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Possibilities of prolonging human life in the near future

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Abstract. People are interested in health and long life. As a result of their activities, health is improving and average life expectancy is increasing in most countries by two to three months every year. It is around 76 years in Estonia and nearly 80 years in the European Union (on average) at present. Life expectancy is projected to increase to 84.6 years for men and to 89.1 years for women in Europe by 2060. However, these figures are likely to be overly pessimistic. There are many ways of accelerating progress. Many of these are health behaviours: avoiding stress, controlling blood pressure, exercising and healthy diets do not require much additional expense. A combination of such measures can have an impressive effect on health and life expectancy. Our experimental studies in the industry have shown that it is possible to postpone age-related changes by up to 20 years at present. More rapid prolonging of human life is possible by advancing biogerontological studies and intervention programmes that need more resources than they currently have available to them.

Key words: human life expectancy, longevity, aging, future

INTRODUCTION

Of the roughly 150,000 people who die each day around the globe, ca two-thirds – 100,000 per day – do so of age-related causes. Approximately 90% die of age-related diseases in industrialised nations. According to Denham Harman (1991), founder of the International Association of Biomedical Gerontology (IABG), age is the main 'risk factor' for diseases. People do not want simply to disappear. Despite the small proportion of people who are uninterested in their health and therefore create problems for the medical world, most people's activities are aimed at maintaining their health through better living and working conditions, better food and medical services. Therefore prolonging the period of healthy years (and life) is of the greatest importance.

Various research fields whose aim is prolonging life have emerged over the years. Life extension science, also known as anti-aging medicine, experimental gerontology, biomedical gerontology (the study of slowing down or reversing the processes of aging to extend both the maximum and average lifespan) and rejuvenation research (the study of slowing or reversing the aging process).

Human life extension is a topical problem at present. Longer life is expected by improved medical care, less alcohol drinking, better diet, exercise and avoidance of smoking. The President of the Biological Section of the European Region of the International Association of Gerontology and Geriatrics for the period 2011–2015

Suresh Rattan (2008) recommends applying hormesis in human aging research and therapy which is based on the principle of stimulation of maintenance and repair pathways through repeated exposure to mild stress.

Many scientists are sceptical about the modification of human aging. They focus on efforts to cure or minimise age-related impairments. Biomedical gerontology is not particularly popular among scientists. Fewer than 100 attended the 13th Congress of the International Association of Biomedical Gerontology in Quebec, Canada in 2009.

In reality, there has been some progress. Every year average life and health expectancies increase in most countries by two to three months. The conditions in which we live are improving, mortality is decreasing, evolutionary pressure for early survival and reproduction is lessening and further resources are able to be invested in body maintenance and repair, which increases both average life expectancy and maximum life span (Westendorp, 2006). In some years there is no progress; in others it can be up to an entire year.

Different concepts are used in studies about prolonging life expectancy. Many of them are vague. Chronological aging is a person's years lived from birth. We encounter the terms 'longevity' and 'life expectancy' widely. The word 'longevity' refers to the number of years that a single person lives, from birth to death. 'Life expectancy' refers to the number of years that the average subject in a population lives. Life expectancy is mostly used for the time from birth, but sometimes from the age of 65. Life expectancy at birth is also a measure of overall quality of life in a country and summarises mortality at all ages. In the article, when we refer to 'prolonging human life', we are talking about prolonging years of human life from birth at the population level, in the country or among a large group of people.

Ordinary people are interested in specific diseases and the mortality associated with them. Population issues seem remote to them. However, 'all-cause mortality' is important when considering extending human life at the population level.

The terms 'absolute risk of death' (i.e. probability of death), 'relative mortality' and 'relative risk of death' (the possibility of dying compared to another contingent of people) are important terms among medical workers and other care specialists.

Most people are worried about their longevity; they think much less about life expectancy in their country. It seems far removed from their everyday problems. Most people think about potential longevity based on information about their relatives and friends. On the basis of these very limited facts they draw conclusions about aging and longevity. As such, myths about longevity are widespread. If one man drinks a lot of alcohol and lives to be 90, another man might think that alcohol does not shorten human life. The term 'longevity' is widely used in science fiction and other non-scientific literature, but also in science. People are very interested in those who live to be more than 100. On the basis of a single person who lives that long we can draw very few conclusions about what we need to do to increase life expectancy in a particular country. Scientific assessments of factors modifying life expectancy should be based on the studies of mortality of hundreds of thousands of people.

