

Changes related to aging and theories of aging

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Abstract

Aging is a complex bio-psycho-social process which could be characterized as universal, intrinsic, progressive and harmful. There are more than 300 theories about aging. Biologists, sociologists and psychologists have proposed different theories about the aging process. All the theories regarding aging are necessary and require the composition of a composite, comprehensive theory, which should include the aspects described in them. One of the most prominent theories of aging is the free radical theory, which explains aging as due to the oxidative stress generated by the oxygen catabolism products.

The control and prevention of aging, in order to prolong the life span and increase the quality of life, can be done through a rigorous program: moderate physical effort, nutritional and non-nutritional antioxidants, reduction of exogenous sources of reactive oxygen species.

Keywords: aging, biological theories, social theories, psychological theories

Introduction

Ageing or aging is a universal and inevitable phenomenon with a progressive decline and uneven deterioration of an organism's internal condition, leading to an increased risk of death.

Aging is a complex process, which involves the accumulation of changes attributed to multiple causes: genetic defects, environmental factors, diseases. 400-500 years ago, human life expectancy was about 30-40 years, but today it has grown to 80 years, on average, in most developed countries. A number of factors have contributed to increased life expectancy and demographic aging: social and economic processes, a decrease in births, the development of medical sciences, improved nutrition and improved health care, all ultimately leading to reduced overall morbidity and mortality (Viña et al., 2007).

In 1998, WHO included the issue of aging among the world's five health problems, along with cardiovascular diseases, cancer, AIDS and alcoholism.

Harman (1956) postulates that aging is the result of the progressive accumulation of changes in the body, which occurs with the passing of time and which causes an increased likelihood of illness and death of individuals.

Strehler (1977) defines aging by means of four characteristics (features):

- universal phenomenon of different degrees in all

individuals of a species

- intrinsic process that depends on endogenous factors
- changes that lead to aging must occur progressively throughout the lifespan
- progressive process that can occur in young people, albeit in a small proportion
- a harmful process associated with aging will only be considered as part of the aging process if it is “bad” for the individual.

Normal changes related to aging

In the body, a series of changes appear with age. They can be interpreted differently according to various theories about the normal aging process, either alone or in combination with other theories.

The major structural/functional changes of aging are presented below (Prada, 2001; Ghidrai, 2002; Cefalu, 2011; Mavritsakis, 2014).

Sensory organs

- *visual*: damage of the cone and rod photoreceptor cells; reduced night vision, accommodative ability; increased glare
- *smell and taste*: atrophy of the taste buds; decreased sensitivity
- *hearing*: impairment of hearing receptors (Corti organ); stiffening of inner ear bones.

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Skin system and annexes: damage to melanocytes, mast cells and Langerhans cells; decreased functional capacity of tactile receptors in the palms; thinning of stratum corneum and subcutaneous layer; increase of pain tolerance; decrease in the amount of collagen and subcutaneous adipose tissue; decrease in the number, size and function of sweat glands; decrease in the number of capillaries; larger vessels reach the surface; decreased melanin production, bleaching and hair loss; decreased nail vascularity and increased longitudinal striations - matte nails.

Skeletal system: affected osteoblasts and osteoclasts; change in bone architecture and accumulation of microfractures, disparity of deposited minerals; changes in the properties of minerals and protein content of matrix, decreased height and thinning of bone; narrowing of intervertebral discs; decrease in the height of the vertebrae; increasing the curves of the spine; damage to the articular cartilage with the formation of new bone at the joint surfaces.

Musculoskeletal system: affected myocytes: apoptosis, reduced size of myofibrils, decreased type 2 muscle fibers; increase in the amount of fatty tissue in the muscles; decreased glycogen stores; decreased hand grip strength.

Cardiovascular system

- *heart:* affected myocytes and pacemaker cells; increase in the amount of lipofuscin in cardiac myocytes; increased stiffness of the left ventricle; decreased diastolic filling and left ventricular relaxation; increased stroke volume; 30-40% reduction in maximal cardiac output; increased stiffness at the base of the aortic and mitral valve cusps;

- *vessels:* decreased elasticity of the aorta and large vessels; increase in systemic and peripheral vascular resistance; decreased sensitivity of baroreceptors in orthostatism; decreased cardiovascular response to stress and physical exercise.

Pulmonary system: increase in the anteroposterior diameter of the thorax - rigid thorax; respiratory muscle hypotrophy; atrophy of the ciliary epithelium and impairment of ciliary function; damage to alveolar cells; decrease of the vital capacity and of the maximal expiratory volume; increase of the residual volume and functional residual capacity; decrease in the number of alveoli; chest wall stiffness; decreased arterial O₂ level and impaired CO₂ elimination.

