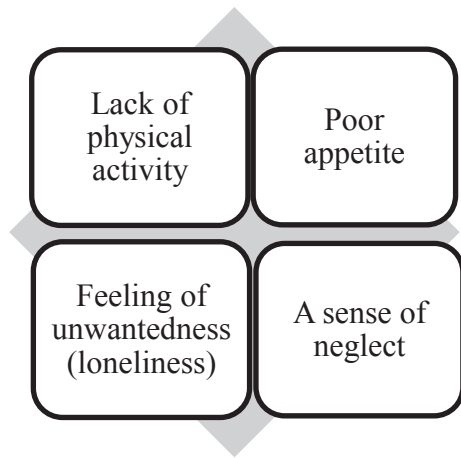


Figure 1. Age-related changes relevant to nutrition. *Note.* From “Human aging: usual and successful,” by J.W. Rowe and R.L. Kahn, 1987, *Science*, 237, p. 143–9. Copyright© Science. Rowl and Kahn, 1987. Reprint with permission.

Table 1
Age stratification among the elderly.

| | | |
|----------------------|-----------------------|----------------------|
| 60–69 y Old | 70–79 y Old old | 80 + y Oldest old |
| 60–74 y Young old | 75–84 y Middle old | 85 + y Old old |

Note. From “National Policy on Older Persons”, by Ministry of Social Justice and Empowerment, Government of India, 1999. Copyright© Government of India. Ministry of Social Justice and Empowerment, 1999. Reprint with permission.

Table 2
World trends in population growth of people aged 60 + years, 1980–2020 (in millions).

| | 1980 | 1990 | 2000 | 2010 | 2020 |
|----------------------|-------|-------|-------|-------|--------|
| World | 381.2 | 484.7 | 608.7 | 754.2 | 1011.6 |
| Developed countries | 173.3 | 203.6 | 234.6 | 232.4 | 308.2 |
| Developing countries | 207.9 | 281.8 | 374.1 | 491.8 | 703.4 |
| China | 78.6 | 101.2 | 131.7 | 167.9 | 238.9 |
| India | 44.6 | 60.2 | 81.4 | 107 | 149.7 |

Note. From “United Nations’ world demographic estimates and projection.”. Copyright© United Nations. United Nations Department of Economic and Social Affairs, Population Division, 2013. Reprint with permission.

2. Age-related changes relevant to nutrition

Nutritional needs change throughout life. Especially for the elderly, these changes may be related to the normal aging process, medical conditions, or life style. Over the past decades, the importance of nutritional status in the elderly has increasingly been recognized in a variety of morbid conditions such as cancer, heart disease, and dementia.^{9,10} Nutrition is an important determinant of health in elderly patients.¹¹ Nutritional status assessment is essential for preventing or maintaining various chronic and acute disease, and even for healing. As people age, various changes occur in the body, which may or may not affect the nutritional status of an individual. A common problem related to aging is loss of bone density, which can increase the risk for osteoporosis. Sarcopenia is the other age-related change. The loss of lean muscle mass can lead to a gain in body fat. Muscle loss is seen even in healthy people, which implies that metabolic changes occur during aging, making it a universal phenomenon. It may be more noticeable by loss of strength, functional decline, and poor endurance. This loss also leads to reduced total body water content.¹²

Various other changes occur throughout the digestive system. There is a decrease in gastric acid secretion, which can limit the absorption of iron and vitamin B₁₂. Saliva production decreases, leading to slower peristalsis and constipation. Appetite and thirst dysregulation also occurs. Sensory changes affect the appetite in many ways. Vision loss makes cooking, and even eating, more difficult. Diminished senses of taste and smell make the food less appealing. These changes typically alter eating habits and reduce nutrient availability and absorption, which can lead to nutritional deficiencies and various health problems.

