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Using Neuro-Stimulating Physical Exercises to Restore Cognitive Functions in the Correction of the Post-COVID Syndrome

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Abstract

Neuro-stimulating exercises used in non-standard combinations make it possible to mitigate the consequences of cognitive deviations in post-COVID syndrome. The combination of eastern health practices and situations of uncertainty created in team sports contribute to the restoration of the body in the shortest possible time, maintaining physical performance, improving concentration, reducing anxiety, and restoring psychological comfort for a long time. The purpose of the current study was to find new methods and means of physical culture, which stimulate the acceleration of body recovery, and the elimination of post-covid syndrome among students. The research tools were international experience in the use of neuro-stimulating physical exercises in everyday practice. The pedagogical experiment was carried out in 2021-2022 at the Russian University of Transport. The testing in May 2022 has shown a significant increase in indicators in the experimental group. There was a decrease in situational anxiety (31.12%), personal anxiety (20.15%), and depression level (38.69%) among the students of the experimental group. At the end of the study, there was a significant improvement in the psychophysical state of the students. Among the students of the experimental group, there were not found any symptoms of the post-COVID syndrome in May 2022. The results obtained in the current study can serve as a basis for further research involving various groups of people and using more advanced technologies and research tools.

Keywords: Post-COVID syndrome, Neuro-stimulating exercises, Students, Team sports, Eastern health practices

Introduction

The COVID-19 pandemic lasts for three years already. Despite the current incidence decline and removal of coronavirus restrictions in many countries, world scientists are still concerned and continue to observe the long-term consequences that are caused by this disease (post-COVID syndrome) (Jimeno-Almazán *et al.*, 2021; Sykes *et al*., 2021; Tirelli *et al.*, 2021). The post-COVID syndrome refers to symptoms that develop after COVID-19 and last from one to seven months, and in some cases even longer (Raman *et al.*, 2022).

For the first time, information about the post-COVID syndrome was recorded in the summer of 2020, when many people who had been ill with a coronavirus infection began to experience significant depressive and anxiety disorders. In September 2020, a separate code "U09.9 – health condition after COVID-19" was already introduced into the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD) to describe the post-COVID syndrome (Parkin *et al.*, 2021; Parums, 2021; Renaud-Charest *et al.*, 2021). At this time, there was formed a base of post-COVID symptoms. The past COVID-19 disease with a wide variety of clinical symptoms, greatly worsens the psychophysical state of the body, affecting human life quality (Hajra *et al*., 2020; Nabavi, 2020; Sudre *et al.*, 2021).

In addition to medicines, many doctors recommend using various means of physical culture (walking in park areas, doing physical exercises in the fresh air, breathing exercises, elements of yoga gymnastics, and team sports games) (Del Rio *et al.*, 2020; Halpin *et al.*, 2021). Neurogymnastics is also considered to be particularly useful for improving attention, memory, and speed of reaction (cognitive functions) to turn on the mechanisms of neuroplasticity in the hemispheres of the cerebral cortex (Carfì *et al.*, 2020). Research around the world has confirmed that exercising can lead to long-term improvement in cognitive function for all age groups (Garrigues *et al.*, 2020; Huang *et al.*, 2021).

The purpose and main objectives of the current study were to find new methods and means of physical culture, which will result in a faster recovery of the body from the post-COVID syndrome among the students.

Materials and Methods

According to the purpose and objectives of the study, there have been used such research methods as a survey, online questioning, pedagogical observations, testing, online testing, and methods of mathematical statistics.

Statistical processing of the obtained results was carried calculating the value of the Student's t-test using a computer. The presence of differences between the observed groups was considered significant in the case of $p<0.01$.

In September 2021, the authors conducted an online survey among the students of the Transport universities of Russia. The

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purpose of this survey was to obtain such information as the number of students who recovered from COVID-19; the number of students experiencing the post-COVID syndrome; the most common symptoms of the post-COVID syndrome. The survey was conducted among first-fifth-year students (aged from 17 to 23 years), with a total number of 6003 people (n=6003).