Gastrointestinal system

- *oral cavity:* thinning of the oral mucosa and receding of the gums; increased thickness of teeth dentin and decreased dental pulp; teeth wear and loss;

- *esophagus:* decreased tone of smooth muscles and lower esophageal sphincter; affected peristalsis;

- *stomach:* affecting mucosal cells; decreased secretion of hydrochloric acid, intrinsic factor and pepsin;

- *liver:* reduction of blood flow; decrease of enzymatic activity; affecting protein synthesis;

- *bowels:* decreased peristalsis and colonic blood flow.

Excretory system

- *kidneys:* apoptosis: decrease in the number of renal cells and functional nephrons; decrease in glomerular and tubular mass; decrease of the glomerular filtration rate, of the tubular volume; changes in the renal blood vessels with decreased blood flow;

- *urinary bladder:* wall modification: fibrous connective

tissue replaces muscle and elastic tissue; weakening of the muscles, decrease of the urinary jet force; hyperreflexion of the detrusor muscle;

- *prostate:* enlargement of the gland with urethral obstruction.

Genital system

- *female gender:* ovarian, uterine, vaginal, vulvar tissue atrophy; decreased tone of the pelvic muscles, uterine prolapse; atrophy of the breast tissue; decreased estrogen production;

- *male gender:* testicular atrophy; sclerosis of the penile vessels; slowed erection and ejaculation; decreased testosterone production.

Nervous system: decrease in the number of neurons and glial cells; decrease in the number of receptors; decrease in the size of the hippocampus and of the frontal and temporal lobes; abnormal reflexes; alteration of locomotor activity; alteration of sensitivity; alteration of psychic functions: decrease in complex visuocognitive skills and logical analysis skills; decrease in processing speed; decrease in reaction time; decrease in the ability to shift cognitive sets rapidly; memory destruction and decline of executive function.

Endocrine system: damage to endocrine cells; variation in hormone levels (decrease or increase).

Blood: decreased marrow cellularity (stem cells); increase in bone marrow fat; reduction in cancellous bone.

Metabolism: reduced anabolism; increased catabolism; narrowed homeostatic control of water and electrolyte balance.

Thermoregulation: inability to conserve or dissipate heat.

Theories of aging

There are several theories about the mechanisms of normal aging, either independently or in combination with other theories. Their large number (over 300), their diversity and coexistence are possible because most do not contradict each other, each theory trying to explain the various changes related to age, the effects produced and their consequences (Medvedev, 1990).

Biologists, sociologists, psychologists and more recently nurses have proposed various theories about the aging process.

I. Biological theories of aging

A classification of theories according to Prada (2001) and Goldsmith (2014) is based on the genetic changes that underlie the aging process and includes theories based on genetic determination and theories without genetic determination.

1.1. Theories based on genetic determination - support the direct intervention of genetic mechanisms in longevity. The programmed part is predictable.

a. Programmed

- Theory of age priming-modifying genes

- Non-specific gene theory

- Specific gene theory

- Longevity gene theory

- Gene redundancy theory

- Gene repair theory

- The theory of slow passive morphological aging

- b. Non-programmed
 - Theory of errors in protein synthesis
 - Somatic mutation theory

I.2. Theories without genetic determination

a. Organ theories - are based on the dysfunction of organs, caused by immunological and neuroendocrine dysfunctions

- Immunological theory
- Neuroendocrine theory

b. Physiological theories - are based on the primary and secondary intervention of intrinsic and extrinsic factors

1. The theory of primary damage caused by metabolic, intrinsic biochemical or external factors

- Metabolic factors
- The theory of self-poisoning
- The theory of accumulation of non-degradable catabolites

- The theory of primary structure disorder in the posttranslational stage

- Intrinsic biochemical factors
- Free radical theory
- External factors

2. The theory of secondary disorders

- Cross-link theory

Another biological classification of aging theories is based on physiological processes that change with age. These processes are manifested at the molecular, subcellular, cellular, tissue and body system level, affecting homeostasis (Carlson & Chamberlain, 2005; Miquel, 1998).

These theories were grouped into two categories: stochastic and non-stochastic (Lange & Grossman, 2017).

I.3. Stochastic theories

According to these theories, there is a series of random events that cause cellular damage which accumulates as the organism ages (Harman, 2006; Goldsmith, 2014). The following stochastic theories of aging are:

a. Free radical theory postulates that aging is due to oxidative metabolism and the effects of free radicals are thought to react with proteins, lipids, carbohydrates and nucleic acids (DNA and RNA), causing oxidative stress and cellular damage (Harman, 1956).

b. Orgel/error theory suggests that cells accumulate in time errors in their DNA and RNA protein synthesis that lead to cell death (Orgel, 1970).

c. Wear-and-tear theory refers to cumulative changes that occur in cells, damaging cellular metabolism (Weismann, 1891).

d. Connective tissue/cross-link theory affirms that in time biochemical processes create connections between structures that are not normally connected.