Malnutrition is both a cause and a consequence of ill health.¹³ It can be of various types: undernutrition, overnutrition, or specific nutrient-related deficiencies. Malnutrition in older patients is regularly underdiagnosed,¹⁴ and hence more education regarding nutritional status is needed among older patients. Malnutrition in older adults can lead to various health problems, including a weak immune system, that increases the risk of infections; poor wound healing; and muscle weakness, which can lead to falls and fractures. In addition, malnutrition can lead to further disinterest in eating or lack of appetite, making the problem worse.¹⁵

Many elderly patients have an increased risk for malnutrition compared with other adult populations. It has been estimated that between 2% and 16% of community-dwelling elderly people are nutritionally deficient in protein and calories.¹⁶ If mineral and vitamin deficiencies are included in this estimate, malnutrition in persons over the age of 65 years may be as high as 35%.¹⁷ Malnutrition in older adults is associated with various health concerns. Malnutrition leads to a weak immune system, increasing the risk of infections, poor wound healing, and muscle weakness, which further leads to falls and fractures.

The problem gets worse as malnutrition can lead to further disinterest in eating or a lack of appetite. Older adults who are seriously ill, and those who have dementia or have lost weight are especially vulnerable to the effects of poor nutrition.¹⁸ Although there is no uniformly accepted definition of malnutrition in the elderly, some common indicators include too little food or a diet lacking in nutrients. In reality, though, malnutrition is often caused by a combination of physical, social, and psychological factors, for example, health concerns, restricted diets, limited income, reduced social contact, depression, and alcoholism. The number for hospitalized seniors is also high. Studies on hospitalized older patients suggest that 20–65% of these patients suffer from nutritional deficiencies,¹⁹ and the prevalence of malnutrition in long-term care facilities is estimated to be between 30% and 60%.²⁰ A careful nutritional assessment and nutritional education are necessary for successful diagnosis of malnutrition in the elderly, and for the development of appropriate and comprehensive treatment plans.

3. Physiological changes

3.1. Body mass and composition

Aging causes various changes in body composition, which have important consequences on health and physical functions. There is a progressive decrease in lean body mass and an increase in body fat.²¹ Decreased physical activity accounts for the increased body fat, and this may lead to decreased energy intake with aging.²² These changes in body composition, including those in fat distribution, may be associated with changes in various physiological functions that affect metabolism, nutrient intake, physical activity, and risk for chronic diseases.²³ There is also an alteration in bone density that results from a decrease in mineral content, which occurs with aging.²⁴ Severe osteoporosis may cause the bones in the legs to bow under the weight of the body. This bowing, together with changes of the spine, makes measurement of height unreliable

in some elderly people, even in those who are able to stand unaided.²⁵ Body weight is easily affected by short-term environmental aspects of life, in addition to the effects of acute and chronic diseases or undernutrition.²⁶

3.2. Physical activity

Total energy expenditure of an individual is reduced with the reduction in physical activity, and this is an important factor contributing to a reduced energy requirement in the elderly.²⁷ However, the energy cost of normal activities has been reported to increase with age for men.²⁸ Studies conducted in elderly people showed that ~70% of the elderly in the 60–69-year age group reported no outdoor activity in the previous 4 weeks, and this proportion was even higher in the over-70-year age group.²⁹ Another feature of aging that may restrict physical activity is that elderly people are prone to developing a variety of degenerative and chronic diseases; chronic obstructive airway disease, angina, and arthritis are some examples. Physical activity contributes to good physical and psychological health at all ages,³⁰ and inactivity associated with minor illness in the elderly often leads to loss of muscle tone and mass, and, thereafter, former physical activity levels may never be regained.

4. Etiology of weight loss

Three distinct mechanisms of weight loss in older people have been identified: (1) Wasting: An involuntary loss of weight is mainly due to poor dietary food intake, which can be a result of diseases and psychological factors causing an overall negative energy balance. (2) Cachexia: It is an involuntary loss of fat-free mass (muscle, organ, tissue, skin, and bone) or body cell mass; it is caused by catabolism and results in changes in body composition. (3) Sarcopenia: Sarcopenia, a decline in skeletal muscle mass, is a major age-related physiological change in older people; reduced physical activity among the elderly has a crucial role, since a lack of exercise causes muscle disease and, with time, muscle loss.³¹

Elderly patients with unintentional weight loss are at a higher risk for infection, depression, and death. Weight loss in the elderly due to voluntary or involuntary causes has been associated with mortality. The leading causes of involuntary weight loss are depression (especially in residents of long-term care facilities), cancer (lung and gastrointestinal malignancies), cardiac disorders, and benign gastrointestinal diseases. Although lean body mass may decline because of normal physiological changes associated with age,³¹ a loss of > 4% per year is an independent predictor of mortality.³² A rapid weight loss of $\geq 5\%$ in 1 month is considered significant and needs to be evaluated immediately by a physician.^{33,34} Polypharmacy can cause unintended weight loss, as can psychotropic medication reduction (i.e., by unmasking problems such as anxiety). However, early identification, assessment, and treatment of weight loss and nutritional deficiencies may prevent morbidities among the elderly.

