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Original Article

The Biophysical Modelling of the Human Aging

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Abstract:
The role of the biophysics consists of the study of the vital processes which take place in the living organisms, their correlations in the discovery of the causal relationships between the phenomena, establishing the underlying connections and the quality differences of the processes which take place in the living organism. In the contemporary times of explosive development of nature sciences, medical biophysics – a borderline science with interdisciplinary aspects – having as object the modelling of the human organism, becomes a basic discipline in the biomedical studies. Medical biophysics can be applied in all the fields of medicine. The problem of aging preoccupied the researchers a lot. Several theories and hypothesis have been issued regarding the causes of aging. The aging itself are an indispensable condition of the evolution of life on earth. The aging is characteristics of the all analyzers. In older age, the perception of posture becomes less steady and precise, because structural changes occur in the spinal column that clearly mislead our organ sensing balance, from the aspect of information. They found that the so-called method of amplitude estimation resulted in values with very dispersed intervals, therefore, they applied the correlation of the analyzers.
Key words: aging, analyzers, biophysical theory, category theory

Introduction

Biophysics is a borderline science between physics, biology and psychology, which studies the laws and regulations of the complex system through mathematical methods: psychological-biological-physical. The apparition of the biophysics is a consequence of the wider and wider use of the physical techniques and theories in the biological and medical sciences. With their help, biophysics deals with the following main aspects:

– the study of the physical phenomena involved in the functioning of the living systems;

– the use of the physical techniques for the research of bio-medical issues;

– the research of the bio-medical effects of the biophysical factors;

– some psychological aspects which are tightly connected to the structure and functioning of living organisms.

The fundamental study topic of biophysics is the life of the organism. The role of the biophysics consists of the study of the vital processes which take place in the living organisms, their correlations in the discovery of the causal relationships between the phenomena, establishing the underlying connections and the quality differences of the processes which take place in the living organism. [1] In any organism there are biological processes taking place, whether it is monocellular or pluricellular.

Biophysics, which became a self-standing discipline, with specific objectives and research methods, opens wide perspectives in the most diverse fields of theoretical and applicative fields of medicine. The means of biophysics are tightly connected with the development of science and

technique, although modern medicine is a reflection of biophysics applicable to the human body.

In the contemporary times of explosive development of nature sciences, medical biophysics – a borderline science with interdisciplinary aspects – having as object the modelling of the human organism, becomes a basic discipline in the biomedical studies. Medical biophysics can be applied in all the fields of medicine. In order to understand the disturbances which take place in the pathological process in the body, we must know the normal evolution of the vital processes. The knowledge of biophysics is necessary for the diagnosis of the disease, for choosing and performing correctly the treatment; this is why no physician can work successfully without knowing biophysics. [2] The efficient management and use of the very diverse data supplied by biophysics request a new way of processing and interpreting which is possible in today's computer era. It is difficult to perform an exhaustive list of all the users of biophysics in the bio-medical scientific research, but one must not forget that at the origins, biophysics was created by scientists and for scientific needs.

The assiduous and passionate work of biophysicists in laboratories supplied the experimental results through which they revealed the intimate mechanisms of the living organisms. Hence the theoretical and experimental research in the field of biophysics supplied truly amazing results, which materialized in medical devices found in the endowment of all the modern clinics in the world (CT, MRI, PET etc).

In the explanation of the structure and function of the living organisms, the biophysicist selects and synthesises everything that the various fields of bio-medicine offer him. This is why the text contains references from the field of these connected disciplines, which are not overlaps, but completions or elements necessary for the understanding of interpretative biophysical modelling. Under functional perspective, biophysics mentions limits between living and non living, normal and pathological; it also offers guiding principles on the correction of the parameters of the deviated characteristics during the disease, based on the knowledge of the modelling of normal functional mechanisms. Currently we can say that the modern medicine starts and ends with biophysics.

Among the new structural and functional, a good part of them refers precisely to human organs (systems, apparatuses) and they cannot be omitted from a book on the medical biophysics topic. In the structure of the material of this book, we granted major importance to the morphofunctional, psychological aspects and even to some pathological aspects.

Dealing with the vital manifestations of the organism, the apparatuses and constitutive systems, the mechanisms and their laws of functioning, the regulation and modelling, as well as the evaluation methods of normal and health state but also their deviations, medical biophysics allows the conclusion of the normal or pathological functionalities, the health or disease state.

