
Ageing Process and Physiological Changes

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Abstract

Ageing is a natural process. Everyone must undergo this phase of life at his or her own time and pace. In the broader sense, ageing reflects all the changes taking place over the course of life. These changes start from birth—one grows, develops and attains maturity. To the young, ageing is exciting. Middle age is the time when people notice the age-related changes like greying of hair, wrinkled skin and a fair amount of physical decline. Even the healthiest, aesthetically fit cannot escape these changes. Slow and steady physical impairment and functional disability are noticed resulting in increased dependency in the period of old age. According to World Health Organization, ageing is a course of biological reality which starts at conception and ends with death. It has its own dynamics, much beyond human control. However, this process of ageing is also subject to the constructions by which each society makes sense of old age. In most of the developed countries, the age of 60 is considered equivalent to retirement age and it is said to be the beginning of old age. In this chapter, you understand the details of ageing processes and associated physiological changes.

Keywords: ageing, physiological changes, elderly health, sensory changes, geriatrics

1. Introduction

The term 'Elderly' is applied to those individuals belonging to age 60 years and above, who represent the fastest growing segment of populations throughout the world. The percentage of elderly in developing countries tends to be small, although numbers are often large. In the year 1990, there were more than 280 million people belonging to the age 60 years or over in developing regions of the world, and 58% of the world's elderly were living in less-developed regions [1].

According to World Population Prospects (1950–2050), the proportion of elderly in developing countries is rising more rapidly, in comparison with developed ones [2]. The report published by the US Department of Health and Human Services shows that more developed nations have had decades to adjust to this change in age structure (**Figures 1 and 2**). As we see in **Figure 1**, it has taken more than a century for France’s population aged 65 or older to rise from 7 to 14%, whereas many developing countries are growing rapidly in number and percentage of older individuals [2].

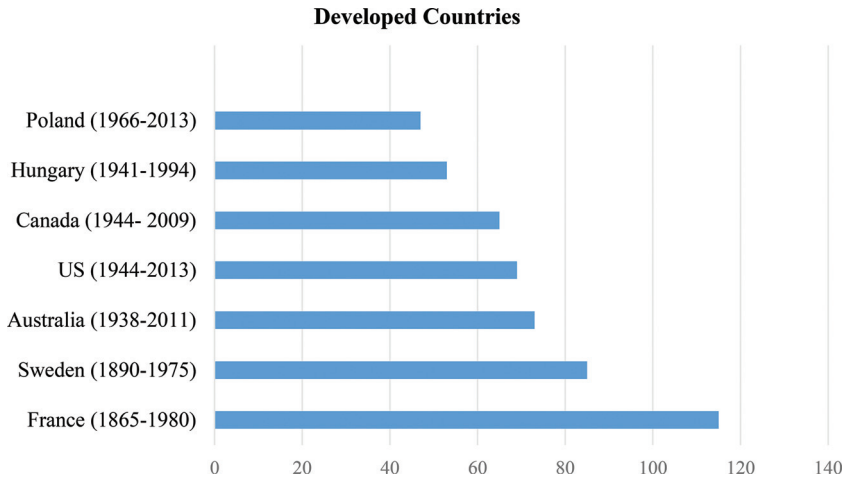


Figure 1. Speed of population ageing in developed countries. Source: U.S. Census Bureau [3]; Kinsella & Gist [4].

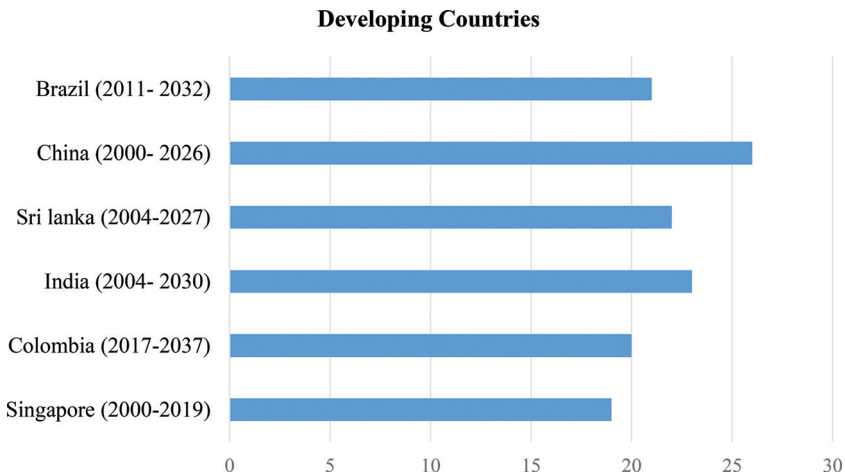


Figure 2. Speed of population ageing in developing countries. Source: U.S. Census Bureau [3]; Kinsella & Gist [4].

