ORIGINAL ARTICLE

IMPACT OF MOTOR ACTIVITY ON THE DYNAMICS OF INTELLECTUAL WORKING CAPACITY AND MENTAL COGNITIVE PROCESSES IN STUDENTS

DOI: 10.36740/WLek202306114

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ABSTRACT

The aim: To study the impact of physical exercises of different intensity on the dynamics of intellectual working capacity and mental cognitive processes in students.

Materials and methods: The research involved 293 students. The research was conducted in 2 stages. The 1st stage involved the study of the level of intellectual activity of students with sufficient (the experimental group, n = 76) and insufficient levels of their motor activity (the control group, n = 217). The 2nd stage provided for the determination of the dynamics of intellectual activity indicators in students (n = 76) before and after physical exercises of different intensity.

Results: It was found that students with sufficient motor activity are characterized by significantly better indicators of intellectual working capacity and mental cognitive processes than students with insufficient motor activity. It was found that low-intensity physical exercises of a recreational nature had a more positive effect on intellectual working capacity in the course of training sessions.

Conclusions: Organized motor activity and optimal physical exertion both during and after the end of intellectual functioning can directly affect the preservation and improvement of students' intellectual working capacity.

KEY WORDS: motor activity, physical exercises, intellectual working capacity, mental cognitive processes, students

Wiad Lek. 2023;76(6):1422-1427

INTRODUCTION

The significant intensification of the educational process in higher educational institutions (HEIs) of Ukraine, which is designed to ensure the high quality of training of future specialists for professional activities, has led in recent years to a significant intellectual overload of students and caused a decrease in their motor activity [1]. This negative trend has been significantly intensified during the period of regular transitions from full-time to distance (online) education. As a result of a heavy learning load with low motor activity (students spend most of their time sitting in classrooms or at computer and phone screens), negative changes began to occur in students' bodies, associated with a general deterioration in health, diseases (pathologies) of many organs and systems, excess weight gain, and problems in the psycho-emotional sphere (irritability, aggressiveness, isolation, poor health, etc.) [2]. The above factors hurt the indicators of intellectual working capacity (IWC) and mental cognitive processes (MCP) of students: academic performance deteriorates, attention, memory, thinking decrease, and fatigue sets in quickly [3]. Fatigue is based on a decrease in the body's functional capabilities and reserves. Since students' learning activities by their nature belong to the types of mental and intellectual labor, one of the first signs of fatigue is a decrease in their IWC.

According to some scientists [4], an effective way to combat fatigue, and deterioration of the intellectual, as well as the physical working capacity of students is to increase the amount of their motor activity (MA) and physical exertion, including their rational dosage during the period of intense intellectual activity. It is proved that physical exercises (PEs) actively influence the effectiveness of students' learning, elements of IWC, and are used to prevent and eliminate mental fatigue in the conditions of intensification of educational activities [5].

Of particular interest among scientists is the question of the rational use of PEs to restore working capacity during intellectual functioning. According to experts [6], a high level of IWC is maintained provided that the optimal excitability of the corresponding cortical areas of the cerebral cortex is maintained. As a result of prolonged intellectual functioning, inhibitory processes occur in the higher parts of the brain, which cause a decrease in attention, memory, the ability to creatively analyze information, and result in errors. A periodic transition to performing physical exercises allows you to accelerate the recovery of IWC, relieve fatigue, and have a general health effect. However, scientists emphasize the need to take into account the amount of physical exertion and the time of exercise in the daily routine for IWC recovery. It is during intellectual functioning, according to scientists [7], that the negative effects of physical exertion are most often encountered. Heavy physical exertion results in a disruption of the nerve centers, to the creation of a new dominant system of inter-center connections in the higher parts of the brain. This can complicate further intellectual functioning which is based on a different mechanism. Significant muscle exertion can create persistent fatigue. If the following processes occur during intellectual functioning, productivity may decrease. Therefore, training sessions with heavy physical exertion should be carried out after the end of intellectual activity, at the end of the working day.

