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Ergonomics slow down ageing and postpone ageing related diseases

Ü. Kristjuhan

Chair of Labour Environment and Safety, Tallinn University of Technology, Ehitajate tee 5, EE19086 Tallinn, Estonia; e-mail: ulo.kristjuhan@ttu.ee

Abstract: For thousands of years, people have been interested in healthy ageing without diseases and in slowing down ageing. They are interested in longer-lasting youthful condition. Ageing is determined by physiology, biological ageing is accumulation of bodily changes that increase the possibility of death. There is no border line between ageing and age-related diseases, but a continuum from ageing to diseases. Longer health is good for a country's economy: social expenses are lower and people will retire later. Scientists have studied possibilities of postponing ageing for decades, but they have not found good solutions. In recent years, some attention has been paid to ergonomics. There is reason to conclude that ergonomics activities can be effective in slowing the pace of ageing. Ergonomics uses very different methods (psychological, physiological, physical, mathematical, etc.) for finding solutions, uses various professional skills (engineering, physiology, health sciences, psychology, etc.), and applies systems approach. Psychological knowledge can help solve many complex prevention problems. Our ergonomic research carried out in 1965−2000 in industrial enterprises in Estonia, Russia, Finland, and other countries also confirms these theoretical considerations. These studies have shown that it is possible to prolong good ability to work and health by up to 20 years. Ergonomics research can have potential in postponing age-related diseases, elucidation of new risk factors to health, and prolonging ability to work.

Key words: ergonomic research, ageing, health, ability to work, diseases, industrial enterprises, risk factors.

INTRODUCTION

When we hear something about ageing, it is usually about ageing-related changes in cells or in laboratory animals. In biology, ageing is mainly studied in short-living laboratory animals (Caenorhabditis elegans, Drosophila, Rodentia), and in connection with genetic problems. Ageing has been postponed several times in laboratory animals (C. Elegans, Drosophila). Despite the laboratory research of the basic biological mechanisms of ageing, these studies have given little information for knowledge about human ageing. Genetic knowledge has been used very little in practice for slowing ageing in human beings. It will probably be useful in the future.

Most scientific articles about ageing don't define what ageing is. Let us agree on the definitions. In this article, we speak about biological ageing on the level of the human organism, organismal ageing. Organismal ageing is accumulation of bodily changes that increase the possibility of death.

People have been interested in essential prolonging of youth and postponing of ageing and diseases for thousands of years. It has been a sweet dream. They do not believe that it is possible.

The aim of this article is to show that ergonomic research can have potential in postponing age-related diseases.

There has been small progress in developed countries: the average life expectancy is slowly increasing in the countries and is mainly increasing among older people. Health expectancy increases. Most prognoses of increases in the average life expectancy are moderately optimistic: 0.1−0.3 years every year.

At present, the average life expectancy of humans is 78−82 years in most developed countries. It is 89.63 years in Monaco according to World Factbook (2014) − the highest in the world. It was 76.2 years in Estonia (2012), a country that was classified as a developing country several years ago.

Studies of ageing in human beings are rarer compared to laboratory researches due to their complexity. People think that there is much scientific research on the issues of human ageing, but in fact, there is no intensive study: the funding of research of this complicated problem is limited. The current ageing research budget of the United States compares unfavourably with the United States chewing gum budget (Goldsmith, 2014).

At present, the average life expectancy in developed countries depends on multiple factors (accidents, deadly diseases, medical services), but first of all on biological ageing. Despite many studies, the situation of the ways and methods for postponing biological ageing is not clear.

There are three main groups of theories of human ageing (Goldsmith, 2014):

1. We age because of fundamental limitations, such as laws of physics or chemistry.
2. Modern non-programmed ageing theories: we age because our bodies do not try harder not to age.
3. Modern programmed ageing theories: we age because we possess what amounts to a suicide mechanism.

All these theories have a lot of proof.

At present, a researcher can often read that there are no methods for postponing (or slowing down) human ageing. However, the theoretical and experimental studies of many researchers (Kirkwood, 2005; de Grey & Rae 2007; Khaw, 2008; Fontana, 2009; Kristjuhan, 2010) show that modulating ageing is possible. The statistical data on increasing the average human life expectancy and health expectancy in parallel in various countries point to factors not related to genetics.