It is expected that by the year 2020, 70% of the world's elderly population will be in developing countries, with the absolute number exceeding 470 million which is double the number of the developed world [5]. The main factor responsible for this changing pattern of population ageing includes a rapid decline in both fertility and premature mortality [6]. Decline in fertility is particularly apparent in some developing countries like China, Cuba and Uruguay, although the fertility level in other developing countries such as Kenya, Zaire and Bangladesh remains high [7].

2. Ageing process and physiological changes

2.1. Changes in nervous system

Ageing is associated with many neurological disorders, as the capacity of the brain to transmit signals and communicate reduces. Loss of brain function is the biggest fear among elderly which includes loss of the very persona from dementia (usually Alzheimer's disease). Multiple other neurodegenerative conditions like Parkinson's disease or the sudden devastation of a stroke are also increasingly common with age [8].

Alzheimer's and Parkinson's diseases are the progressive neurodegenerative diseases associated with ageing [9]. Alzheimer's is characterised by progressive cognitive deterioration along with a change in behaviour and a decline in activities of daily living. Alzheimer's is the most common type of pre-senile and senile dementia. This disease causes nerve cell death and tissue loss throughout the brain, affecting nearly all its functions. The cortex in the brain shrivels up and this damages the areas involved in thinking, planning and remembering. The shrinkage in a nerve cell is especially severe in the hippocampus (an area of the cortex that plays a key role in the formation of new memories) as well as the ventricles (fluid-filled spaces within the brain) also grow larger. Alzheimer's disease causes an overall misbalance among the elderly by causing memory loss, changes in personality and behaviour-like depression, apathy, social withdrawal, mood swings, distrust in others, irritability and aggressiveness [10, 11].

Nearly, 33 million Indians have neurological disorders, and these occur twice as often in rural areas [12]. According to the World Health Organisation (WHO) [13], nearly 5% of men and 6% of women aged 60 years or above are affected with Alzheimer's-type dementia worldwide. In India, the total prevalence of dementia per 1000 elderly is 33.6%, of which vascular dementia constitutes approximately 39% and Alzheimer's disease constitutes approximately 54% [14].

Stroke is another common cause of mortality worldwide [13]. However, in India, the prevalence rate of stroke among elderly is reported to be very low compared to Western countries [15–17].

2.2. Cognition

A mild decline in the overall accuracy is observed with the beginning of the 60s that progresses slowly, but sustained attention is good in healthy older adults. Cognitive function declines and

impairments are frequently observed among the elderly. Normally, these changes occur as outcomes of distal or proximal life events, where distal events are early life experiences such as cultural, physical and social conditions that influence functioning and cognitive development [17].

Cognition decline results from proximal factors (multiple serial cognitive processes) including processing speed, size of working memory, inhibition of extraneous environmental stimuli and sensory losses. This is a threat to the quality of life of those affected individuals and their caregivers [18].

Impaired cognition among elderly is associated with an increased risk of injuries to self or others, the decline in functional activities of daily living and an increased risk of mortality [19–21]. Mild cognitive impairment is increasingly being recognised as a transitional state between normal ageing and dementia [22, 23].

2.3. Memory, learning and intelligence

According to various studies [24–26], the effect of normal ageing on memory may result from the subtly changing environment within the brain. The brain's volume peaks at the early 20s and it declines gradually for rest of the life. In the 40s, the cortex starts to shrink and people start noticing the subtle changes in their ability to remember or to do more than one task at a time. Other key areas like neurons shrink or undergo atrophy and a large reduction in the extensiveness of connections among neurons (dendritic loss) is also noticed. During normal ageing, blood flow in the brain decreases and gets less efficient at recruiting different areas into operations. The whole group of changes taking place in the brain with ageing decreases the efficiency of cell-to-cell communication, which declines the ability to retrieve and learn [27]. It also affects the intelligence, especially fluid intelligence (problem-solving with a novel material requiring complex relations) declines rapidly after adolescence. Perceptual motor skills (timed tasks) decline with age [28].