The experimental platform for the study was the volleyball classes at the Russian University of Transport (Moscow) during the academic year 2021-2022. Those who had recovered from COVID-19 and had symptoms of the post-COVID syndrome were included in the experimental group of 25 people and there was one control group of 25 first-year students (n=50).

In order to mitigate the consequences of the coronavirus infection COVID-19 and improve students' health through physical culture, the authors have developed a recovery method using a set of neuro-stimulating exercises.

The originality of the authors' technique was the complex use of neuro-stimulating exercises, which were based on elements of non-traditional health-improving gymnastics in combination with sports games (volleyball) in the PT classes at the university.

Studying and mastering the technique of multidirectional and complex movements of oriental gymnastics combined with complex coordination game exercises of volleyball, there is involved a wide range of neurons in the brain of those tested, which contributes to the creation of new and restoration of previously formed neural connections (Postol & Shchadilova, 2022).

The theoretical prerequisites for this health-improving technique were the study of Oriental health-improving practices and a system developed by American scientists Paul Dennison and Gale in the 90s of the XX-th century. They developed the "Brain Gym" program (neuro-gymnastics) for the intellectual development of a person.

The main principle of neuro gymnastics is the simultaneous and synchronous work of the right and left hands, while each performs its movement. It is this kind of gymnastics that is needed for the coordinated work of the left and right hemispheres of the brain.

As a result, due to the performance of properly selected physical exercises, the mechanisms for the high-quality work of the human brain are activated intrinsically. Endurance and strength training, in which coordination is important, as well as their combination, improve a person's cognitive abilities and mental health.

These can be games, for example, tennis, golf, volleyball, and oriental martial arts, such as surfing, horse riding, gymnastics, and cycling. Team sports (football, hockey, volleyball, and others) contribute to the development of analytical thinking and speed of reaction.

When playing volleyball, the focus instantly changes, and incoming information must be processed quickly. Complex neuro gymnastics exercises contribute to the involvement of unused brain neurons, forming new connections, improving memory, increasing concentration, developing divergent thinking, and relieving cognitive disorders. Regular exercise also has a positive effect on sleep.

The pedagogical experiment was started in September 2021 and was finished in May 2022. In November 2021 and February 2022, due to the situation with the COVID-19 pandemic, the students of the university were on distance learning. According to the medical examination results, the students participating in the pedagogical experiment did not have any deviations in their health condition. The experimental technique, which consisted of theoretical and practical parts, was used in the 90-minute classes twice a week.

An energy gymnastics hand from Yoshiro Tsutsumi was used in the final part of the lesson to reduce anxiety and increase stress resistance, improve attention, memory, and thinking, and recover the body after exercising. Also, these gymnastics was used to strengthen and restore the ligaments of the muscles and tendons of the hands after playing volleyball.

Energy gymnastics hand from Yoshiro Tsutsumi helps to find peace of mind, significantly reduce the level of anxiety, significantly develop, and improve cognitive abilities, and perfectly adapt to the environment (I-Shen, 2007).

There are 9 basic exercises in gymnastics, the exercising lasted 5-7 minutes. PT classes for the control group were held according to the educational program of the department "Physical culture and sport" of the RUT (MIIT).

In the experimental group, PT classes were conducted according to the technique developed by the authors, which included the complex use of neuro-stimulating exercises (Chinese qigong gymnastics, energy gymnastics hand from Yoshiro Tsutsumi, and the American psychologist P. Dennison, yogi breathing exercises with volleyball exercises) and complex coordination exercises to develop attention taken from volleyball practice.

Results and Discussion

The questionnaire developed by the authors was conducted online in September 2021 among the students of the Russian University of Transport.