Scientists [8] note that the selection and duration of PEs in the process of intellectual activity depend on the nature of such functioning. If it consists of habitual intellectual operations that do not contain complex analytical components, then in this case, moderate exertions of increased duration and intensity will not cause a decrease in the productivity of the main work. However, if intellectual functioning is creative in nature and involves analyzing a wide range of information, then the system of inter-center connections should not be disrupted by switching to intense muscle activity. In this case, a positive effect is achieved by light PEs, the performance of which does not disturb the dynamic stereotype of the main work in the cortex.

According to experts [9], within the daily or weekly cycles of activities, in which mental work and other types of work alternate, there must be a place for training sessions aimed at improving physical fitness. Depending on the conditions, they can take the form of regular physical education training sessions, independent training, or athletic training. It is better to conduct training sessions with high physical activity in the afternoon so that complete recovery of IWC occurs during evening rest and night sleep.

THE AIM

The aim is to study the impact of physical exercises of different intensity on the dynamics of intellectual working capacity and mental cognitive processes in students.

MATERIALS AND METHODS

The research was conducted at the Department of Health and Sports Technologies of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" (Kyiv, Ukraine) in 2021. The research involved 293 students (168 men and 125 women) of the first and second instructional years of technical specialties.

The research was conducted in 2 stages. The 1st stage involved the study of the level of intellectual working capacity as well as the indicators of attention and memory of students with sufficient (the experimental group, n = 76) and insufficient levels of motor activity (the control group, n = 217). The level of MA was determined by interviewing students and assessing their involvement in various forms of MA: a sufficient level involved systematic physical exercise throughout the day and week (morning physical exercises, physical education training sessions at the HEI, club training sessions by sports, independent training); insufficient level – irregular, occasional attendance of physical education training sessions at the HEI, absence of morning exercises, independent and club training sessions in the daily routine. The 2nd stage provided for the determination of the dynamics of IWC and MCP indicators in students (n = 76) before and after physical exercises of different intensity, which was determined by the value of HR. Thus, two groups of students were randomly created: the EG1 (n = 38) and the EG2 (n = 38). The EG1 had low-intensity training sessions (students' heart rate during the training sessions did not exceed 130-150 beats / min), and the EG2 had high-intensity training sessions (heart rate – 160-180 beats / min). The duration of the training sessions was 90 minutes.

We used the following scientific methods: theoretical analysis and generalization of scientific and methodological literature, testing of students' indicators of IWC and mental cognitive processes, and methods of mathematical statistics. The IWC was assessed by Anfimov's correction task (a form with 1480 characters (37 lines of 40 characters each) [10]. The test lasts 10 minutes. The task was to consistently cross out the letters C and K in the form (M). At the same time, it was necessary to process as many characters as possible (H) and make as few mistakes

Table I. The level of IWC and MCP indicators in students with sufficient (EG, n = 76) and insufficient (CG, n = 217) levels of MA (Mean ± SD), c. u.

The studied indicators	EG (n=76)	CG (n=217)	Level of significance (p)
Volume of information (number of processed characters)	1261.5±14.3	1235.2±6.7	>0.05
Number of mistakes made	14.6±0.95	18.1±0.68	<0.01
Work accuracy indicator	91.2±0.51	89.4±0.34	<0.05
Intellectual working capacity	1147.8±13.2	1099.3±7.5	<0.01
Scope of attention	7.3±0.15	6.9±0.11	<0.05
Visual memory	6.1±0.17	5.7±0.10	<0.05

Table II. Dynamics of students' IWC and MCP before and after training sessions with PEs of low (EG1, n = 38) and high (EG2, n = 38) intensity (Mean ± SD), c. u.

