Accelerated Aging as a Risk of Education Digitalization: Possibilities for Prevention

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Abstract—The work is devoted to analyzing the negative effects of digitalizing education and considering the possibilities for their prevention. The urgency of this problem under the current conditions of combating the novel-coronavirus-infection pandemic and moving a significant part of education and leisure to the virtual space is noted. A significant increase in the frequency of mental and physical maladjustment symptoms, a decrease in performance indicators and a deterioration of the biological-age parameters are recorded in participants in the experiment against the background of a deficit in physical activity and an increase in the duration of information consumption. The geroprotective effect of correcting the lifestyle of students with an emphasis on the use of such health-preserving elements of behavior as informational hygiene, strict compliance with recommendations for optimizing sleep, rest, motor and nutritional regimens, in terms of qualitative and quantitative indicators (with the exception of bad habits and excessive entertainment), is shown.

Keywords: active aging, biological age, health-preserving behavior, working capacity, digitalization of education

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INTRODUCTION

The contradiction between a steady increase in life expectancy and the enhanced impact of factors contributing to deterioration of the health and premature aging of representatives of various ages and professional groups of the population, which emerged at the end of the 20th century, has escalated against the background of the transition of mankind to a new technological order associated with the digitalization of all spheres of life and activity in the early 20s of the 21st century [6, 8, 11, 15].

In 2020–2021 against the background of quarantine or other restrictive measures due to the fight against the pandemic of the novel coronavirus infection, positive (expressed in the most convenient and quick handling of information and an increase in labor productivity because of this) and negative (characterized by a change in the psychological portrait of people, hypodynamia and a decrease in the level of health of various segments of the population) effects of the digitalization of education, which we schematically present in Figs. 1 and 2 based on the analysis of literature data, became especially noticeable [9, 10, 14, 20].

In addition, a return of long-forgotten social diseases has been noted in recent years, and various forms of addictive behavior have become widespread among young people, which increases the already excessive range of risk factors that impede the achievement of active and healthy longevity [4, 7, 18].

One of the conditions for the success of any activity is the presence of an appropriate level of health, which manifests in the form of good health and a sufficient level of professional performance. Otherwise, low resistance to adverse external influences will contribute to a decrease in the efficiency of educational and labor processes, quality of life and life expectancy [11, 21]. Under current conditions, the attention of scientists to the problem of compiling so-called road maps of life extension, the content of which, in our opinion, should be closely related to the formation of a healthy lifestyle culture, especially of young people, the main reserve of sustainable development and national security of the country, is justified [2, 12, 13].

The aim of the work is to study the place and role of the optimization of physical activity and rationalization of nutrition in the road map for achieving active and healthy long lives of students under conditions of digitalization of the educational process and a growing level of information consumption.

MATERIALS AND METHODS

The study was carried out at Rostov-on-Don and St. Petersburg universities in the fall semester of the
2020–2021 academic year. Students of humanitarian specialties were acquainted with the plan and methods of the forthcoming study and gave voluntary written consent to participate in the experiment.

At the first stage of the experiment, two groups of young people were formed by random sampling: experimental (61 persons) and control (52 persons). The selected students (age 19.7 ± 1.65 years) did not engage in any type of physical activity (either on their own or in sports groups). All subjects had no health disorders and underwent an initial psychophysiological examination in the following order according to well-known methods [1]:

— characteristics of well-being, activity, mood (WAM);
— study of the frequency of some subjective symptoms of maladaptation by the method of questioning;
— finding numbers with switching (black-and-red table);
— determination of biological age by the Voitenko method with an assessment of the maximum time of static balancing and holding one’s breath upon breathing in, followed by comparison with the values of the proper biological age;
— study of the level of physical activity based on the results of a pedometer using special applications built into phones and/or fitness bracelets, which the participants of the experiment wore from the moment they woke up until they went to bed.

In the second stage of the study, the persons of the experimental group adhered to an algorithm of health-preserving behavior for 4 months. The algorithm included strict adherence to recommendations for optimizing study load, sleep, rest, motor mode (with the exception of bad habits and excessive entertainment), and additional emphasis was placed on the rationalization of nutrition in terms of quantitative and qualitative indicators. To control the correctness of the course of the experiment, each subject provided an hourly report daily (due to identified violations, some of the subjects were suspended from taking part in the experiment).

The subjects of the control group at this time continued to lead their usual way of life, combining studying with working in various organizations, with periodic lack of sleep, the use of tobacco and alcohol-containing products, violation of their dietary regimen and menu. During the final stage of the study (after 4 months), the subjects of the experimental and control groups were re-examined in all areas as the initial examination. The obtained data were processed using the Microsoft Excel software package. The significance of differences between the compared samples was assessed using Student’s parametric t test.