2.4. Special senses

2.4.1. Vision

Ageing includes a decline in accommodation (presbyopia), glare tolerance, adaptation, low-contrast activity, attentional visual fields and colour discrimination. Changes occur in central processing and in the components of the eye. These numerous changes affect reading, balancing and driving [29].

2.4.2. Hearing

Ageing causes conductive and sensory hearing losses (presbycusis); the loss is primarily high tones, making consonants in speech difficult to discriminate [30].

2.4.3. Taste acuity

Losing sense of taste is a common problem among adults [31]. Taste acuity does not diminish but salt detection declines. Perception of sweet is unchanged and bitter is exaggerated. The

salivary glands get affected, and the volume and quality of saliva diminish. All changes combine to make eating less interesting [32]. Studies show that the physiological decline in the density of the taste acuity and papillae results in a decline of gustatory function [33]. In fact, studies done on taste dysfunction show that ageing-associated changes in the density of taste acuity may affect taste function differently in different regions of the tongue [34]. Taste perception declines during the normal ageing process. A study done on the healthy elderly shows that after about 70 years of age, taste threshold begins to increase resulting in dysgeusia [34]. Chewing problems associated with loss of teeth and use of dentures also interfere with taste sensation and cause reduction in saliva production [32].

2.4.4. Smell

As we get older, our olfactory function declines [35]. Hyposmia (reduced ability to smell and to detect odours) is also observed with normal ageing [36]. The sense of smell reduces with an increase in age, and this affects the ability to discriminate between smells. A decreased sense of smell can lead to significant impairment of the quality of life, including taste disturbance and loss of pleasure from eating with resulting changes in weight and digestion [36].

It has been reported that more than 75% of people over the age of 80 years have evidence of major olfactory impairment. Many long-term studies show the evidence of a decline in olfaction considerably after the seventh decade [37]. Another study found that 62.5% of 80–97-year-olds had olfactory impairments [38]. However, it is widely accepted that taste disorders are far less prevalent than olfactory losses with age [38]. Ageing also causes atrophy of olfactory bulb neurons. Central processing is altered, resulting in a decreased perception and less interest in food [39].

2.4.5. Touch

As we age, our sense of touch often declines due to skin changes and reduced blood circulation to touch receptors or to the brain and spinal cord. Minor dietary deficiencies such as the deficiency of thiamine may also be a cause of changes [40]. The sense of touch also includes awareness of vibrations and pain. The skin, muscles, tendons, joints and internal organs have receptors that detect touch, temperature or pain [41].

A decline in the sense of touch affects simple motor skills, hand grip strength and balance. Studies have shown that muscle spindle (sensory receptors within the muscle that primarily detects changes in the length of this muscle) and mechanoreceptor (a sense organ or a cell that responds to mechanical stimuli such as touch or sound) functions decline with ageing, further interfering with balance [42].

3. Changes in musculoskeletal system

Normal ageing is characterised by a decrease in bone and muscle mass and an increase in adiposity [43, 44]. A decline in muscle mass and a reduction in muscle strength lead to risk of

fractures, frailty, reduction in the quality of life and loss of independence [45]. These changes in musculoskeletal system reflect the ageing process as well as consequences of a reduced physical activity. The muscle wasting in frail older persons is termed 'sarcopaenia'. This disorder leads to a higher incidence of falls and fractures and a functional decline. Functional sarcopaenia or age-related musculoskeletal changes affect 7% of elderly above the age of 70 years, and the rate of deterioration increases with time, affecting over 20% of the elderly by the age of 80 [46]. Strength declines at 1.5% per year, and this accelerates to as much as 3% per year after 60 years of age [47]. These rates were considered high in sedentary individuals and twice as high in men as compared with those in women [48]. However, studies show that on an average, men have larger amounts of muscle mass and a shorter survival than women. This makes sarcopaenia potentially a greater public health concern among women than among men [48].

Skeletal muscle strength (force-generating capacity) also gets reduced with ageing [45, 46] depending upon genetic, dietary and, environmental factors as well as lifestyle choices. This reduction in muscle strength causes problems in physical mobility and activity of daily living. The total amount of muscle fibres is decreased due to a depressed productive capacity of cells to produce protein. There is a decrease in the size of muscle cells, fibres and tissues along with the total loss of muscle power, muscle bulk and muscle strength of all major muscle groups like deltoids, biceps, triceps, hamstrings, gastrocnemius (calf muscle), and so on. Wear and tear or wasting of the protective cartilage of joints occurs. The cartilage normally acts as a shock absorber and a gliding agent that prevents the friction injuries of the bone. There are stiffening and fibrosis of connective tissue elements that reduce the range of motion and affect the movements by making them less efficient. As part of the normal cell division process, telomere shortening occurs. DNA is more exposed to chemicals, toxins and waste products produced in the body. This whole process increases the vulnerability of cells.

