

PHYSIOLOGICAL CHANGES DURING AGING

ALTERAÇÕES FISIOLÓGICAS DURANTE O ENVELHECIMENTO

CAMBIOS FISIOLÓGICOS DURANTE EL ENVEJECIMIENTO



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ABSTRACT

Population aging is a growing global phenomenon, marked by a significant increase in the proportion of older adults, driven by declining fertility rates and rising life expectancy. In Brazil, this process is occurring rapidly, bringing important implications for public health and social organization. Aging is characterized by progressive, heterogeneous, and multifactorial changes that affect various body systems, including the nervous, sensory, immune, endocrine, cardiorespiratory, musculoskeletal, gastrointestinal, urinary, and integumentary systems. These changes involve functional decline, structural alterations, and reduced adaptive capacity, directly impacting individuals' autonomy, quality of life, and functionality. Among other aspects, there is a reduction in neural plasticity, sensory changes (vision,

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hearing, smell, and taste), sleep fragmentation, immunosenescence, hormonal imbalances, decreased cardiorespiratory capacity, and loss of muscle mass and bone density. Additionally, socioeconomic, cultural, and individual factors significantly influence how aging manifests. Thus, understanding the physiological changes associated with senescence is essential for developing strategies for prevention, health promotion, and maintenance of functionality, contributing to healthy and active aging.

Keywords: Older Adults. Health. Functionality.

RESUMO

O envelhecimento populacional constitui um fenômeno global crescente, marcado pelo aumento expressivo da proporção de pessoas idosas, impulsionado pela redução das taxas de fecundidade e pelo aumento da expectativa de vida. No Brasil, esse processo ocorre de forma acelerada, trazendo importantes implicações para a saúde pública e para a organização social. O envelhecimento é caracterizado por alterações progressivas, heterogêneas e multifatoriais, que afetam diversos sistemas do organismo, incluindo os sistemas nervoso, sensorial, imunológico, endócrino, cardiorrespiratório, musculoesquelético, gastrointestinal, urinário e tegumentar. Essas mudanças envolvem declínio funcional, alterações estruturais e redução da capacidade adaptativa, impactando diretamente a autonomia, a qualidade de vida e a funcionalidade dos indivíduos. Destacam-se, entre outros aspectos, a redução da plasticidade neural, alterações sensoriais (visão, audição, olfato e paladar), fragmentação do sono, imunossenescência, desequilíbrios hormonais, diminuição da capacidade cardiorrespiratória e perda de massa muscular e densidade óssea. Além disso, fatores socioeconômicos, culturais e individuais influenciam significativamente a forma como o envelhecimento se manifesta. Dessa forma, compreender as alterações fisiológicas associadas à senescência é fundamental para o desenvolvimento de estratégias de prevenção, promoção da saúde e manutenção da funcionalidade, contribuindo para um envelhecimento saudável e ativo.

Palavras-chave: Idosos. Saúde. Funcionalidade.

RESUMEN

El envejecimiento poblacional constituye un fenómeno global creciente, caracterizado por el aumento significativo de la proporción de personas mayores, impulsado por la reducción de las tasas de fecundidad y el aumento de la esperanza de vida. En Brasil, este proceso ocurre de forma acelerada, lo que genera importantes implicaciones para la salud pública y la organización social. El envejecimiento se caracteriza por cambios progresivos, heterogéneos y multifactoriales que afectan diversos sistemas del organismo, incluidos los sistemas nervioso, sensorial, inmunológico, endocrino, cardiorrespiratorio, musculoesquelético, gastrointestinal, urinario y tegumentario. Estos cambios implican un deterioro funcional, alteraciones estructurales y una reducción de la capacidad adaptativa, impactando directamente la autonomía, la calidad de vida y la funcionalidad de los individuos. Entre otros aspectos, se destacan la reducción de la plasticidad neural, alteraciones sensoriales (visión, audición, olfato y gusto), fragmentación del sueño, inmunosenescencia, desequilibrios hormonales, disminución de la capacidad cardiorrespiratoria y pérdida de masa muscular y densidad ósea. Además, factores socioeconómicos, culturales e individuales influyen significativamente en la forma en que se manifiesta el envejecimiento. De esta manera, comprender los cambios fisiológicos asociados a la senescencia es fundamental para el desarrollo de estrategias de prevención, promoción de la salud y mantenimiento de la funcionalidad, contribuyendo a un envejecimiento saludable y activo.



Palabras clave: Adultos Mayores. Salud. Funcionalidad.