RESULTS AND DISCUSSION

According to publications, the average physical activity of students during 8 months of classes is approximately 8–11 thousand steps per day; 3–4 thousand steps in the 2-month examination period, and 14–19 thousand steps in the 2-month vacation period [5]. Moreover, experts note that the level of physical activity during the holidays is close to the biological need for movement, and during classes and exams, the natural need is satisfied only by 50–65 and 18–22%, respectively [5]. According to our results, in the first
stage of the experiment (beginning of September 2020), the satisfaction of such a natural need among students in the control and experimental groups was performed, respectively, by 47.03 and 46.12% of the average statistical data of publications (16500 steps per day), which we took as 100% (Fig. 3a).

In addition, at the beginning of the experiment, the duration of working at a computer (or using other electronic gadgets) during classes, work and rest was an average of 8.5 ± 1.75 h/day in the control and experimental groups in a sitting/lying position (some classes were online). The low level of motor activity and an excessive volume of information consumption can explain a higher biological age by an average of 40% over the calendar one (due to low values of static balancing) and the presence of some symptoms of maladaptation, which we recorded at the beginning of the academic year, although their frequency in the studied groups of students was insignificant (Table 1, see Fig. 3b). Our results are consistent with published data that with the development and introduction of digital technologies, along with a reduction in real intersubject interaction, there is a redistribution of the youth time budget towards an increase in the proportion of communication with a computer even for the purpose of rest and entertainment in the evening, at night and on weekends (communication via social networks, computer games, watching videos, listening to music, etc.).

Fig. 3. Average daily volume of motor activity in students of the control (CG) and experimental groups (EG) at different stages of the study, thousands of steps (a), and the frequency (% of the total number of respondents) of subjective symptoms of maladaptation (b). Here and in Fig. 4: * Differences are significant between the control and experimental groups at the same points in the experiment; ** differences are significant within the group in relation to the first point of the experiment (p < 0.05).
This negatively affects health and indicators of the functional state that determine the performance efficiency, including class activity [6, 10, 20].

Considering the obtained results of the initial examination and the approaches described by various authors to compiling road maps for prolonging life and achieving active longevity [3, 12, 13], in order to prevent the undesirable consequences of a decrease in physical activity and an increase in the volume and intensity of information consumption in the experimental group, it was recommended to carry out aerobic exercise with restructuring of the sleep regimen (duration of at least 8 h, the time of falling asleep should be in the range from 22 to 24 h) and compliance with generally accepted rules of information hygiene.

As a result of motor-mode correction (walking 11000 steps in fresh air at a moderate/fast pace without switching to running), the daily biological need for motor activity of the students of the experimental group was satisfied by 66.7%, which \( p < 0.05 \) exceeded the corresponding indicator in the control group by 57% (see Fig. 3a). It should be noted that, in addition, in the experimental group, food intake was divided into 5 meals: three main and two snacks; monitoring the energy value and the ratio of proteins, fats, carbohydrates, mineral food components and vitamins was carried out using mobile applications available in modern phones.

Particular attention of the participants of the experimental group was drawn to the need for careful selection of products to exclude sugary carbonated drinks.

**Table 1.** Studied psychophysiological parameters in subjects before and after 4 months of the experiment, \( M \pm m \)

| Used method                                      | Control group                                      | Experimental group                                     |
|--------------------------------------------------|---------------------------------------------------|--------------------------------------------------------|
| Before experiment (initial level)                |                                                   |                                                        |
| Speed of switching attention, black-and-red table, points | 3.51 ± 0.19 Corresponds to average level | 3.38 ± 0.09 Corresponds to average level |
| Static balancing, s                              | 22.24 ± 1.16 Corresponds to age of 36–40 years    | 23.08 ± 1.95 Corresponds to age of 36–40 years         |
| Holding one’s breath upon breathing in, s        | 46.88 ± 5.64 Corresponds to age of 21–30 years    | 47.52 ± 3.67 Corresponds to age of 21–30 years         |
| Biological age, years                            | 27.59                                             | 27.37                                                  |
| Biological age–proper biological age, years      | –3.41 II FC biological age                        | –3.62 II FC biological age                             |
| After experiment                                  |                                                   |                                                        |
| Speed of switching attention, black-and-red table, points | 2.59 ± 0.14 \(-26\%) Corresponds to the level below average | 4.09 ± 0.15 \(+21\%\); \(+58\%) Corresponds to the level above average |
| Static balancing, s                              | 16.32 ± 0.84 \(-27\%) Corresponds to age of 46–50 years | 28.85 ± 1.07 \(+25\%\); \(+77\%) Corresponds to age of 31–35 years |
| Holding one’s breath upon breathing in, s        | 44.29 ± 3.47 Corresponds to age of 21–30 years    | 62.78 ± 4.81 \(+32\%\); \(+42\%) Corresponds to age of \( <20 \) years |
| Biological age, years                            | 30.31 (+10\%)                                     | 24.21 (−12\%)                                         |
| Biological age–proper biological age, years      | –0.68 III FC biological age                       | –6.78 II FC biological age                             |

\* Differences are significant between the control and experimental groups at the same points in the experiment; \*\* differences are significant within the group in relation to the initial level \( p < 0.05 \).
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fast food, fried/smoked food, chips and similar ingredients, the negative impact of which on health, life expectancy and quality of life is described in many studies [13, 18, 19].