With ageing, toxins and chemicals build up within the body and tissues. As a whole, this damages the integrity of muscle cells. Physical activity also decreases with age, due to a change in lifestyle. Somehow, the physiological changes of the muscles are aggravated by age-related neurological changes [49]. Most of the muscular activities become less efficient and less responsive with ageing as a result of a decrease in the nervous activity and nerve conduction.

A study was done by Williams et al. [50], who evaluated the muscle samples from both elderly and young adults and suggested that limb muscles are 25–35% shorter and less responsive in elderly healthy individuals when compared to young adults. In addition, the overall fat content of muscles was also higher in elderly population, suggesting transformation in the normal remodelling with age. Age-related musculoskeletal changes are much more prominent in fast-twitch muscle fibres as compared to slow-twitch muscle fibres. With ageing, the total water content of the tissue decreases and loss of hydration also adds to the inelasticity and stiffness. Alterations in the basal metabolic rate and slowing metabolism (as part of the physiological ageing process) result in muscle changes. This leads to the replacement of proteins with fatty tissue (that makes muscle less efficient).

Hormonal disorders can affect the metabolism of bones as well as muscles. Research suggests that menopause in women marks the aggravation in the deterioration of musculoskeletal changes due to lack of oestrogen that is required for the remodelling of bones and soft tissues. Certain systemic conditions like vascular disorders or metabolic disorders, in the case of

diabetes, affect the remodelling of tissues as the rate or volume of nutritional delivery for the regeneration of cells is compromised. It is very important to control the pathological processes to optimise healing and repairing the potential of the musculoskeletal system. Essential vitamins like vitamin D and vitamin C play major roles in the functional growth of muscles and bones. Lack of certain minerals like calcium, phosphorus and chromium can be the result of age-related digestive issues. As such, it results in imbalance in the production of certain hormones like calcitonin and parathyroid that regulate the serum concentration of vitamins and minerals (due to tumours that are highly prevalent in elderly) or it causes a decreased absorption from the gut.

Age-related deterioration of muscular strength and balance control mechanisms has been associated with a reduced performance on functional tasks [51–53]. Comparing the isometric strength levels of the same muscle group, the loss of strength begins sooner among women than among men. It is reported that women are weaker than men in the absolute strength of various muscle groups in all stages of life. Various studies state that women have a longer life span, so the prevalence of disability among women is also more compared with men and it is marked with advancing age [54–56].

4. Body composition changes in old age

The human body is made up of fat, lean tissue (muscles and organs), bones and water. After the age of 40, people start losing their lean tissue. Body organs like liver, kidneys and other organs start losing some of their cells. This decline in muscle mass is associated with weakness, disability and morbidity [57, 58].

The tendency to become shorter occurs among the different gender groups and in all races. Height loss is associated with ageing changes in the bones, muscles and joints. Studies show that people typically lose almost one-half inch (about 1 cm) every 10 years after age 40 [59]. Height loss is even more rapid after age 70. These changes can be prevented by following a healthy diet, staying physically active and preventing and treating bone loss [60, 61].

Changes in the total body weight vary for men and woman, as men often gain weight until about age 55 and then begin to lose weight later in life. This may be related to a drop in the male sex hormone testosterone. Women usually gain weight until age 67–69 and then begin to lose weight. Weight loss later in life occurs partly because fat replaces lean muscle tissue and fat weighs less than muscle [60]. Studies have also shown that older people may have almost one-third more fat compared to when they were younger. Fat tissue builds up towards the centre of the body, including around the internal organs [60, 62, 63].

5. Obesity in elderly: prevalence

Today, as standards of living continue to rise, weight gain is posing a growing threat to the health of inhabitants from countries all over the world. Obesity is a chronic disease, prevalent in both developed and developing countries, and it is affecting all age groups. Indeed, it is now so common

that it is replacing the more traditional public health concerns, such as infectious diseases and undernutrition, as the most common and significant contributors of ill health [64–67] (**Figure 3**).