According to the online survey results, it turned out that 91% of the total number of respondents had been ill with COVID-19. More than 72% of them had the post-COVID syndrome. Most young people complained about the following symptoms:

- chronic fatigue, poor physical activity – 61%;
- increased anxiety, and depression – 18%;
- deterioration of memory, memorization, and perception of new information – 9.3%;
- poor concentration of attention – 7.1%;
- dizziness – 3.2%;
- problems with coordination of movements – 1.4%.

At the Russian University of Transport, there was carried out testing according to the method of Charles Spielberger (State-Trait Anxiety Inventory (STAI)), adapted by Yu.L. Khanin in

September 2021 and in May 2022 to identify the levels of personal and situational anxiety among the first-year students.

The testing, which was carried out at the beginning of the experiment (September 2021), showed that the results of the experimental and control groups did not have significant differences (P> 0.01) **(Tables 1, 2)**. The students of both groups had a high level of personal and situational anxiety.

The testing in May 2022 showed a significant improvement in the indicators among the students of the experimental group (P<0.01) compared to the control one.

Table 1. Changes in indicators of personal and situational anxiety (the method of Charles Spielberger (State-Trait Anxiety Inventory (STAI)), adapted by Yu.L. Khanin) among the students of the experimental and control groups.

Indicators	Control group M±m, n=25		Experimental group M±m, n=25	
	start of research	9 months of research	start of research	9 months of research
Personal anxiety	50.28 ±1.28	48.36 ±0.64	50.25 ± 1.11	39.92 ± 0.63
(PA)	< 0.01		< 0.01	
Situational anxiety	54.03±1.96	49.0±1.03	54.13±1.72	37.28±0.27
(SA)	< 0.01		< 0.01	

Note: p – is the mathematical significance of the differences in indicators inside the group.

In an attempt to determine indicators of anxiety and depression the students were tested according to the Hospital Anxiety and Depression Scale (HADS) developed by Zigmond and Snaith. This testing was also conducted in September 2021 and May 2022.

The testing conducted in September 2021 showed that the results of the control and experimental groups had no significant differences (P> 0.01), **(Table 2)**.

The indicators of the HADS in September 2021 showed that the students in both groups had subclinical anxiety at the beginning of the academic year. The indicators of depression levels in these groups were within the normal range. The HADS in May 2022 identified a significant improvement in the results in the experimental group compared to the control group. There was a significant improvement in both the experimental and control groups, (P<0.01). The indicators of the HADS-D (depression) in both groups were within normal limits at the end of the pedagogical study (May 2022).

Table 2. Changes in testing indicators. Hospital Anxiety and Depression Scale (HADS) among the students of the experimental and control groups.

Indicators	Control group M±m, n=25		Experimental group M±m, n=25	
	start of research	9 months of research	start of research	9 months of research
HADS-A (anxiety)	9.3±1.44	8.1±0.67	9.27±0.41	6.39±1.15
	< 0.01		< 0.01	
HADS-D (depression)	6.81±0.63	6.03±0.44	6.9±0.81	4.23± 0.92
	< 0.01		< 0.01	

Note: p – is the mathematical significance of the differences in indicators inside the group.

In order to estimate the psychophysical state, there were used the following tests: ‘tapping test’, Romberg’s test (Romberg maneuver), Schulte Table, and ‘catching the ruler’. The testing conducted at the beginning of the pedagogical study (September 2021) showed that the results of the control and experimental groups did not have significant differences (P> 0.01), **(Table 3)**. While analyzing all indicators of mental state testing in May 2022, there was identified a significant improvement in the experimental group, (P < 0.01).

Table 3. Changes in the psychophysical parameters of the students in the control (CG) and experimental (EG) groups

Indicators	Control group M±m, n=25		Experimental group M±m, n=25	
	start of research	9 months of research	start of research	9 months of research
‘tapping test’ (quantity)	108±0.89	112± 0.63	108.1±1.77	121.9±0.65
	< 0.01		< 0.01	
‘catching the ruler’ (cm)	30.47±1.07	27.15±0.11	30.51±1.71	23.8±1.19
	< 0.01		< 0.01	
Romberg’s Test (sec)	13.65±0.96	15.18±1.14	13.63±1.05	19.8±0.93

		< 0.01		< 0.01
Schulte Table (sec)	52.3±2.01	43.1±1.15	52.27± 0.85	36.9±0.72
		< 0.01		< 0.01

Note: p – is the mathematical significance of the differences in indicators inside the group.