The modelling uses very frequently the general laws of isomorphisms. Through modelling, we can find the system's transfer function (the way the system acts upon the entry size) or when it is known, the entry size can be found. The modelling of some bio-medical systems eases the analysis of the processes which take place in that particular original and allow the study of their action in the conditions which are difficult or even impossible to organize.

The progresses of the medical biophysics and multiple possibilities of medical investigations allow the decoding of the intimate mechanisms involved in the pathogenesis of various diseases.

Hence, it is entirely justified – in our opinion – the apparition as frequently as possible of biophysics books which include the latest news in the field of modelling of human apparatuses, all the more that biophysics is studied on all the levels of formation of the physician.

We are certain that in the future in the medical field the research will stress the in-depth knowledge of the human organism's functional processes and the valuing at wide scale of the conquest of biophysics, for the prevention and reduction of diseases.

The high-tech devices, the apparition of new investigation possibilities of understanding the medical biophysics allows the entrance in the

depth of the biologic processes, in the intimacy of normal, perinormal and pathologic life.

As a borderline science, medical biophysics remains the reference term of any medical act, whether it is preventive, exploratory, curative, recovery or predictive. [3]

The unity between the biologic, psychical and social factors determines the course of the biophysical processes in the human organism. This is why breaking the biological apart from the psychological or social environment and the ignorance of the qualitative particularities of these processes can lead to gross errors.

Knowing the biophysical phenomena and discovering the laws which lie at their basis, biophysics in itself, creates conditions for the conscious intervention, oriented as purpose in the development of these processes for their modification in the way desired by the person. This is why biophysics has a practical importance in the development of knowledge in the human future.

What is aging?

The main theories about aging are biophysical, cellular, tissue related, visceral and humoural. The biophysical theories stress some modifications such as hydrations, alteration of colloidal mixtures, decrease of the nuclein amount, structural modifications in proteins, inactivation of biocatalysts, decrease of cellular electric resistance, decrease of the mitogenetic radiant power, decrease of the membrane permeability. Cellular theories explain aging by: chromosomal alterations, alteration of the nucleus – plasma ratio, the hindering of nucleus – plasma changes, the decrease of the vegetative protoplasm through differentiation and accumulation in paraplasm, alterations in mitochondria, in ribosomes and centriols. Tissue related theories applicable to pluricellular organisms make the biological insufficiency (on behalf of wear) of a certain organ, system or tissue responsible for the aging of the entire organism. In a broad biological perspective, death and aging itself are an indispensable condition of the evolution of life on earth, making "room" to the repeated development of the competition between individuals and the repeated selection of the most qualified ones. [4]

According to the wear theory, the aging appears due to the impact of the damaging factors on the organism, weakening its resistance to the aggressions which weaken its adaptation mechanism. The pathological states of wear, especially the chronic ones, are considered age acceleration factors, equivalent with the environment's toxic factors. The age intervenes through the simple fact of living, hence aging appears in normal life conditions as well, only later. [5]

The first sign of general aging of the organism is the aging of the sexual endocrine glands. Since the biological meaning of life is reproduction, the life of the organisms seems to be programmed for this purpose. The development and permanent regeneration of the organism takes place as long as the biological sense of life can be achieved.

Aging and its final product – death – are an expression of the enthropic evolution of systems, hence the energy and structural harmony of the living under the impact of the equalising tendencies and disorganising, proper to the universal entropy, would grow poor progressively from the energetic point of view and would disorganise according to the second principle of thermodynamics. [6]

At the aging of the organism the energetic restoring availability decreases, leading in the end to death. A theory about the "inertization" of the macromolecular reactivity through the progressive appearance of crossed bonds which reduce the chemical reactivity of various macromolecules a lot. Oxidation processes and the reducing ones have also been incriminated as the cause of aging. Another theory implies that the free radicals would produce a blocking, an inertization of the recreation substances from a living organism, action accompanied by important deficiencies in biological process leading to the organism aging. [7]

Further on we present a biophysical model of aging, using the schemes of the category theory. As time progresses, the structural states of the system characterizing living organisms change but remain compatible with the living organism, just as functional states of living systems change, but they are also compatible with life. The values of every i, j, ..., k parameter characterizing organisms

also change, nevertheless the living individual is still able to perform its physiological functions. [8]