As per World Health Organisation (WHO), globally, approximately 2.3 billion elderly people are overweight and more than 700 million elderly people are obese [68]. Most elderly belonging to the middle and high socio-economic groups are prone to obesity and complications related to obesity, due to sedentary lifestyles and a reduced physical mobility [69]. Obesity is considered as one of the major risk factors which causes the onset and increases the severity of non-communicable diseases (NCDs). It is a worldwide health problem, affecting elderly from both developed and developing countries. In elderly, obesity contributes to the early onset of chronic morbidities and functional impairments which lead to premature mortality [70].

5.1. Obesity among elderly: developed countries

The population in developed countries have proportionally a greater number of older adults living to older ages, and the prevalence of obesity is rising progressively, even among this age group [71].

The prevalence of obesity among elderly belonging to United States ranges from 42.5% in women to 38.1% in men, belonging to the age group 60–79 years. The prevalence differs for the elderly belonging to the age group 80 years and above, that is, 19.5% for females and 9.6% for males [72–74].

Comparatively, the prevalence of obesity in Europe is slightly lower but it is still a significant health issue. The prevalence of obesity among elderly in the United Kingdom is 22% among women and 12% among men aged 75 years or older [70, 75–77]. These statistics bode ill as the proportion of world's elderly population is growing rapidly (**Figure 4**).

In Australia, the percentage of weight gain has been so high that instead of losing weight with an increase in life, men and women aged 60–70 weigh more on average than they did when they were 20 years younger (**Figure 5**). Australian studies show that the prevalence of obesity

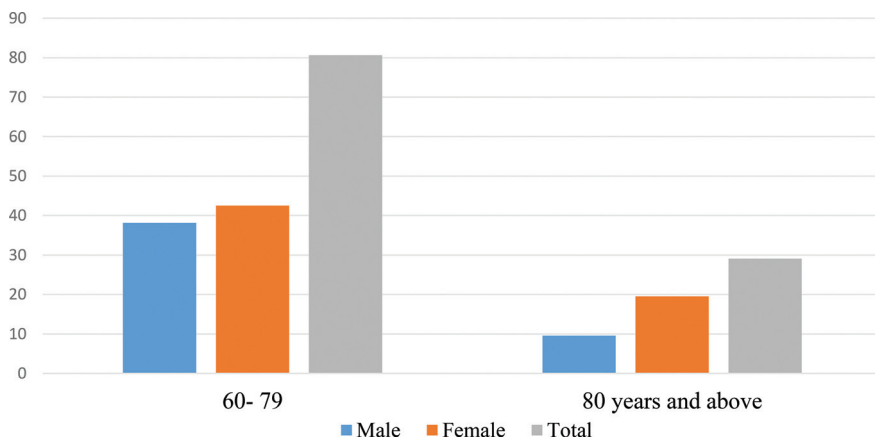


Figure 3. Prevalence of obesity among elderly aged 60 years and above, by sex: The United States, 2013. Source: [68].