5. Age-associated changes in the gastrointestinal system

Effects of aging on the perceptions of smell and taste have been observed, which may alter or decrease food intake. This is a common perceived problem among elderly individuals who complain of a loss of both taste and smell.³⁵ There may be a progressive loss in the number of taste buds per papilla on the tongue. The remaining taste buds, which detect primarily bitter or sour tastes, show a relative increase with aging.³⁴ Impaired appetite is often associated with a reduction in taste and smell, which occurs in up to 50% of elderly people.³⁶ Improperly fitting dentures may unconsciously change eating patterns because of difficulty with chewing, leading to the intake of a soft, low-fiber diet without important fresh fruits and

vegetables. There are some documented gastrointestinal changes in the elderly that can affect their food intake, for example, changes in peristaltic activity of the esophagus, which may result in a delay in esophageal emptying.³⁷ Widespread nutritional deficiencies are also associated with bacterial contamination of the small bowel.^{38–40} It was found that 17 of 24 malnourished patients had bacterial contamination of the small bowel.⁴⁰ There was a significant improvement in the nutritional status of elderly patients after treatment of bacterial contamination with antibiotics.^{38,40} Other gastrointestinal changes occur with age and may affect food intake. For example, greater satiation after a meal and a delay in gastric emptying have been observed in older people.

6. Age-associated changes in the renal and genitourinary systems

The kidneys' job is to keep the body's fluids, electrolytes, and organic solutes in a healthy balance. The functional units of the kidney are a million or so nephrons present in the renal cortex, which filter most of the constituents of the blood other than red blood cells and protein, reabsorb needed substances, secrete hydrogen ions to maintain the acid–base balance, and secrete wastes.⁴¹ In addition to gastrointestinal physiological changes, renal function declines with age. There is a decrease in kidney mass, blood flow, glomerular rate (10% decrement per decade after the age of 30 years), and the elasticity, muscle tone, and capacity of the bladder. Severity can vary, but most cases are mild or moderate in older people, do not cause symptoms, and do not progress to kidney failure. Renal impairment may also affect vitamin D metabolism and result in a reduction of vitamin D levels, which contributes to osteoporosis in the elderly.⁴²

7. Age-associated changes in the nervous system and cognition

With advancing age, risks for cognitive decline increase, affecting the independence and quality of life. Insufficient intake of selected vitamins, or certain metabolic disorders, may affect cognitive processes by disrupting the nutrient-dependent processes within the body that are associated with the management of energy in neurons, which can subsequently affect synaptic plasticity or the ability to encode new memories.⁴³ The earliest signs of mild cognitive impairment or pre-Alzheimer's disease are decreases in the ability to prepare food, forgetting to eat, and inability to access food, which can further impair oral intake.

Vitamin deficiencies, particularly vitamins B₁₂, B₆, and folate, are associated with cognitive impairment.^{44–46} Nutritional interventions have an impact on vascular disease prevention. It is well established that a diet low in fat and cholesterol is beneficial in modifying vascular risk factors. Emerging research suggests that supplementation with omega-3 fatty acids (such as those found in salmon and other cold-water fish) and consumption of cruciferous vegetables (such as broccoli, cabbage, and cauliflower) are all associated with stroke prevention^{47–49} and may be beneficial if integrated into the diet of all elderly patients with vascular disease or vascular risk factors.

Other important antioxidants with possibly beneficial outcomes include food with high levels of phytochemicals and flavonoids. Tomatoes, citrus fruit, blueberries, and certain spices⁵⁰ are known to reduce oxidative stress and cognitive impairment.

