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Original Article

The Biophysical Modelling of the Time-Function

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Abstract:
This claim is supported by the fact that life expectancy of around 100 years has not changed since the historical record. What has changed is the number of people who are approaching or reaching this apparent limit, but without human life being extended. From a biological point of view, every living organism has a dual purpose: its own survival and the reproduction of the species. Given that life expectancy at birth was generally below 40 years in all countries before 1900, the ageing period was usually closely linked to reproduction. The functional, physiological changes that occur during ageing have also long been recognised. The ontogenetic development of an individual is nothing more than the playback of a "prewritten program", spread out over time. The process of ageing is thus included in the programme, without its beginning and end being clearly defined. The period of ageing is very often accompanied by various pathological changes, in other words, most diseases are much more likely to occur at an older age than before. Given that ageing is the last stage of post-embryonic development, it is likely to be dominated by minor or major pathological processes. Ageing does not start in the whole body at the same time. It is well known that, for example, the atrophy of the thymus gland in humans begins as early as 13–15 years of age, and that of the gonads in women between 45–52 years of age, while in contrast, certain areas of the pituitary gland show high levels of activity until late adulthood. It can be observed that the rate at which several age-related changes unfold is not significant in old age, but earlier in life.

Key words: biophysics, ageing, main stages

Introduction

An eminent scholar of gerontology, F. Bourlier, has argued that "if in the future we wish to better understand the causes and effects of ageing at the molecular, cellular, organ, organism or population level, we must not use a single technique, but all those which, from biophysics to sociology, will enable us to approach the effects of Time on Life from several angles." So gerontology (the discipline of ageing, or more specifically human ageing) is very young and its methods are diverse. [1] Of course, this is not to say that ageing – an intrinsic attribute of the living state of matter – has not been the subject of human thought for the past decades, but it is safe to say that the intellectual products of ageing have been almost shrouded in naivety, and that basic research has been going on for only a few decades. To date, gerontology has been dominated primarily by formal statistical surveys, rather than basic research on the subject. This claim is supported by the fact that life expectancy of around 100 years has not changed since the historical record. What has changed is the number of people who are approaching or reaching this apparent limit, but without human life being extended.

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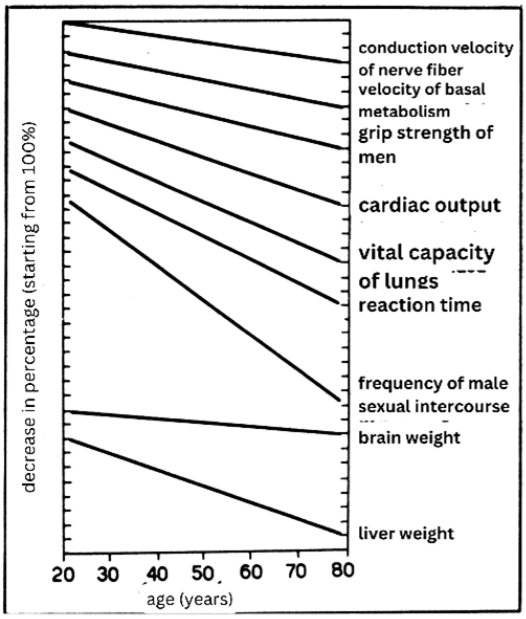

Figure 1: Relative changes in some biological parameters depending on age (1 unit = 5%)

Having said these, without wishing to be exhaustive, the theoretical hypotheses on ageing are presented below.

1. Lorenzo Balthasar Gracian claimed in 1653 that stupidity is the shortener of life! In his work, he gives concrete suggestions on how to achieve a longer life. [2] This claim is worth examining because it links ageing to human qualities that are not causally related either biologically or philosophically. Hundreds and thousands of such misconceptions and pseudo-scientific truths have littered the intellectual products of the past centuries and have decisively prevented a scientific approach to ageing.

2. From a biological point of view, every living organism has a dual purpose: its own survival and the reproduction of the species. Given that life expectancy at birth was generally below 40 years in all countries before 1900, the ageing period was usually closely linked to reproduction. On this basis, women were considered old after they stopped bleeding monthly, and men from the age of 40 upwards, when the frequency of penile erections decreases. [3] The same idea has been supported by the very many species in the animal kingdom that die out very quickly after a single or repeated act of reproduction, due to extremely strong selection.

3. It has been known for thousands of years that the most striking signs of ageing are both morphological and functional changes. We now know that all organs in the human body undergo minor changes as we age. [4] Instead of listing them in their entirety, we will mention only some of them, which can be easily detected by external macroscopic examination, such as wrinkling, greying, balding, muscle atrophy, bending of the spinal column, skin pigmentation, etc.

4. The functional, physiological changes that occur during ageing have also long been recognised (Figure 1). It is a well-known phenomenon in sport that the winners of the fast-moving events come from the twenties. With age, the functionality of some analysers also decreases significantly. [5] One example of this is that the adaptability of the lens of the eye is significantly reduced after the age of 40, while the ability of the inner ear to conduct sound is significantly reduced after the age of 50.