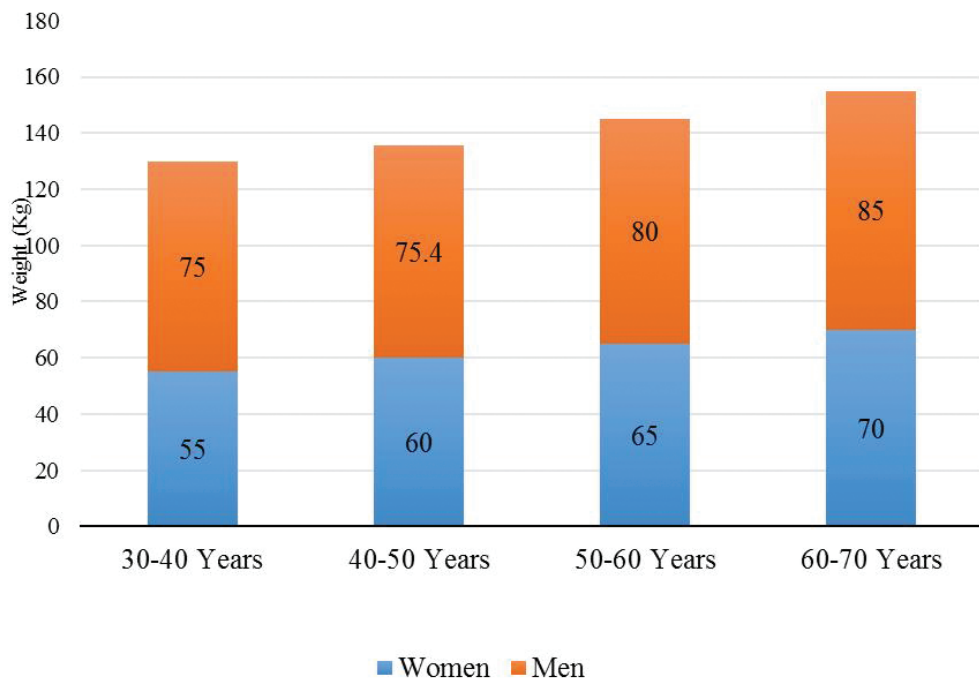


Figure 4. Trends in weight by age cohort, 1980–2000 (Australia). Source: Bennett et al. [81].

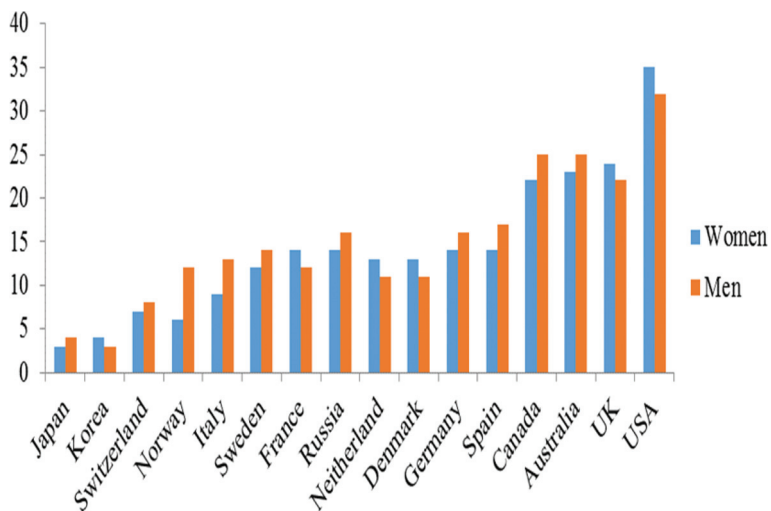


Figure 5. Worldwide prevalence of obesity among elderly women and men with BMI of ≥ 30 kg/m². Source: OECD [79]. Analysis of health survey data.

among elderly has increased in the age group of 60–69 years at about 24% for males and 30% for females, whereas it is less common among the elderly belonging to age group 80 years and above [78, 80]. Studies show that the percentage of Australian elderly reporting increased abdominal fat is markedly increasing over the years. Based on waist circumference, more than 30% of elderly males and 44% of elderly females in Australia are currently at a substantially increased risk of NCDs [78, 80, 81].

Studies from the Netherlands show that obesity was present in 18% of men and 20% of women belonging to the age group of 60 years and above [82]. Also, the increase in waist circumference ranged from 40% among males to 56% among females [82, 83].

In France, studies show that the prevalence of obesity among elderly was relatively stable during early years (1980–1991), 6.4–6.5% in males and 6.3–7.0% among females [83], but studies from recent years [84, 85] have highlighted a sharp increase in obese elderly, 19.5% for both males and females; this prevalence rate decreased gradually after 70 years of age, that is, from 19.5 to 13.2% [86]. The Scottish Health Survey shows that in 10 years (2003–2013), the prevalence of obesity has increased as the body mass index (BMI) continues to rise in people 60–70 years of age, especially among females [87]. In this same period, there was an increased curve shown for the waist circumference (5–10 cm) in both the sexes between 50 and 70 years of age. This inappropriate increase in waist circumference and a slight increase in BMI in the Scottish Health Survey may indicate a substantial gain in visceral fat mass and loss of lean tissue that predisposes to ill health in the obese elderly [88, 89].

In Spain, 35% of subjects aged 65 years or older suffered from obesity (30.6% of males and 38.3% of females) and 61.6% had an increased waist circumference (50.9% of males and 69.7% of females) [88].