Let us look at aging in the diagram form of category theory:

$$\begin{array}{ccccccccc} N^{*}_{ij\cdots k} & \xrightarrow{\alpha} & N^{*1}_{ij\cdots k} & \cdots & N^{*m}_{ij\cdots k} & \xrightarrow{\eta} & N^{**}_{ij\cdots k} & \xrightarrow{\sigma} & N^{***}_{ij\cdots k} \\ \downarrow\Psi & & \Phi\downarrow & \cdots & \Sigma\downarrow & & \Omega\downarrow & & \Theta\downarrow \quad \Gamma\downarrow \\ E^{*}_{ij\cdots k} & \xrightarrow{\gamma} & E^{*1}_{ij\cdots k} & \cdots & E^{*m}_{ij\cdots k} & \xrightarrow{\nu} & E^{**}_{ij\cdots k} & \xrightarrow{\tau} & E^{***}_{ij\cdots k} \end{array}$$

The skin ages extremely fast. In old age, the epidermis thickens to a multiple extent compared to its original state, and this hinders greatly the effective functioning of the sense organs in the skin because the value of the threshold often increases by multiple times than in young age. Touching the surface and the sensing of small objects implies serious difficulty, because the value of the threshold is increased by multiple times. In old age, due to the feebleness of oculomotor muscles, the lens are no longer capable of changing their curvature as forcefully as in young age. Unfortunately, around 4 billion of the 7 billion people living today need visual correction (glasses, contact lenses), which is approximately 65% of humanity.

Unfortunately, in older age, sounds of less intensity do not vibrate due to the feebleness of the eardrum. There is a chain of bones in the middle ear, and with aging, due to the atony of the muscles moving the bones and the deformations of auditory ossicles, the range of high sounds is reduced more and more. The narrowed auditory canals exclude high sounds from the perceptible range over 50 years. At the age of thirty, we can hear about 15,000 Hertz (cricket, bird chirp), while at the age of 70 we only perceive 5,000 Hertz (barking). The sounds are transferred through the bones that forming the skeleton of the head as well, which is exposed to an essential modification in old age, because the inner structure of the bones forming the skull is modified, by losing water, these become more hollow, and thus hearing is perturbed. The average person can differentiate between 2.000–4.000 smells. In old age, the olfactory epithelium perceives very few smells, according to some estimates, only 200–500. Even in these cases, the perception becomes uncertain resulting also from the fact that the olfactory area is a diffuse range of the cerebral cortex. [9]

One can sense five basic tastes: sourness, bitterness, alkalinity, sweetness and saltiness. In old age, the ability of proper perception of sweet and salty tastes is lost. Therefore, if an elderly person complains about something being unsalted, it may not be the case. The perception of bitterness and sourness is likely to last because the palate also senses these tastes.

In older age, the perception of posture becomes less steady and precise, because structural changes occur in the spinal column that clearly mislead our organ sensing balance, from the aspect of information.

The main characteristics of senility can be summarized as follows: rising conservativism; due to the weakening of the controlling role of the cortex, certain personality traits become prevalent; for example, an old person becomes distrustful, meager, a hypochondriac; the decline of interest in new things, and even hostility towards them; a decline in memory, in the ability to observe and retain things; tiredness in mental activity; every performance slows down, the body becomes physically tired, organized mobility deteriorates.

Modelling

According to Stevens, the relative change of the stimulus (ΔI/I) is proportional with the relative change of the stimulus (ΔÉ/É):

$$\frac{\Delta \acute{E}}{\acute{E}} = k.\frac{\Delta I}{I}$$

Solving the above equation results in the following power function:

$$\acute{E} = k.\left(\frac{I}{I_0}\right)^n$$

where $\mathbf{I_0}$ is the intensity of the threshold stimulus, **n** is the constant characteristic of the type of perception. If we illustrate the power function in a log-log coordinate system, we get straight lines. Attempts were made to determine the value of **n** with psychophysical methods. [10]

They found that the so-called method of amplitude estimation resulted in values with very dispersed intervals, therefore, they applied the correlation of

the analyzers. The **n** was determined for each sensory organ, but its value depended to a great extent on the form of the stimulus that reached the sense organ, and on the state of the sense organ compared to its environment. Thus, Steven's law depends to a great extent on whether the sensory organ of the given person is of an average or an above-average sensitivity (sight for painters; hearing for musicians; touch for the blind).

The aging of the analyzers

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