In older age, there are also significant changes in the water content of organs (Figure 2), which determine ageing on several levels, such as muscle fatigue, osteoporosis, changes in ion concentrations, decreased or increased enzyme activities, and many other physiological changes that are the result of changes in water balance. As the speed of response to stimuli also decreases with age, adaptability deteriorates. [6]

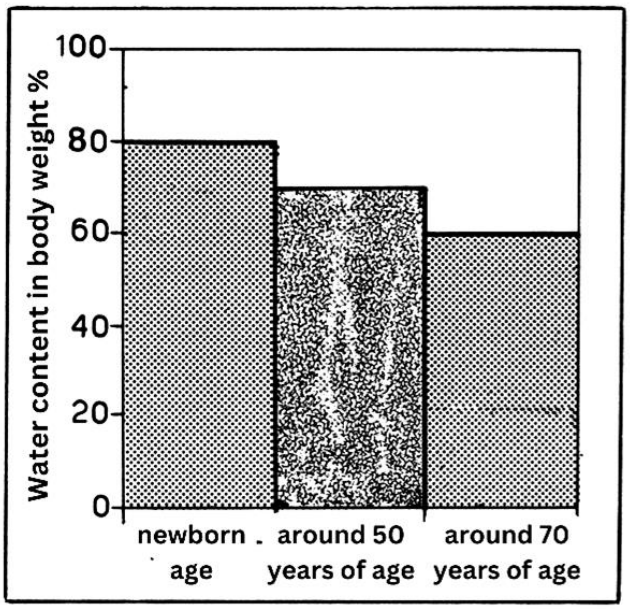

Figure 2: Changes in relative water content during different periods of ontogenesis

5. The ontogenetic development of an individual is nothing more than the playback of a "prewritten program", spread out over time. This program is located in the chromosomes, the DNA molecule, and determines almost entirely the structure and function of the individual, leaving room for environmental influences. [7] The process of ageing is thus included in the programme, without its beginning and end being clearly defined. In other words, this means that the individual lives for a finite period of time according to the program, but death is neither a fact nor a formality in this program, but a natural consequence of the finiteness of the program.

6. The period of ageing is very often accompanied by various pathological changes, in other words, most diseases are much more likely to occur at an older age than before. [8] As Professor Haranghy, a renowned pathologist, has shown in his autopsies of nearly a hundred very old people who died of "old age", such people usually showed a number of pathological changes. So, if they had not died at that time, their death would have been imminent anyway, from causes that had not been diagnosed before. It follows from this view, which is almost unanimously accepted by gerontological authors, that a person cannot die a natural death under present conditions, but that death is always caused by some disease process. Given that ageing is the last stage of post-embryonic development, it is likely to be dominated by minor or major pathological processes.

7. Ageing is therefore a process that takes place over time, which is true in the sense that ageing starts at the moment of birth. In fact, this can easily be supported by the fact that the younger the individual, the more intense its relative ageing. This means that a 70-year-old person ages by 1.4% in a year, a 10-year-old child ages by 10%, while a 1-year-old child ages by 100% in 1 year. [9] Depending on relative ageing, the ageing process slows down with age. This is also well illustrated in a biological sense, because young individuals go through more significant developmental stages than older individuals.

The Main Stages

There are two main stages of human development: intrauterine development, which usually lasts 9 months, and extrauterine development, which has a biological upper limit of 120 years, as we know it today. There are 3 main stages of extra-uterine development and growth: the evolutionary period, during which the morphological and physiological characteristics of the species are established, together with genetically determined individual traits; the so-called mature stage, when the organism's parameters, through their dynamic balance, ensure excellent homeostasis; and the third, regression stage, which used to be identified with ageing, but these often do not coincide. [10]

There are four main characteristics of the ageing process: heterochronic, heterotropic, heterokinetic and heterocateften.

Ageing does not start in the whole body at the same time. It is well known that, for example, the atrophy of the thymus gland in humans begins as early as 13–15 years of age, and that of the gonads in women between 45–52 years of age, while in contrast, certain areas of the pituitary gland show high levels of activity until late adulthood. So heterochronicity refers to differences in the ageing rate of individual tissues, organs and organ systems. It is no coincidence that we did not start the list with cells. The ageing and death of different cells is not the same as the ageing and death of the body, although they undoubtedly influence each other. In support of this, it is sufficient to consider that no individual usually has red blood cells older than 4 months, while the neuronal cell population does not increase in number after one day of age. [11]

The ageing process is not expressed in the same way in different organs, and even in different structures of the same organ. This is called heterotopia. Examination of the adrenal cortex clearly shows that the glomerular zone, which produces mineralocorticoids that mostly regulate ionic balance, and the reticular zone, which produces steroids such as sex hormones, are the main sites of ageing, while the fascicular zone, which produces glycocorticoids, shows little change.

Ageing is heterokinetic because age-related changes develop at different rates. In some tissues they appear quite early but unfold slowly and steadily, while in others they appear later but unfold more rapidly. For example, the first signs of ageing in the skeletal system and joints appear quite early and often lead to old-age osteoporosis after a slow development. [12] In contrast, changes in many structures of the central nervous system may not be detectable for a long time, but once they develop, they are quickly felt in many organ systems.

Heterocatefteneity means that changes with age can take different directions. In an ageing body, some life processes are inhibited while others are activated.

It can be observed that the rate at which several age-related changes unfold is not significant in old age, but earlier in life. Many aspects of function change significantly in the fifth decade, such as the cardiovascular system, stomach and intestinal function, endocrine system activity, blood cholesterol levels, etc. Therefore, the sooner we take an active and complex approach to the ageing body, the better chance we have of succeeding!

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