5.2. Prevalence of obesity: developing countries

Over the past years, obesity among elderly was considered as a problem only in high-income countries, but the trend is changing now; excess weight, as well as obesity, is dramatically increasing in low-income and middle-income countries as well, particularly in urban settings [90]. Various studies show a significant change in the mean body weight, physical activity and diet along with progressive economic development in developing countries. Possibilities are high that obesity and its co-morbidities will continue to affect an increasing number of populations in these regions. Lifestyle and environmental factors are acting in a synergistic manner to fuel the obesity epidemic. As per WHO estimates, there is a decline in undernourished population across the world, whereas the overnourished population has increased to 1.2 billion [90]. A WHO report shows that more than 1 billion elderly are overweight and 300 million are obese. The problem of obesity is increasing in the developing world with more than 115 million people suffering from obesity-related problems [90]. The obesity rate has increased threefold or more since 1980 in the Middle East, the Pacific Islands and India [91, 92]. However, the prevalence of obesity is not as high in all developing countries, like China and some African nations [93].

As per the WHO report, the prevalence of overweight and obese elderly in China was 19.0 and 2.9%, respectively. However, the prevalence has increased over the past years; in the latest study, the prevalence of overweight and obesity among elderly was 21.0 and 7.4% [94, 95]. There was a slight increase in the prevalence of overweight and obesity among women than among men in China.

According to WHO estimates, among all Gulf regions, Kuwait ranked number one with the highest prevalence of overweight and obesity (78.8%) among elderly (60 years and above) [92]. Worldwide, Kuwait is ranked 11th, that is, the highest in obesity among the Arab countries and the Middle East [93, 96]. Studies from Sri Lanka show a prevalence rate of 25.2% for overweight and 9.2% for obesity. The prevalence of central obesity among elderly was highest at 26.2% [97, 98]. The prevalence of overweight and obesity in Brazil was 41.8% for females and 23.4% for males. According to the prevalence studies of obesity among elderly in Nigeria [99], overweight among elderly ranged from 20.3 to 35.1% and obesity ranged from 8.1 to 22.2%. WHO reported that the prevalence of obesity in Sub-Saharan African countries ranged between 3.3 and 18.0% and that obesity has become a leading risk factor for diabetes mellitus and cardiovascular diseases in the urban areas of Africa [93, 99]. The situation can get worse within a decade if the present trend continues and overweight could emerge as the single most important public health problem in adults. Overweight or obesity may not be a specific disease but it is certainly considered as a major contributory factor leading to various degenerative diseases in adult life. Prevention and control of this problem must, therefore, claim priority attention [100].

As per a study done in Delhi on urban elderly, nearly 14% of men and more than 50% of women belonging to what may be a higher-income group (HIG) were overweight (BMI >25) and obese (BMI >30) [101]. The prevalence of abdominal obesity among the elderly group was also reported as high. Assuming that the HIG in India number is around 100 million (half the number of the middle class), it may be computed that there are roughly 40–50 million overweight subjects belonging to the HIG in the country today. Visweswara et al. [102] studied females of Hyderabad (60 years and above) belonging to the high socio-economic status and reported the prevalence rate of obesity as 36.3%. Gopinath et al. [103] studied urban elderly in Delhi and reported the rate of prevalence of obesity as 33.4%. A study done in the Union Territory of Chandigarh showed an increase in BMI (>25) resulting in the high prevalence rate of overweight (33.14%) and obesity (7.54%) among elderly [104, 105].

6. Causes of obesity among elderly

The relationship between energy intake and energy expenditure is an important determinant of body fat mass. Obesity occurs when the consumption of calories is more than the calorie expenditure. The possible causes of obesity are depicted in **Figure 6**. Various studies indicate that how much we eat does not decline with advancing age; therefore, it is likely that a decrease in energy expenditure particularly in the beginning of old age (50–65 years) contributes to the increase in body fat as we age [62, 106]. At the age of 65 years and above, hormonal