1 INTRODUCTION

A change in the population design is observed, where the number of elderly people only increases over the years. According to the World Health Organization (WHO, 2024), by 2030, 1 in 6 people in the world will be 60 years old or older. At that time, the share of the population aged 60 and over will increase from 1 billion in 2020 to 1.4 billion. By 2050, the world's population of people aged 60 and over will double (2.1 billion). The number of people aged 80 and over is expected to triple between 2020 and 2050, reaching 426 million.

In Brazil it is no different, with falling fertility rates and increased life expectancy due to improvements in health care and socioeconomic conditions resulting in a rapid aging of the population.

This is not a phenomenon unique to the country and reflects a global trend, but the demographic transition in Brazil is occurring at a very accelerated rate. While France saw its proportion of elderly people double from 10% to 20% in 140 years, in Brazil, this process should occur in just 25 years. Thus, by 2060, more than a quarter of our population will be over 60 years old (Mrejen, 2023).

Aging is a natural and important event, which occurs due to the accumulation of biological and functional transformations over time, resulting in senescence or a gradual reduction in the efficiency and functioning of the body's systems. This process occurs differently in all parts of the body.

Among the most noticeable changes are decreased skin elasticity, weakening of bones, and reduced muscle strength. In addition, senescence involves changes in the cardiovascular, respiratory, nervous, digestive, and sensory systems, which are impacted due to the drop in metabolism and the process of cell death (Pontes *et al.*, 2025).

The aging process is individual, however, it is heterogeneous, being strongly influenced by variables such as income level, sex, race/color, ethnicity, territory, among others. It is also important to highlight that the elderly population is made up of a very expressive age range, ranging from people aged 60 to those aged 100 years or older (Brasil, 2023).

The physiological changes of aging occur regardless of any factor, as it is inherent to the process of life. Therefore, the importance of knowing the changes that occur at this stage of life is demonstrated, as they go beyond simple organic changes, being a complex act for science, where understanding these changes that affect senescence, also helps in prevention, in improving the quality of life and functionality of this elderly person.

2 NERVOUS SYSTEM

The neurological changes of aging tend to manifest more rapidly after the age of 50 and are caused by changes in the central nervous system that include: neuroanatomical changes (brain atrophy, neuronal death), changes in neurotransmissions (decline in cholinergic transmission, decreased dopaminergic synthesis, decreased catecholamine synthesis); neurophysiological changes (decreased cerebral blood flow), among others (Cochar-Soares *et al.*, 2021).

According to Barreto (2020), magnetic resonance imaging scans have shown that brain aging is associated with structural atrophy such as: frontal cortex, hippocampus, thalamus, and nucleus accumbens. The author also observes that, in addition to the loss of gray matter and white matter, there is an increase in the cortical ventricles, sulci and subarachnoid spaces. These structural changes also have repercussions in different cortical regions, including the frontal, parietal, and temporal lobes.

The aging process brings changes in brain function, not only structural changes. There is a reduction in synaptic plasticity, where the brain's ability to organize and its connections in response to new experiences and changes ends up becoming one of the most critical factors. With advancing age, this ability decreases, leading the brain to have difficulty adapting to new changes and learning (Alves, 2024).

There can also be a drop in cerebrovascular function, leading to changes in the small arteries and arterioles. These characteristics of cerebrovascular aging can lead to certain complications such as: endothelial senescence; oxidative stress and inflammation; microvascular rarefaction; arterial stiffness; reduction of the vascular lumen and reduction of cerebral blood flow (Barreto, 2020).

3 SENSORY SYSTEM

3.1 VISION

Within the sensory system, vision is the sense that undergoes the most significant changes. From the fourth decade of life, some changes are noticed, both in the structure of the eye and in visual function. This occurs due to different factors, such as the loss of elasticity of the eyelids, where they become more flaccid and wrinkled, diseases of the eye, such as cataracts, and also acquired neurological or systemic diseases, such as diabetes.

In addition to these examples, other physiological changes in the vision of the elderly may also occur, such as: reduced visual acuity, narrowing of the field of vision, sensitivity to strong light, difficulty seeing at night, confusion between dark colors, and dryness in the eyes (Cordeiro *et al.*, 2021).

It is important to highlight some common pathologies in the elderly population, including presbyopia, characterized by decreased contrast sensitivity, difficulty adapting between light and dark, and reduced color perception. In addition, cataracts, marked by the opacity of the lens, are also frequent in aging.