The studied indicators	EG1		p	EG2		p
	Before	After		Before	After	
Volume of information	1257.8±19.1	1255.2±20.3	>0.05	1268.1±18.7	1249.4±19.2	>0.05
Number of mistakes made	15.3±1.04	13.8±0.99	>0.05	14.1±1.02	16.5±1.07	>0.05
Work accuracy indicator	89.3±0.81	90.6±0.79	>0.05	90.4±0.94	87.4±0.90	<0.05
Intellectual working capacity	1119.4±22.7	1142.2±21.9	>0.05	1141.3±23.2	1086.9±24.1	>0.05
Scope of attention	7.1±0.32	7.3±0.30	>0.05	7.2±0.34	6.7±0.35	>0.05
Visual memory	5.9±0.39	6.0±0.37	>0.05	5.8±0.40	5.6±0.41	>0.05

as possible (O). A mistake is considered to be the omission of letters that should be crossed out, as well as incorrectly crossed-out letters. Based on the test results, we determined the rate of accuracy (A) and IWC: $A = M / (M + O) \times 100$; $IWC = A / 100 \times H$. The scope of attention and visual memory of students was assessed using the numerical operations method, the essence of which is to operate with certain volumes of information in the form of one-digit numbers. A 25-cell form with numbers from 1 to 40 (15 numbers were omitted) was used. According to the test conditions, the student should find and cross out the numbers missing in the test form as quickly as possible (1-minute test). After that, using another form, the students had to write down the difference between the crossed-out numbers they had to memorize and the number 10.The scope of attention and visual memory were assessed on a 9-point scale. During each subsequent test, the position and order of the letters in the correction task form and the numbers in the forms were changed.

The significance of the difference in the results of the students was determined during the studying based on the Student's test. The significance for all statistical tests was set at $p<0.05$. All statistical analyses were performed with the SPSS software, version 21, adapted to medical and biological researches. This research followed the regulations of the World Medical Association Declaration of Helsinki. Informed consent was received from all students who took part in this research.

RESULTS

The analysis of the results obtained at the 1st stage of the research showed that most of the studied indicators in students with a sufficient level of MA were significantly ($p < 0.05$; $p < 0.01$) better than those with an insufficient level of MA (Table I). Thus, only in terms of the number of processed characters, the indicators of the EG and the CG do not have a significant difference ($p < 0.05$). The number of errors in the CG was higher than in the EG by 3.5 c. u.; the indicators of accuracy, IWC, the scope of attention, and visual memory were better in the EG by 1.8, 48.5, 0.4, and 0.4 c. u., respectively. This indicates that MA is an effective factor in improving students' IWC and MCP while studying at the HEI.

The comparative analysis of students' IWC and MCP indicators before and after the training sessions with low- and high-intensity PEs in the educational process (in the intervals between academic studies) shows that all the studied indicators either improved or did not change after PEs performance in the EG1, where training sessions with PEs were characterized by low intensity. The most qualitative changes ($p > 0.05$) were found in the reduction of the number of errors (by 1.5 c. u.), in the accuracy indicators (by 1.3 c. u.) and in IWC (by 22.8 c. u.) (Table II).

There was deterioration in all indicators in the EG2, where the training sessions with PEs were conducted with high intensity, in contrast to the EG1. The most pronounced changes were found in the indicators of accuracy (by 3.0 c. u., at $p < 0.05$), the number of errors

made during the processing of the correction task (by 2.4 c. u., at $p < 0.05$), IWC (by 54.4 c. u., at $p < 0.05$) and the scope of attention (by 0.5 c. u., at $p < 0.05$). The obtained results indicate that training sessions with PEs in the process of academic studies should not give a heavy load on students. However, low-intensity training sessions with a health-improving effect are quite effective in improving both students' IWC and MCP.