The testing of such technical volleyball techniques as free throws and the ball above when doing the lower pass, which was carried out in September 2021, showed that at the beginning of the academic year the students of control and experimental groups could hardly ever determine the distance to the target or rationally select a ball flight path. There were 37% of students with satisfactory results and 63% of them with unsatisfactory ones. Only 24% of students managed to hold the ball above when doing the lower pass more than 20 times. The indicators of the control and experimental groups did not have significant differences (P<0.01) **(Table 4)**. The indicators of the testing for the free throws' accuracy in May 2022 demonstrated a significant improvement in the experimental group compared to the control group (P<0.01). A significant improvement in the results was noted in both the experimental and control groups (P<0.01). 96.2% of students in the experimental group and 56.9% in the control group managed to hold the ball above when doing the lower pass more than 20 times (May 2022), which demonstrates an improved concentration of attention, improved technical skills in both groups, while the overall results were much better in the experimental group.

Table 4. Change in testing indicators. Volleyball technical indicators

Indicators	**Control group M±m, n=25**		**Experimental group M±m, n=25**	
	start of research	**9 months of research**	**start of research**	**9 months of research**
free throws (out of ten times)	4.8± 1.18	5.5±1.3	4.79±1.92	7.2± 0.65
		< 0.01		< 0.01
the ball above when doing the lower pass (the number of passes out of 20 times)	9.7±1.85	15.2±0.17	9.68±1.11	20.5± 0.87
		< 0.01		< 0.01

Note: p – is the mathematical significance of the differences in indicators inside the group.

The post-COVID syndrome causes failure of most body systems, such as cardiovascular, respiratory, nervous, autonomic, digestive, and immune. The condition arising from this syndrome is very dangerous for a young person and negatively affects his psychophysical state.

The testing carried out according to the method of Charles Spielberger (State-Trait Anxiety Inventory (STAI)), adapted by Yu.L. Khanin in May 2022 to identify the levels of personal and situational anxiety showed a significant improvement in the indicators among the students of the experimental group (P<0.01) compared to the control one (Shaheen *et al*., 2022).

As for personal anxiety, there was a decrease in the indicator by 10.33 points, the anxiety level decreased by 20.55% in the experimental group; and in the control group, the indicator decreased by 1.92 points, and the anxiety level decreased by 3.81%.

As for situational anxiety, there was a decrease in the indicator by 16.85 points, the anxiety level decreased by 31.12% in the experimental group; and in the control group, the indicator decreased by 5.03 points, and the anxiety level decreased by 9.3%.

The results of this testing (the end of the experiment) showed that the students of the experimental group, who were taught according to the methodology developed by the authors, significantly decreased their anxiety levels. The personal and situational anxiety levels decreased and became within the normal range (mean). In the control group, although there was a significant change in indicators (P<0.01), the decrease in the anxiety level was not significant, and the level of situational and personal anxiety remained high.

The Hospital Anxiety and Depression Scale (HADS) by Zigmond and Snaith conducted in May 2022, identified a significant decrease in anxiety and depression in the experimental group compared to the control group. There was a significant improvement in both the experimental and control groups, (P<0.01).

As for the HADS-A (anxiety), the anxiety indicator decreased by 2.88 points (31.06%) in the experimental group, and it reduced by 1.2 points (12.9%) in the control group.

As for the HADS-D (depression), the anxiety indicator decreased by 2.67 points (38.69%) in the experimental group, and it reduced by 0.78 points (11.4%) in the control group.