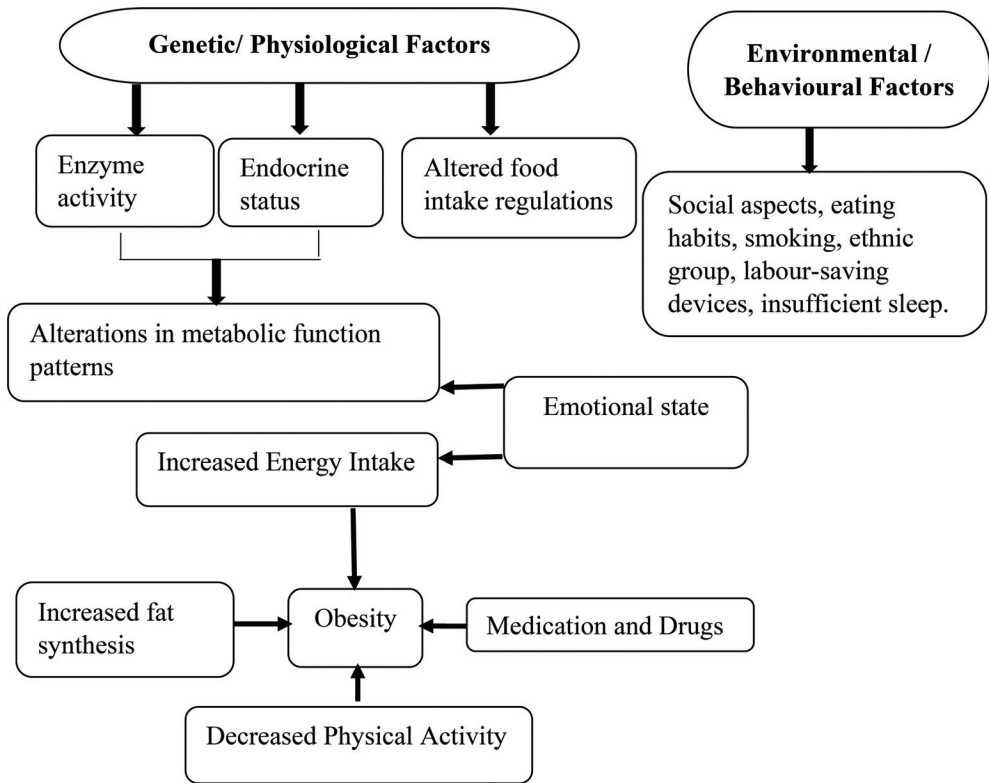


Figure 6. Possible causes of obesity. Source: La Berge [108].

changes cause an accumulation of fat. Ageing is associated with a decline in the secretion of growth hormone, serum testosterone, resistance to leptin and a reduced responsiveness to thyroid hormone [107]. Studies show that resistance to leptin could cause a decrease in the ability to regulate appetite downward [74]. Several other genetic, environmental and social factors contribute to obesity among elderly.

6.1. Genetic factors

Science does show a link between obesity and heredity [109]. Various studies indicate that obesity is related to the inherited genes and there is a link between obesity and heredity [110–113]. According to a study, visceral fat is more influenced by the genotype than subcutaneous fat [114].

6.2. Environmental and sociological factors

Like genetics, environment also has a major role to play in obesity. The food we consume, physical activity and lifestyle behaviour are all influenced by the environment. For example, the adoption of modern diet over traditional diet, the trend towards 'eating out' rather than

preparing food in the home, the development of high-rise buildings that often lack sidewalks and a deficit of readily accessible recreation areas are some of the common environmental factors associated with obesity.

Poverty and low education level also appeared as a reason for obesity among elderly. Studies state that the lack of nutritional knowledge, purchase of low-cost fat and organ meat are also associated with overweight and obesity. Poor hygienic conditions also appeared as a major reason [114].

6.3. Other causes of obesity

Other health issues and illnesses that are associated with obesity and weight gain are hyperthyroidism, polycystic ovary syndrome, Cushing's syndrome and depression [2]. Obese elderly are more likely to report symptoms of depression, such as hopelessness, sadness or worthlessness [115]. Sleep plays a major role. Lack of sleep contributes to obesity [106]. Certain drugs, such as antidepressants and steroids, may stimulate appetite or cause water retention or reduce the metabolic rate [82], causing an increase in weight. Health issues like arthritis and joint pain decrease mobility and activity intolerance, contributing to obesity [116]. Joint pain decreases mobility, and activity intolerance may lead to weight gain because of a decreased activity. Older adults are more likely than younger adults to experience functional limitations associated with chronic illnesses that may begin a stress-pain-depression cycle that can result in lifestyle patterns leading to obesity [117]. Finally, the complex relationship between lifestyle pattern and functional ability merits attention as a contributor to obesity [93].

7. Conclusion

In developing countries, as compared to developed countries, gerontology has drawn comparatively lesser attention. This is because the increased life expectancy of elderly resulting in a demographic transition which developing countries are witnessing today has already been faced by developed countries, several decades back. However, in recent years with a rising percentage of elderly population, epidemiologists, researchers, demographers and clinicians have focussed their attention towards elderly care health issues and various problems associated with ageing and numerous implications of this demographic transition.

Elderly face various problems and require a multi-sectoral approach involving inputs from various disciplines of health, psychology, nutrition, sociology and social sciences.

Conflict of interest

There is no conflict of interest.

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