8. Associated changes in the immune system

Immune response dysfunction with increased susceptibility to infection, reduced efficacy of vaccination, chronic inflammatory

state. The immune defense system is adversely affected by the aging process,^{51,52} and there is strong evidence that a poorly functioning immune system can contribute to decreased disease resistance and reduced life expectancy in the elderly. Elderly people are more likely to die of infections than young adults,⁵³ and malnutrition is related to an increased risk of sepsis in the elderly.⁵⁴ Infections of all kinds increase the metabolic rate, making it more difficult for older persons to eat enough to keep up with elevated energy demands.⁵⁵

9. Social and psychological factors related to aging

Although not having many close friends contributes to poor health in many older adults, those who also feel lonely face even greater health risks. It is difficult to change some of the already established food habits, carried over from childhood. Food habits are influenced by several factors such as family, education, occupation, economic status, lifestyle, and cultural norms. Factors that have a negative influence on the health and nutrition of the elderly are a lack of family support in times of need (because of widely prevalent nuclear family system), feeling of not being wanted, economic constraints, a lack of value system among the members in the family, stressful conditions leading to tensions, and loneliness leading to disinterestedness in living and eating, resulting in malnutrition.

10. Protein undernutrition

Protein undernutrition is a known factor in the pathogenesis of osteoporotic fractures in the elderly. There is no consensus on the definition of protein energy malnutrition in elderly people.⁵⁶ One view categorizes protein energy malnutrition as an inadequate intake of calories and protein (marasmus-type malnutrition). Another suggests that protein energy malnutrition arises from a response to a biological stress (low-albumin malnutrition; Figure 2).⁵⁷ Classically, in marasmus-type malnutrition, patients lose weight by decreasing body fat and muscle mass while maintaining a normal serum albumin. This type of weight loss is more typical of a senior living either in the community or in a long-term care setting. Low-albumin malnutrition is more typical of a hospitalized patient, but the mechanisms of bone loss resulting from this deficiency are still poorly understood. The metabolic stress of insufficient protein intake, as well as the effects of hepatic, renal, or

bowel disease, will further impair an older patient's overall nutritional state. Protein undernutrition has been associated with an increased risk of injury in elderly patients,^{58,59} while protein supplementation has been shown to help reduce unfavorable outcomes following injury in patients over the age of 65 years.^{60,61}

11. Nutritional requirements in older people

11.1. Mediterranean diet

Currently, a Mediterranean diet is recommended due to the growing evidence of lower risk of mortality associated with it, especially in older adults who have had coronary heart disease, as this diet is rich in fruit and vegetables. "Mediterranean diet" is a modern nutritional recommendation originally inspired by the traditional dietary patterns of Greece, southern Italy, and Spain.⁶² The principal aspects of this diet include proportionally high consumption of olive oil, legumes, unrefined cereals, fruits, and vegetables, moderate to high consumption of fish, and moderate consumption of dairy products (mostly as cheese and yogurt).⁶³ A study looked at diet and nutritional status of men and women in Denmark. The Mediterranean diet differs from the North European diet with regard to both the types and the qualities of the food eaten. The North European diet was found to be sandwich-based meals, which include large amounts of butter, sausages, and cheese. The result of this study also showed that a Mediterranean diet pattern favorably affects survival in elderly people.⁶³

12. Okinawa diet

Okinawa diet plan has taken the center stage of discussion among nutrition scientists and health-conscious individuals alike. The traditional diet of the islanders contains 30% green and yellow vegetables. Although the traditional Japanese diet usually includes large quantities of rice, the traditional Okinawa diet contains smaller quantities of rice; sweet potato is used instead of rice as the staple food. The Okinawa diet has only 30% of sugar and 15% of the grains of the average Japanese dietary intake.⁶⁴

13. Specific nutrient needs

Ideally, no specific nutrient requirements have been worked out for the elderly in India. ICMR has given a table of reduced calorie