Age-related diseases develop from age-related changes (Kirkwood, 1999; Kirkwood, 2005). There is a continuum from ageing to diseases. The risk factors of age-related diseases are well-known. If we diminish the risk factors of age-related diseases, we decrease the pace of ageing. The time (years) of the onset of age-related diseases is the measure of ageing. There is a need for experimental studies showing prolonging of healthy years as a result improvement of working and living conditions.

MATERIALS AND METHODS

The ageing processes in humans occur slowly, from child's age to old age and death. The pace of ageing is not constant. Therefore, experimental studies to elucidate the influence of different working and living conditions on human ageing require several decades. This is complicated: working and living conditions are changing, people are changing their lifestyle, using various medicines, etc. We have not found such long-term experimental studies in the scientific literature. Such studies have probably not been carried out.

From 1965 to 2000 (Kristjuhan, 2010), we carried out ergonomic studies on healthy workers and made various recommendations to managers and workers in enterprises that were interested in improving working conditions and in better health of workers. Our ergonomic studies in the course of 35 years opened possibilities for us to assess changes in human ageing.

Our studies were carried out mainly through research contracts in Estonia, as well as in Finland, Sweden, Japan, Great Britain, Russia, and Moldova. The special ergonomics problems we studied were based on the wishes of managements. The subjects of the investigation (2,147 in total) were representatives of different jobs of light, dairy, automotive, and building materials industries (garment workers, shoemakers, weavers, spinners, metalworkers, engravers, sorters, smiths, bookkeepers, etc.). The physiological and ergonomics problems were studied in workshops where the environmental conditions were mostly satisfactory, corresponding to the international standards. Some workshops were noisy, but the workers wore antiphons. The studied groups included 30–50 male and female workers. Most studies were carried out three times during a shift, in the beginning, one-two hours after the beginning, and in the end of the shift, in the course of a few weeks. Several groups of workers were studied repeatedly.

We used a combination of methods, usable under the conditions of the enterprise, e.g. questionnaires, tests of the intensity of sensations and feelings of discomfort, critical flicker frequency, electromyography, reaction time testing, measurement of heart rate and blood pressure, exact measurements of limb perimeters, skin temperature, dynamometry, etc. We developed some research methods ourselves. We developed special devices for precise measurement of skin temperature (< 0.1°C) and limb perimeter meters for precise measurement (< 0.2 mm) of upper limbs in field conditions.

We developed a device for precise measurement of skin temperature in workshop conditions as there were no good technical solutions in the literature. The device was based on radiation measurement and was developed together with the Institute of Technical Termophysics of Kiev (Ukraine).

We developed perimeter gauges and calibrated rulers as the scientific literature does not offer practical methods for the measurement of small changes of limb perimeters (from 0.5 to 2.0%) in field conditions. The perimeter gauges consist of two or three millimetre wide measuring tapes and loads at their ends. The studied limb segment measured was supported so that it was horizontal. The measuring tape with loads was put around a marked place on the limb. The perimeter was measured with the help of a calibrated ruler. It was possible to find the localizations of physiological processes and their duration.

In our studies, we paid much attention to quantitative assessment of discomfort during working hours and after. By discomfort we mean antagonistic health effects that include many sensations and unpleasant feelings (aversion to activity, pain, being tired, itching, thinking about unpleasant things, etc.). Discomfort is an indication that something may be harmful: insufficient adaptation, stress, etc. It is information about very small changes to which most people usually do not pay any attention.

There are close associations between health and discomfort. The World Health Organization states that 'health is a state of complete physical, mental and social well-being.' Health is somewhat antagonistic to discomfort. Taking measures to alleviate discomfort can enable us postpone age-related disorders and consider individual aspects of ageing.

Subjective sensations are essential signals about something being wrong in the organism and the need to change the human activity or environment. Dozens of years ago, our experimental studies showed that subjective sensations mostly appear earlier than the changes registered by apparatus (Kristjuhan, 1985). An organism uses signals from the musculoskeletal system, but also from other organs that are under strain to avoid harmful activity.

We widely used 100 or 150 mm long visual analogue scales (VAS) for the assessment of discomfort sensations and feelings of fatigue in 4−11 body regions.

The author has worked out a chart of the human body that is divided into 100 regions for detailed analysis and quantitative assessment of fatigue and discomfort (Kristjuhan, 2010). Every region has specific reasons and physiological mechanisms of discomfort.