When formulating recommendations for diet rationalization, we relied on numerous experimental data [3, 16] on the benefits of substances such as stimulators of telomere lengthening and telomerase activity, ingredients with anti-inflammatory and antioxidant properties (omega-3 fatty acids, polyphenols, flavonoids, ubiquinone and many others) in the composition of products. It was also proposed to diversify the menu with products containing amino acids (histidine, valine, isoleucine, leucine, tryptophan, threonine, lysine, methionine, phenylalanine, arginine), which are necessary for the prevention of osteoporosis, insomnia, depression, improvement of hematopoiesis and the activity of the immune system, memory and learning abilities [17].

After 4 months of the experiment, at the end of the semester on the eve of the winter session, the control group showed a significant increase in the frequency of subjective symptoms of maladaptation (see Fig. 3b) and a deterioration in the indicators of well-being (by 32%) and activity (by 22%) under stable mood values, which indicates an increase in fatigue and psychoemotional stress. A decrease in the attention parameters by 26% recorded at the same time contributed to a deterioration in performance efficiency, which manifested in an increase in the duration of completing homework and a further increase in the use of electronic gadgets up to 10.75 ± 0.85 h (Fig. 4, see Table 1).

On the contrary, the four-month health-preserving behavior of the subjects of the experimental group significantly contributed to an improvement in subjective (see Figs. 3b and 4) and objective indicators (see Table 1) both in comparison with the control group and in comparison with their initial values.

Thus, consistently high indicators of well-being, activity, mood and a significant increase in the speed of switching attention may indicate preservation of a high level of physical and mental performance and effectiveness of the educational process among students of the experimental group even at the end of the semester under the tense conditions of test week and preparation for the examination session.

It is also necessary to note improvement in such indicators of biological age as the duration of holding one’s breath and static balancing in the experimental group, while in the subjects of the control group, significant deterioration in these indicators contributed to an increase in the rate of aging as evidenced by the values of biological age and proper biological age (see Table 1).

An additional factor contributing to maintaining a high level, and in some cases even improving the studied indicators in the experimental group of students, was a decrease in the duration of information consumption of various electronic gadgets by an average of 1.5 h due to increased physical activity.

CONCLUSIONS

A comparative analysis of published data on the expected positive consequences and general risks of digitalization of higher education in conjunction with our own results of examination of the control group allows us to draw a conclusion about the danger of a decrease in the level of physical activity and an increase in the duration of use of information and communication technologies to the health of students.
In the control group of students, against the background of a lack of physical activity and an increase in the duration of information consumption, at the end of the fall semester compared with the beginning of the academic year, a significant increase in the frequency of subjective symptoms of maladaptation, a decrease in the attention parameters, a deterioration in the ratio of well-being and activity indicators to the value of mood were recorded. This indicated an increase in fatigue, psychoemotional stress and a decrease in the activity efficiency, accompanied by an increase in the rate of aging (according to the dynamics of biological age values, static balancing, holding one’s breath and the difference between real and proper biological age).

The efficiency of the algorithm of health-preserving behavior of students used in the experimental group allows one to substantiate the need to consider the factors described in the work when formulating road maps for extending life to minimize the negative consequences of education digitalization. At the same time, an important nuance was the revealed difficulty of students from the experimental group complying with not only the diet, but also its quantitative and qualitative characteristics (due to the specifics of the pace and rhythm of student life). As a result, it was not possible to achieve a slowdown in the aging rate of students in the experimental group compared with the initial level, although a lack of deterioration in comparison with the control group indicates the geroprotective prospects of the measures taken.

In the future, to eliminate the identified difficulties in the rationalization of students’ nutrition, we plan to use short peptides with a known structure in the form of biologically active food supplements, anti-stress, geroprotective and nootropic effects of which have been proven in the study of managing the body’s reserve capabilities [11, 13, 16].

**COMPLIANCE WITH ETHICAL STANDARDS**

*Conflict of interest.* The authors declare that they have no conflict of interest.

*Statement of compliance with standards of research involving humans as subjects.* All procedures performed in studies involving human participants were carried out in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants involved in the study.

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