An analysis of the indicators of the HADS test conducted in May 2022 revealed a good decrease in the levels of anxiety and depression in the students of the experimental group. The results of the level of anxiety (HADS-A) in May 2022 in this group became within the normal range. The indicators of the testing in the control group showed the presence of subclinical anxiety, despite a slight decrease in results. The indicators of depression level (HADS-D) in these groups were within the normal range.

The test scores of students in the control group, despite a slight decrease in results, showed subclinically expressed anxiety. The results of the level of depression (HADS-D) in both the control and experimental groups remained within the normal range.

The results of testing psychophysical qualities, which were carried out in May 2022, also revealed a higher improvement in all test indicators in the experimental group, which was engaged in the rehabilitation methodology developed by the authors with the complex use of elements of neuro-stimulating exercises **(Table 3)**. Both in the control and experimental groups, there was a significant improvement in the results, ($P<0.01$).

As for the 'tapping test', the indicator increased by 13.8 points (12.76%) in the experimental group, and in the control group, an improvement was by 4 points (3.7%).

As for 'catching the ruler', the indicator increased by 6.71 cm (21.9%) in the experimental group, and in the control group, an improvement was by 3.32 cm (10.89%).

As for Romberg's test, the indicator increased by 6.17 sec (45.26%) in the experimental group, and in the control group, an improvement was by 1.53 sec (11.2%).

As for Schulte Table, the indicator increased by 15.37 sec (29.4%) in the experimental group, and in the control group, an improvement was by 9.2 sec (17.59%).

Thus, the results of testing psychophysical qualities among the students of the experimental group were rather better than those among the students of the control group, which demonstrated an improvement in students' health.

The indicators of the testing for the free throws' accuracy and holding the ball above when doing the lower pass in May 2022 demonstrated a significant improvement in the experimental group compared to the control group ($P<0.01$). A significant improvement in the results was noted in both the experimental and control groups ($P<0.01$).

As for free throws, the indicator increased by 2.41 times (50.3 %) in the experimental group, and in the control group, an improvement was by 0.7 times (14.58%).

As for holding the ball above when doing the lower pass, the indicator increased by 10.82 times (111.7%) in the experimental group, and in the control group, an improvement was by 5.5 times (56.7%).

In May 2022 (at the end of the pedagogical study), the students of the experimental group showed significant improvements in their psychophysical and emotional condition, concentration of attention, and body recovery after physical and mental stress, which indicates the productivity of the authors' technique.

Conclusion

The consequences of the COVID-19 pandemic remain a long-term problem for those who have been ill. Post-COVID syndrome is characterized by deterioration of memory and sleep and unreasonable anxiety. Negative symptoms have been noted in all age groups. When studying at a university it is a necessity to learn a large amount of new information, there is a need for a long concentration of attention.

For the purpose of restoring the students' cognitive processes, the authors used a combined technique of neuro-stimulating effects, composed of exercises from Oriental practices (Energy gymnastics hand from Yoshiro Tsutsumi and the "Brain Gym" program of P. Dennison) and special exercises that teach the technique of playing volleyball at the PT classes at the university.

As a result of the study, there has been identified a significant decrease in situational and personal anxiety, as well as there has been an improvement in the levels of anxiety and depression in the experimental group, which became within the normal range at the end of the pedagogical study.

The analysis and estimation of the results of the 'tapping test', 'catching the ruler', Romberg's test, and Schulte Table conducted at the end of the study, have shown a significant improvement in the mental state in the experimental group ($P <0.01$).

The indicators of the testing of free throws and holding the ball above when doing the lower pass have demonstrated a significant improvement among the students of the experimental group compared to the control group ($P<0.01$), which indicated an improved concentration of attention and technical skills.

At the end of the experiment, there have been found no symptoms of the post-COVID syndrome among the students of the experimental group. The consequences of the impact of coronavirus infection on the cognitive sphere of an individual have been eliminated. There has been proven efficiency of the authors' technique.

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