I.4. Non-stochastic theories

These theories are founded on a programmed perspective that is related to genetics or one's biological clock (Goldsmith, 2011). The following non-stochastic theories of aging are:

a. The programmed theory - based on the idea that cells divide until they can no longer do so, triggering, as a result, apoptosis or cellular death (Gonidakis & Longo, 2009; Sozou & Kirkwood, 2001).

b. Gene/biological clock theory which postulates that cells have a genetically programmed aging code (Slagboom

et al., 2000).

A modern biological classification based on evolutionary concepts of theories about aging, proposed by Jin (2010), includes 2 main categories: the programmed theories and the non-programmed aging theories.

1. Programmed theories imply that aging follows a biological timetable (regulated by changes in the expression of genes that affect the systems responsible for maintenance, repair and defense responses):

a. Programmed longevity (Davidovic, 2010) - considers aging to be the result of a sequential on/off switching of certain genes, with senescence being defined as the time when age-associated deficits are manifested

b. Endocrine theory (van Heemst, 2010) - based on the fact that all components of the human body are controlled by the endocrine system, which behaves like a biological clock, accepting as possible the existence of a death hormone

c. Immunological theory (Cornelius, 1972) - based on the fact that with age the capacity of the immune system decreases, which leads to vulnerability to infections, diseases and death.

2. Non-programmed aging theories / damage or error theories are based on evolutionary concepts, in which aging is considered the result of the body's inability to better combat natural deteriorating processes:

a. Wear-and-tear theories (Weismann, 1891) – based on the idea that aging is a side effect of the physiological work of cells; the vital parts of our cells and tissues wear out, resulting in aging

b. Rate or living theory (Hulbert, 2007; Rollo, 2010) - considers that the higher an organism's rate of oxygen basal metabolism, the shorter its lifespan

c. Cross-linking theory (Bjorksten, 1968) - states that cross-linked protein accumulation damages cells and tissues, slowing down the body's processes and thus resulting in aging

d. Free radical theory (Harman, 1956) - based on the idea that aging is the result of the progressive accumulation of changes in the body, attributed to an increased rate of oxidative free radicals and a decreased antioxidant defense. Diet, lifestyle, drugs, radiation are accelerators of free radical production within the body (Porr, 2000; Tache, 2001).

e. Neuroendocrine theory – adherents of the theory support the role of hypothalamic neurohormones and the hypothalamic-pituitary axis in regulating the endocrine glands (thyroid, gonads, adrenals) as well as the role of insulin and melatonin in regulating changes related to age and aging (Rodenbeck & Hajak, 2001).

f. Immunological/autoimmune theory - states that the normal aging process is related to faulty immunological functions (Effros, 2004). The immune system is programmed to decay over time, leading to increased vulnerability to infections and thus, to aging and death.

II. Sociological theories of aging (Lange and Grossman, 2017)

These theories are based on changing roles, relationships, status and generational cohort which impact the older adult's ability to adapt.

Sociological theories of aging are:

- a. Activity theory
- b. Disengagement theory

- c. Subculture theory
- d. Continuity theory
- e. Age stratification theory
- f. Person-environment fit theory
- g. Gerotranscendence theory

III. Psychological theories of aging (Lange & Grossman, 2017)

These theories explain aging in terms of mental processes, emotions, attitudes, motivation and personality development. Psychological theories of aging are:

- a. Human need theory
- b. Theory of individualism
- c. Stages of personality development theory
- d. Life course (lifespan development) theory
- e. Selective optimization with compensation theory

Conclusions

1. Aging is a dynamic, complex degenerative process, characterized by the morphofunctional and psychological decline of the body. The beginning of aging would be the end of the period of development and growth, a process that continues throughout life, until death.

2. The multitude and diversity of theories about aging try, each, at the same time, to capture the various aspects and causes of aging. These theories are intertwined. The importance of postulating comprehensive theories of aging is that it lays the ground for new experiments that will help us better understand the aging process and thus improve the longevity and quality of life of animals, and in the last instance of human beings.

3. The theory of free radicals formulated by Harman (1956), the best known and accepted, argues for the role of reactive oxygen species, with their consequences, the gradual decrease of endogenous antioxidant defense in the conditions of a gradual increase of environmental oxidants.

4. The control and prevention of aging, in order to prolong the life span and increase the quality of life, can be done through a rigorous program: moderate physical effort, nutritional and non-nutritional antioxidants, reduction of exogenous sources of reactive oxygen species.

Conflicts of interests

There are no conflicts of interests.

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