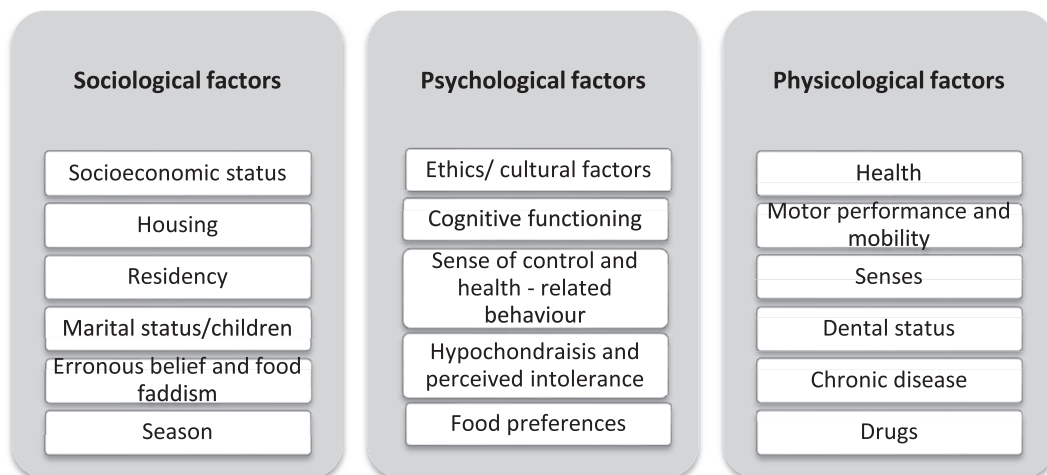


Figure 2. Factors that can contribute to protein energy malnutrition in the elderly. *Note.* From "Essentials of clinical geriatrics. 3rd ed," by Kane RL, Ouslander JG, Abrass IB, 1994. New York: McGraw-Hill. Copyright@ Springer. Kane RL, 1994. Reprint with Permission.

intake with advancing age. It is assumed that there are some differences in the requirements of the elderly as compared to those of young adults, because calorie intake is proportional to energy expenditure.

14. Energy

Elderly people require less energy than young adults because of a reduced basal metabolic rate; as a result, there is a reduction in the levels of activity. Energy requirement is dependent on a number of factors, including age, gender, body composition, weight, and activity levels. Generally, energy requirements decrease due to loss of fat-free mass. As a consequence, resting energy expenditure is found to be lower in elderly individuals than in young adults. In those older people who have very low energy requirements, there is a risk of their diet not meeting micronutrient requirements; the quality of diet is therefore of prime importance to ensure that deficiencies do not develop. Older people should be encouraged to meet their energy requirement through a healthy diet. Recommended energy intake for the elderly is 1.41.8 multiples of the basal metabolic rate to maintain the body weight at different levels of physical activity (Table 3).⁶⁵

15. Protein

Protein is necessary for building up muscles, and to replenish vital body fluids, and wear and tear of the body. It is also required for the metabolic processes of the body in the form of enzymes and hormones. Older persons are vulnerable to protein–energy malnutrition associated with a progressive decline in body protein manifested by declining fat-free mass.⁶⁶ The reduction in fat-free mass is attributed mainly to the loss of skeletal muscle and is associated with reduced muscle strength as well as predisposition to many metabolic disorders. The requirement of protein for older persons is 0.91.1 g/kg/d. Adequate protein intake can be achieved by the inclusion of milk and milk products, eggs, meat, fish, and chicken, as well as pulses and nuts in the diet. However, it is advisable to consume eggs, whole milk, and fatty meats sparingly as they are rich sources of fat and cholesterol.⁶⁷

16. Fat

Fat is a concentrated source of energy. It makes food palatable and help in the absorption of fat-soluble vitamins such as A, D, E, and carotenes. Fats and oils are concentrated sources of energy. According to the World Health Organization (2002),⁶⁷ except for in cases of overweight or obesity, there is no need to restrict fat intake beyond 30 energy % for sedentary and 35 energy % for active older persons. However, consumption of saturated fats should be

minimized and should not exceed 8 energy %. It is desirable to include a variety of fats in the diet, particularly n-3 fatty acids found in fish, soy, linseed, canola seed and oil, seaweed, and green leaves. Fats and oils such as ghee, butter, and refined oils should be taken in moderation. Fried food, rich pastries, and fatty meat should be avoided.⁶⁶