DISCUSSION

Physical education is an integral part of the formation of a harmoniously developed modern specialist. It is proved that systematic optimal training sessions with PEs contribute to health promotion, improvement of physical and intellectual working capacity as well as the quality of education of students [11]. Scientists argue that intellectual functioning and intellectual development require an appropriate physical condition of students, that is, intellectual activity directly depends on MA [12]. Scientists describe the dependence of intellectual functioning productivity on physical activity as follows: the effectiveness of intellectual functioning in conditions of low MA decreases by 50 % on the second day. During intellectual activity, blood flow to the brain vessels increases, peripheral vessels of the extremities constrict, and the vessels of the internal organs dilate, i. e., reactions are reversed from those characteristics of muscle exertion. During PEs performance, many impulses are sent to the cerebral cortex from all organs and systems, especially from muscles and the entire musculoskeletal system, the importance of which is extremely important for the recovery of fatigue, ensuring thinking processes and sustainable intellectual activity. Thus, motor activity and physical exertion are a prerequisite for successful, fruitful, and long-term intellectual activity [13].

Specialists [14] note that PEs used in the educational process has a double effect on the students' body: specific and nonspecific. The specific effect is manifested in the direct participation of the motor analyzer in various learning activities: the ability to hold a static posture; performing movements necessary for intellectual functioning, i. e. finger and hand movements while writing; eye movements, moving the torso in space; manipulating various objects. The nonspecific effect is that muscle activity causes an increase in the tone of the cerebral cortex, thus creating favorable conditions not only for the functioning of existing connections but also for the development of new ones. However, physical exercises have the most beneficial effect on students' bodies only within the limits of optimal load. Excessive motor activity in the process of studying (between academic studies) can hurt the body – the general condition worsens, the activity of the nervous system is disturbed, recovery processes slow down, excessive fatigue and overstrain arise and accumulate. That is why it is necessary to perform PEs with high intensity after the end of the academic day so that the body can recover by the next day [15].

In the course of our research, we found that MA is an important factor not only in promoting students' health but also in improving their IWC and MCP: students who had a sufficient amount of MA had significantly better indicators of intellectual and mental functioning (attention, memory). At the same time, the use of optimal physical exertion in the students' working day routine performs the function of active rest and recreation to prevent their intellectual fatigue. Thus, PEs has a positive impact on the effectiveness of students' learning, on the indicators of their intellectual functioning and is a means of relieving negative emotions and intellectual fatigue. Our results confirmed the conclusions of scientists, where it was found that PEs in the process of intellectual functioning contributed to the improvement of mobility of nervous processes and thus created prerequisites for the longer preservation of IWC. At the same time, one should avoid excessive physical and emotional stress when performing PEs in the process of intellectual functioning, which can increase the excitability of the central nervous system and complicate further involvement in intellectual activity.

CONCLUSIONS

It was found that students who systematically engage in PEs and have a sufficient amount of MA have significantly ($p < 0.05$; $p < 0.01$) better indicators of IWC and MCP than students with insufficient MA. The difference between the EG and the CG in terms of the number of errors, accuracy, IWC, the scope of attention, and visual memory was 3.5, 1.8, 48.5, 0.4, and 0.4 c. u., respectively.

It was found that in the process of academic studies, low-intensity PEs of recreational nature had a more positive effect on the indicators of IWC. Thus, most of the indicators of students' intellectual functioning improved after training sessions in the EG1, in contrast to the EG2, where training sessions were of a training nature of high intensity. Such training sessions should take place only after the end of intellectual functioning. Thus, organized MA and optimal physical exertion during and after the end of intellectual functioning can directly affect the preservation and improvement of students' intellectual working capacity.

Prospects for further research are aimed at studying the impact of physical exertion of different intensity on the indicators of physical development and health of students.

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This research was carried out according to the research work of National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" for 2018-2023 on the theme of "Information technologies for assessing and correcting the state of health of students in higher educational institutions" (state registration number 0117U006954).

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Conflict of interest:
The Authors declare no conflict of interest.

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Received: 10.10.2022
Accepted: 21.05.2023

A - Work concept and design, **B** – Data collection and analysis, **C** – Responsibility for statistical analysis, **D** – Writing the article, **E** – Critical review, **F** – Final approval of the article