What is aging?

The evolutionary process has had no need to develop organisms that live forever. A mouse may live three years while some fish live more than a hundred. The long life

of an animal has little species advantage. Compared to his ancestors, *homo sapiens* live only marginally longer.

Human (biological) aging is the random accumulation of damage in cells and tissues at the level of the human organism during life that increases the probability of death (Rattan, 2012). Aging is a complex, multifactorial process. There are processes at the level of cells, organs and systems and within the organism as a whole. Every human undergoes many beneficial and adverse processes and effects at the molecular, cellular and organ level and throughout their organism in the course of their life. Oxygen and active free radicals fulfil important roles in these processes, in which systems responsible for maintenance, repair and defence are involved. The different degree of damage in people mainly depends on: (1) all material substrata of the specific organism, including genes; and (2) environmental factors, including:

- physical factors;
- chemical factors;
- psychological factors;
- social factors; and
- biological factors.

Aging is associated with degenerative processes leading to conditions such as cardiovascular diseases, musculoskeletal disorders, cancers, dementia and visual and hearing loss. There are many theories on aging. Different theories should not be considered as mutually exclusive, but complementary in their explanation of aging processes (Tosato et al., 2007).

We mostly pay attention to aging at the level of the organism, as prolonging human life expectancy depends on this at present. We do not consider processes at the level of organs, cells, macromolecules, etc. Sometimes we read about 'successful aging', which means the 'absence of diseases and disabilities, maintenance of high levels of physical and cognitive abilities, and preservation of social and productive activities' (Motta et al., 2005). The value of this term comes under discussion in fundamental research. In fact, the aging process in older people is almost always accompanied by disease. Sometimes we also read about 'normal aging', but it is not clear what normal is. What was normal a century ago is not normal today. We do not use this term, as it weakens the fight against aging.

Many biogerontologists consider aging a disease. It is increasingly being regarded in a similar fashion to other conditions: as potentially treatable.

How to control aging

Studying genes will create the basis for a scientific revolution in future medicine. High expectations of genetic research for the prevention of age-related diseases are widespread, but there have only been a small number of medical successes with gene therapy. Aging control is easier via environmental factors, including food (the environment within).

Environmental factors are usually considered as adverse in medical literature. In reality, they can also be beneficial to the body. Environmental factors are long-term health determinants. As aging is a very individual and multifactorial process, controlling it should also be individual. As there is no borderline between aging and age-related diseases, factors that cause aging are often the same as age-related diseases – so controlling these factors will partly enable aging to be controlled.

As science develops in the future we will come to know much more about risk factors. The number of potential physical, chemical, psychological, et al. factors and their combinations is infinite. We know little today about their optimums – the best values of parameters of the environment for the body. Risk factors have not been extensively studied in detail. At present we can only prolong youth and postpone aging using the best available knowledge.

The study of causes of aging and its risk factors seems simple. The search for a single cause or a handful of causes and risk factors for longevity is widespread. Recommendations have been made in their thousands which unfortunately are mostly contradictory. In fact, there are many concomitant factors, so to determine the real role of certain factors would take thousands of subjects over many years. Such research would require experiments, cohorts and longitudinal studies.

The effects of single risk factors are predominantly modest: one to two years added to life. For example, Katzmarzuk and Lee (2012) showed that reducing excessive sitting to less than 3 hours per day increases life expectancy by two years, while reducing excessive television viewing to 2 hours per day increases life expectancy by 1.38 years in the United States.

Whether we can accelerate the process of boosting population life expectancy markedly and the extent to which this is possible are interesting questions.

Situation in the world today

Average life expectancy in the world, according to the World Factbook (2012), is 67.59 years: 65.59 years for men and 69.73 years for women (2012 estimation). It tends to be better in developed countries and worse in developing countries. Health is improving and life expectancy is increasing in most countries every year. It is almost 80 years in the European Union (on average) at present. Life expectancy is projected to increase to 84.6 for men and to 89.1 for women by 2060 (2012 Ageing). There is some correlation with economic development, but we also find high life expectancy in less economically developed countries (e.g. Jordan and Cuba).