Another important cause of visual impairment in the elderly is age-related macular degeneration, considered one of the main factors in the evolution to blindness in old age (Spadacio, *et al.*, 2023).

According to Fernandes *et al.*, (2024), low vision is directly linked to physical performance, where it can generate difficulties in performing daily and leisure activities, leading to the loss of autonomy in activities of daily living (ADLs) and contributing to the emergence of biopsychosocial factors, such as anxiety, depression, internal conflicts, fear of falls and fractures.

3.2 SMELL AND TASTE

In natural aging, there is a reduction in the secretion and fluidity of nasal mucus, in addition to partial replacement of the sensory epithelium by respiratory mucosa, a decrease in the thickness of the mucosa and a reduction in the number of neurons; any change that increases the volume or consistency of mucus can impair olfactory perception, so symptomatic rhinitis must be treated properly to preserve olfactory capacity (Pedrão, 2022).

The reduction in taste sensitivity with advancing age can be attributed to anatomical changes in the tongue, such as a decrease in the number of taste buds and taste buds present in each papilla throughout aging.

A significant decrease in vascular density at the tip of the tongue is also observed in elderly men and women compared to the younger population. Modifications to the sensory nerve endings of the three cranial nerves in the papillae and taste buds are also likely to occur (Chia *et al.*, 2023).

3.3 HEARING

Hearing loss is often caused by factors such as genetics and lifelong exposures, such as noise, ototoxic agents and diseases. About 60% of the elderly over 65 years of age can be affected by hearing loss, being progressive, symmetrical, bilateral and sensorineural

This condition negatively impacts mental health, social and occupational life. There is a direct relationship between hearing loss and cognitive decline in the elderly, which can contribute to dementia, both due to reduced cognitive reserve and associated social isolation and frailty (Paiva *et al.*, 2023).

Presbycusis, the main cause of hearing loss in the elderly, can arise due to damage to the sensory cells of Corti's organ, afferent neurons, the stria vascularis, the basilar membrane or the central nervous system, impairing, respectively, the ability to hear high-frequency sounds, distinguish words, perceive the intensity of sound, hear all frequencies or correctly understand perceived sounds (Pedrão, 2022).

3.4 SLEEP

Sleep is primarily regulated by two mechanisms: the circadian system and the homeostatic sleep-wake process. The circadian system is fundamental in determining the time, duration and structure of sleep, directly influencing deeper sleep REM (rapid eye movement) sleep.

Many determinants of sleep vary according to the circadian phase, both in young and elderly adults, and proper alignment between the time of sleep and the circadian rhythm is essential to maintain good sleep duration and quality.

During the biological day, the circadian drive for wakefulness has a progressive increase, reaching its peak at night, known as the "wakefulness maintenance zone", when the homeostatic pressure of sleep is also elevated. Under ideal conditions, the interaction between the circadian rhythm and the homeostatic process allows for the proper consolidation of sleep and wake periods (Duffy *et al.*, 2015).

Changes in the circadian and homeostatic sleep systems have been linked to the changes in sleep patterns that occur with aging. In older people, it is common to observe an advance in the circadian phase in classic hormonal markers, such as melatonin and cortisol.

Aging can influence the intensity of circadian propensity for sleep and wakefulness. When the interaction between circadian and homeostatic processes changes, the sleep-wake cycle tends to become more fragmented. This can reduce the occurrence of concentrated sleep in a single period of the day (Deantoni *et al.*, 2024).

Factors such as sleep fragmentation, reduction of deep phases (N3) and REM sleep, as well as greater latency to fall asleep, lead to impairment of memory consolidation, emotional regulation and physical recovery.

These changes are associated with problems such as depression, mild cognitive impairment, increased risk of falls, and domestic accidents. Changes in the circadian rhythm, such as the anticipation of sleep and wakefulness schedules, occur due to lower melatonin production and atrophy of the suprachiasmatic nuclei of the hypothalamus (Anjos *et al.*, 2025).

3.5 IMMUNE SYSTEM

With aging, biological changes occur that negatively affect the immune system, regardless of the lifestyle adopted.

In aging, there is an increase in the circulating level of inflammatory cytokines, a phenomenon that leads to compromised immune responses, thus increasing the risk of infections, reducing the effectiveness of vaccines, and favoring the emergence of age-related diseases, such as neoplasms, a process called immunosenescence (Cochar-Soares *et al.*, 2021).

Another characteristic aspect of aging associated with the immune system is called inflammaging, which is characterized by high levels of pro-inflammatory markers.