The chart (body map) takes into account the following:

- Spatial expansion of the symptoms of fatigue in different body regions
- Disposition of anatomical regions
- Symptoms of pathology of the musculoskeletal system
- Localization of symptoms caused by unfavourable changes in the visceral organ
- Spatial threshold of discomfort sensations
- Making the distinction between the regions of fatigue symptoms easy for workers
- Special role of upper extremities
- Maximum equality of the sizes of different regions.

Workers assessed the discomfort intensity in these regions on the 10-point scale (10 = intensity which disturbs work). Most workers found discomfort signs in 10–15 regions. Assessment in some small regions is not easy for workers, but possible and informative. Some Japanese scientists have distinguished as many as 104 anatomically identifiable parts of the body surface while studying fatigue (Kumaki, 1988).

Wilcoxon's matched pairs test was used in the discomfort studies and the *t*-test was used to assess most other ergonomics parameters.

In addition, qualitative research was also used: in discussions of ideas with workers and managers, taking into account continuous changes in lifestyle. We also used inductive strategies for finding solutions. Unfortunately, sometimes the optimal ranges of the physiological parameters that we needed were debatable in science.

RESULTS AND DISCUSSION

Ergonomics solutions

Our studies in enterprises were aimed at elucidating the most important health risk factors and their elimination. On the basis of the research data, we provided recommendations to managers and individuals: changing the technology, machine construction, colour of equipment and rooms, workstation design, new working zones, improving working conditions (parameters of noise, lighting, temperature, etc.), including music systems at the workplace, personal protective equipment (headsets, special shoes), work organization including work rotation and flexible work-rest schedules, corrective measures of workplace ergonomics, self-care procedures or doctor's visits, correct diet (optimum quantity of vitamin C, optimum calorie and sodium intake), changes in behaviour to decrease discomfort, preventive exercises, and improving labour productivity.

We developed some apparatus for preventing age-related diseases ourselves.

We developed a special apparatus for the prevention of leg fatigue: an air jet massage device. Most people working in standing position feel the fatigue of legs at the end of the work shift or in the evening. Simple measures like mechanical massage, periodic brief sitting down, physical exercise, and so on had no sufficient physiological effect. Hydro massage is effective but expensive: requires much room, water is splashed, and the devices may spread infectious skin diseases. The massage device developed by the authors is similar to the chair, in which a person sits and stretches his or her leg at a convenient 45° angle. The whole surface of the calf is gradually covered by the action of the air jet, making it possible to effectively combine the cooling and massage effects of the air jet with the physiological characteristics of the human body. After the air jet massage, the intensity of fatigue decreases significantly. Its effect lasted more than 50 min. Subjective fatigue symptoms in toes and heels which had less contact with the air jets practically disappeared (Kristjuhan et al., 1998).

Sometimes we recommended sets of exercises according to the peculiarities of work. In addition to the promotion of exercises, chronic disease prevention strategies were focused on reducing sitting time, e.g. creating workstations where work was possible in sit-to-stand workstations.

Postponing age-related diseases

The data about ageing were a by-product of our studies. When we studied the same workers during the second study period, we assessed the influence of our recommendations. We paid special attention to the time of the onset of musculoskeletal and cardiovascular diseases as well as changes in the ability to work. Comparison of the data received as a result of the research pointed to close connections between the environment, individual behaviour, and the ageing peculiarities in the human organism. Age-related changes and diseases appeared later, they were postponed up to 20 years when all recommendations were fulfilled (or in subjects who worked and lived in best conditions) compared to the persons who did not follow our recommendations. Consequently, ageing processes were slower.

Most scientific studies about prolonging the years of health and life by elimination of risk factors or adding a positive factor usually show a smaller effect, but they mainly concern a single factor. Increasing physical activity to the optimum is very widespread as an effective measure. According to Reimers et al. (2012), the data all 13 cohort studies on life expectancy in physically active individuals compared to that in physically inactive control subjects showed a higher life expectancy in physically active subjects, ranging from 0.43 to 6.9 additional years (average 34 years). A complex of various measures would be more effective.

Khaw et al. (2008) showed that the mortality risk for those with four compared to zero health behaviours (currently not smoking, not physically inactive, moderate alcohol intake (1−14 units per week), and plasma vitamin C > 50 mmol l^{-1}) was equivalent to being 14 years younger in chronological age. Improvement of working and living conditions can probably markedly prolong years of health and postpone age-related diseases.

CONCLUSIONS

Ergonomic research can have potential in prolonging ability to work. Our ergonomic research and practical implementations postponed age-related diseases up to 20 years.

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