According to the latest figures from Statistics Estonia (2012), average life expectancy in Estonia in 2011 was 76.3 years: 71.2 years for men and 81.1 years for women. In Europe, the best is in Monaco, where the population-level figure is 89.68 years (85.74 years for men and 93.77 years for women) (CIA. World Factbook, 2012). The best figures were reported for Asian-Americans in the United States: 92.44 years (89.68 years for men and 95.69 years for women) (USA, 2011). Such high life expectancy is hard to believe. But according to data from Harvard University, Asian females in Bergen County, New Jersey, had a life expectancy of 91 as early as the period from 1997–2001 (Murrey et al., 2006).

Increasing life expectancy – longitudinal and experimental studies

In the 20th century, life expectancy mainly increased through decreasing child mortality. So far this century, two-thirds of increased life expectancy can be attributed to the decline in mortality of people aged 65 and older. There are many hypotheses and theories as to why life expectancy is increasing. This is most likely the result of complex overall improvements in living and working conditions, medical services and increased awareness of these conditions and health education. Quality of life is improving. Most people utilise some of what they know to live longer, sometimes

unintentionally: knowledge of physical, chemical, psychological and social risk factors of diseases and causes of all-cause mortality; knowledge about health promotion and medical cures; and better food also plays a role.

Ford et al. (2011) examined the relationship between four lifestyle behaviours (never smoked, healthy diet, adequate physical activity, and moderate alcohol consumption) and all-cause mortality in a national sample in the United States. They used data from 16,958 participants aged 17+ in the National Health and Nutrition Examination Survey III Mortality Study from 1988–2006. The rate advancement periods representing the equivalent risk from a certain number of years of chronological age for participants who exhibited all four high risk behaviours compared to those who had none were 11.1 years for all-cause mortality, 14.4 years for malignant neoplasms, 9.9 years for major cardiovascular disease and 10.6 years for other causes.

Khaw et al. (2008) examined the relationship between lifestyle and mortality in a prospective population study of 20,244 men and women aged 45–79 living in the general community in the United Kingdom with no known cardiovascular disease or cancer in a baseline survey from 1993–1997 and followed up in 2006. Participants scored one point for each health behaviour: currently not smoking, not physically inactive, moderate alcohol intake (1–14 units per week), and plasma vitamin $C > 50$ mmol l^{-1} indicating fruit and vegetable intake of at least five servings a day, for a total score ranging from 0–4. The mortality risk for those with four compared to zero health behaviours was equivalent to being 14 years younger in chronological age.

Many older people think they can do nothing about their health. This point of view is erroneous. Knoops et al. (2004) showed that even among individuals aged 70–90, adherence to a Mediterranean diet and healthy lifestyle is associated with a more than 50% lower rate of all-cause and cause-specific mortality.

Clarke et al. (2009) examined 18,863 men from 1967–70 and followed them for 38 years. Compared with men in the lowest 5% of the risk score based on smoking, diabetes, employment grade, continuous levels of blood pressure, cholesterol concentration and body mass index (BMI), the men in the highest 5% had a 15-year shorter life expectancy from the age of 50 (20.2 *vs* 35.4 years).

Kopes-Kerr (2010) highlighted ten major studies on the effects of primary prevention. These studies demonstrate significant correlations between specific healthy lifestyle behaviours and decreases in major chronic diseases (e.g. diabetes mellitus, heart disease, stroke and cancer) and all-cause mortality.

From 1965 to 2000, we carried out physiological and ergonomic studies in industry. The subjects of investigation (2,147) were workers in different jobs, such as light industry and the dairy, automotive, and building materials industries (garment workers, shoemakers, weavers, spinners, metalworkers, engravers, sorters, smiths, etc.). Our experimental studies using a combination of psychological and physiological methods and practical interventions in the industry in Estonia, Finland, Russia and Moldova over 30 years showed that it was possible to postpone age-related changes by up to 20 years (Kristjuhan, 2010).

Reducing behavioural and environmental health risk factors is the main goal of prophylactic measures against aging at present. Studies show that using the best available knowledge and measures will currently enable average life expectancy to be increased to up to 90 years, and even more in the near future. There is a need for

widespread education of the population about scientific information on the problems of human aging and rejuvenation and possible solutions. Economic stimuli for biogerontological research and intervention are also important (Kristjuhan, 2012).

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