This chronic inflammation is closely linked to immunosenescence and results from factors such as thymus involution, imbalance between naïve and memory cells, dysregulated metabolism, and epigenetic changes. The senescence of T cells and their pro-inflammatory activity also contribute to this process.

It is known that the molecular mechanisms are not yet fully understood, yet senescent T cells and inflammaging are believed to be the main drivers of immunosenescence (Liu *et al.*, 2023).

Every process described leads to the impairment of both innate and adaptive immunity, causing a reduction in responses to infections, reducing the production of antibodies and the effectiveness of vaccines.

In the adaptive immune system, T lymphocytes (CD4+ helpers and CD8+ cytotoxic) have lower clonal diversity and accumulation of senescent cells, which reduces their response to new antigens.

B lymphocytes, on the other hand, have a reduction in the formation of naïve cells and less differentiation into plasma cells, leading to the production of lower-affinity antibodies and limited immunological memory.

Natural killer (NK) cells, of innate immunity, also suffer functional decline, with less cytotoxic capacity to eliminate infected or tumor cells, increasing susceptibility to infections and neoplasms (Matos and Brandão, 2025).

3.6 ENDOCRINE SYSTEM

The endocrine system also undergoes complex changes with aging, marked by gradual and progressive declines in anabolic hormones such as sex steroids and growth hormone (GH), while catabolic hormones are relatively preserved.

This reduction in the production of sex hormones results in andropause in men and menopause in women, influencing several physiological and pathological changes associated with aging.

With the decline in serum GH levels from the second decade of life, there is less secretion of GH-releasing hormone (GHRH), which leads to a reduction in insulin-like growth factor type 1 (IGF-1), characterizing the so-called somatopause (Speranza *et al.*, 2022).

Between endocrine factors and the aging relationship, changes in the hypothalamic-pituitary-adrenal (HPA) axis also occur, with increased cortisol secretion and a flatter diurnal pattern. Studies show that with age, there is a weaker wake-up response to cortisol, slower decline throughout the day, and higher nighttime levels of the hormone.

Between the ages of 20 and 80, average cortisol levels increase between 20% and 50%, and basal HPA axis activity rises. Although the diurnal secretion pattern is maintained, there is a reduction in the amplitude of peaks and periods of low secretion, indicating a progressive impairment of circadian cortisol regulation with aging (Stamou *et al.*, 2023).

Cortisol also interferes with positive well-being, if there is a lower production of cortisol throughout the day. Elevated cortisol interferes with lipid metabolism, immune regulation, central adiposity, hippocampal integrity, and bone calcification.

In addition, positive emotions reduce inflammatory and cardiovascular responses to stress and are associated with lower levels of inflammatory markers in older women (Ávila, 2021).

Insulin sensitivity due to bodily changes, such as reduced physical activity, hormonal changes, oxidative stress and inflammation, and islet cell dysfunction is also a significant factor contributing to abnormal glucose metabolism (Speranza *et al.*, 2022).

3.7 GASTROINTESTINAL SYSTEM

The normal gastrointestinal system is essential for the well-being and maintenance of quality health for the human body. Gastrointestinal function shows modest changes with advancing age.

Intestinal constipation, one of the most common gastrointestinal disorders in senescence, is widely observed in clinical practice in the elderly and is characterized by slow intestinal transit, difficulty defecating and abnormal fecal accumulation (Li *et al.*, 2023).

Other gastric alterations associated with aging are: modifications in the stomach microbiota, weakening of mucosal protection mechanisms, reduction of gastric blood flow and, as a consequence, impairment in repair processes.

These changes make older people more vulnerable to the emergence of various diseases, such as gastric ulcers, atrophic gastritis, and peptic ulcers.

Older adults are also more likely to experience gastrointestinal adverse effects caused by medications, which can lead to reduced treatment adherence and contribute to increased risks of morbidity and mortality (Dumic *et al.*, 2019).

3.8 CARDIORESPIRATORY SYSTEM

During senescence, structural and functional changes also occur in the cardiovascular system, some of which are: decreased arterial flexibility and reduced heart pumping force. In addition, the support of the arteries and the decrease in vascular response limit circulation and increase the risk of atherosclerosis, which further compromises heart health (Pontes *et al.*, 2025).