17. Carbohydrate

Carbohydrates are energy-giving nutrients, and the body needs carbohydrates because it cannot make it for itself from other nutrients. Carbohydrates are energy-yielding substances. Senses of taste and smell are less sharp among older people, which interfere with the appetite for many foods. During old age, loss of teeth makes it difficult to chew food properly. Elderly people tend to consume more carbohydrate-rich food, which require minimum chewing, are easily digested, need minimum cooking time, stand maximum storage, and are cheaper than protein-rich food. Carbohydrates form the bulk of daily diet of the elderly. In the Indian dietary, 55–65 energy % should be provided by carbohydrates. Care should be taken to restrict the amount of sugar and refined cereals in the diets, and include whole cereals, pulses, fiber-rich fruits, and vegetables instead.⁶⁶

18. Fiber

Apart from digestible carbohydrates such as cereals and sugar, several foods contain nondigestible carbohydrates in the form of cellulose, gums, and pectin. They are called dietary fiber because they are indigestible. Dietary fiber contributes to the bulk of stools, and helps relieve constipation and lower blood cholesterol level, especially among elderly people. Consumption of 25-30 g of fiber daily is considered to be beneficial.⁶⁶

19. Calcium and vitamin D

These help in maintaining good bone health. Therefore, it is advisable to increase the intake of calcium-rich food such as milk and milk products such as cottage cheese and curd, green leafy vegetables, and sesame seeds (til). If elderly people are confined indoors and are not exposed to sunshine, they should be given vitamin D supplements. Anemia is another common nutritional problem in old age, and efforts must be made to include iron-rich green leafy vegetables, fresh food, jaggery, rice flakes, etc. in the diets of elderly people.⁶⁶

Vitamin A (beta-carotene), vitamin E, and vitamin C are protective antioxidants. Liberal intake of food rich in beta-carotene, such as green, yellow, and orange vegetables and fruits, is advocated due their antioxidant properties. Citrus fruits, green leafy vegetables, cabbage, green chilies, amla, guava, and sprouted pulses are rich sources of vitamin C.⁶⁶ Folate, found in green leafy vegetables, pork, liver, pulses, groundnuts, and oilseeds, is associated with a diminished risk of vascular disease. In addition to the recognized essential nutrients, there are many other food components, collectively known as phytochemicals, about which little is known, but through their biological effects, they can lower the risk of major health problems such as cancer and heart disease. Hence, consumption of food rich in phytochemicals such as green tea, red wine, garlic, tomatoes, and so on should be encouraged. Many degenerative age-related diseases aggravate the tendency toward dehydration in older persons. Generally, adults require ~30 mL/kg of fluids per day. These fluids need not be restricted to water only and may include other fluids such as milk, juices, soft drink, soup, tea, and coffee. However, tea and coffee should be taken in moderate amounts only.⁶⁷

Table 3
Energy requirements for Indian elderly people (≥ 60 years) at different body weights.

| | Body weight (kg) | Sedentary (kcal) | Moderate (kcal) |
|--------|------------------|------------------|-----------------|
| Male | 50 | 1688 | 1985 |
| | 55 | 1786 | 2101 |
| | 60 | 1883 | 2216 |
| | ≥ 65 | 2008 | 2446 |
| Female | 50 | 1630 | 1917 |
| | 55 | 1706 | 2007 |
| | 60 | 1782 | 2097 |
| | ≥ 65 | 1900 | 2200 |

Note. From "Nutrient requirement and recommended dietary allowance for Indians," by National Institute of Nutrition, ICMR, 2009. Copyright© ICMR. National Institute of Nutrition, 2009. Reprint with Permission.

20. Conclusion

Consuming food rich in nutrients and other bioactive components such as phytochemicals may help protect people against major age-related disorders. Positive changes in the quality or amount of food consumed are never without benefit, regardless of age or physical status. Older people who are frail are at a risk of malnutrition, so the aspects of healthy eating guidelines related to reducing consumption of energy-dense food are inappropriate. For many years, changing nutritional requirements at different life stages remained under-researched, with scientists focusing on first understanding the fundamental roles that macronutrients and micronutrients, and their combinations play in health. As our basic understanding has increased, research has turned to exploring the implications through our life course. Our understanding of specific requirements, particularly at the early and later stages of life, is fast changing, and with the population aged over 60 years set to increase globally in future, the research in this field is likely to increase further.

Conflicts of interest

No potential conflicts of interest were disclosed.

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