According to Oliveira *et al.* (2022), aging primarily affects the large elastic arteries, leading to increased stiffness, wall thickening, and lumen dilation. Changes that occur due to the "cyclical stress" caused by the heartbeat, which leads to the fragmentation of elastic fibers and replacement by collagen, resulting in a more rigid wall, a process known as arteriosclerosis, distinct from atherosclerosis, which involves inflammation and accumulation of lipids in the intima layer.

Those who suffer most from age changes are the large elastic arteries, which act as shock absorbers, while the muscular arteries and arterioles, which function as conductors, are less affected. Increasing blood pressure accelerates these structural changes, anticipating arterial aging.

The aging process affects or decreases the capacity of maximum oxygen volume (VO₂max) of the elderly subject, mainly due to physiological, organic, structural and hormonal changes. The decrease in this capacity significantly interferes with activities of daily living, since there is less uptake, absorption and distribution of oxygen in the body.

A reduction in ventilatory and pulmonary function, a greater imbalance in ejection volume and cardiac output, increased respiratory effort, reducing the strength and resistance of the respiratory muscles, and a decrease in lung compliance and elasticity, increasing the residual volume (Carvalho and Iwamoto, 2022).

3.9 URINARY SYSTEM

Aging also causes structural changes in the kidneys, including reduced cortical volume, increased surface roughness, and a higher occurrence of benign cystic tumors.

There is also a reduction in cortical volume and an increase in medullary volume, causing a decrease in total renal volume and cortical atrophy. With increasing age, there may be an increase in the incidence of benign tumors, such as hamartomas and angiomyolipomas, as well as calcifications, cortical scars, fibromuscular dysplasia, and atherosclerosis of the renal artery (Zhang *et al.*, 2024).

Studies show that after the age of 40 the glomerular filtration rate decreases and suffers a greater acceleration after the age of 65, reaching about half of the original value between 30 and 80 years of age.

There is also a drop in the maximum capacity of urinary concentration in people aged 60 to 79 years, there is a reduction of about 20%, and at 80 years of age this capacity is less than half compared to the peak of youth. These changes can increase the risks of water deficiency and dehydration in older adults (Li *et al.*, 2023).

3.10 MUSCULOSKELETAL SYSTEM

In the musculoskeletal system, there is a loss of muscle mass and strength, a process known as sarcopenia. This condition contributes to a large part of the decrease in functional capacity of older people, leading to reduced mobility and increasing the risk of falls and injuries.

There is also a loss of bone density, directly related to the drop in estrogen levels in women after menopause, increasing the likelihood of osteoporosis and fractures, especially in regions such as the hip, spine, and wrist (Pontes *et al.*, 2025).

The loss of muscle strength is an important factor, as it directly affects the quality of life of the elderly, causing losses in the performance of instrumental activities of daily living, such as shopping, and in the basic activities of ADL.

Depending on the degree of impairment and reduced functional capacity, simple tasks, such as taking care of oneself or getting up from a chair, may require more effort than usual. And the lack of physical activity can contribute to this progressive loss of strength (De Souza *et al.*, 2023).

3.11 SKIN

Skin aging is a process in which there is a reduction in skin quality, due to the actions of chronological aging, photoaging, hormone deficiency and environmental factors.

There is also a decrease in the number of fibroblasts responsible for collagen synthesis and the vessels that irrigate the skin, which contributes to increased sagging and, consequently, to the appearance of wrinkles (Chaudhary *et al.*, 2020).

There are several factors that contribute to the degradation of the skin's elastic fibers. These factors can be classified into intrinsic and extrinsic. The intrinsic ones are related to the individual's genetic factors and appear naturally over time and it is individual.

Extrinsic factors, on the other hand, are associated with external influences to which the individual is exposed during life, such as ultraviolet radiation, smoking, and pollution. The sum of these factors intensifies and accelerates damage to skin fibers (da Silva *et al.*, 2024).

The epidermis becomes thinner and the dermal-epidermal junction flattens, increasing skin fragility and the risk of shear injuries, as can occur in the removal of adhesive dressings in the elderly. This fragility also favors bleeding between the dermis and epidermis, resulting in ecchymosis.

The loss of dimples at this junction reduces the area available for the transfer of nutrients, including protective lipids from the stratum corneum, which contributes to skin dryness (xeroderma) and to the impairment of the skin barrier function, in addition to decreasing the synthesis of vitamin D.

At the same time, the reduction in the number of sweat glands with reduced sweat, dermal blood vessels, and subcutaneous tissue thickness impairs thermoregulation, making the elderly more vulnerable to adverse effects in both hot and cold environments (Speranza *et al.*, 2022).

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