Adaptation responses of the body to mental and local physical load in students athletes

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Abstract. The functional status of the heart and central nervous system in athletes and untrained students aged 18-20 years was studied after local physical exertion and cognitive tests. The results revealed an increase in heart rate and blood pressure, as well as the amplitude of the mode and stress index in heart rhythm, which indicates a different degree of functional stress in all subjects during all tests. The features of increasing situational anxiety and slow EEG rhythms in athletes and untrained students were also identified. Given the functional tension of the heart and central nervous system, psychophysical correction of the body using relaxation techniques is recommended for the prevention of overstrain.

Keywords: students-athletes, functional tension, heart rhythm, electroencephalogram.

I. INTRODUCTION

Regular physical exercises and sports have a positive effect on the psychophysiological functions and form mental and emotional resistance to stress from childhood. Young people, combining academic and sports activities, experience a double load. There are different opinions about the impact of training loads on athletes. In particular, the authors of [7] write that during the academic activities of students, mechanisms for repairing damaged DNA molecules are activated. Other studies show that intense mental activity has a negative impact on the psychological status of students, which was reflected in the deterioration of their psychological status during intense study [8].

Unfavorable factors of students' life include intense mental work, increased static load, limited physical activity with a predominance of local muscle loads, etc.

In the literature, there are no unambiguous points of view on the nature of cognitive activity in athletes. It was shown [6] that the effect of sports training on cognitive functions changes with age. Many authors [3] report that athletes are more effective than untrained persons in coping with cognitive tests.

However, the features of the mechanisms of cognitive functions in athletes needs further comprehensive study. The forecast of possible deviations in the functional status of athletes and timely corrective actions will help maintain good health and improve academic performance.

The purpose of the article was to study the adaptive responses of the cardiovascular and central nervous systems to mental and local physical activity in athletes studying at university.

II. MATERIALS AND METHODS

110 volunteers aged 18-20 (19.5 ± 1.3) years participated in the study. The subjects were divided into 2 main groups: the first group consisted of students who are not actively involved in sports (20 boys, 20 girls), the second group included swimmers (25 boys, 15 girls) of high qualification (from candidates for the Master of sport to Master of sport). The research was conducted on voluntary informed consent of the subjects, in compliance with the protocol approved by the Ethical Board of the Russian Academy of Sciences.

The following methods have been used for the study: the personal and situational anxiety test [5]; cognitive test to assess the development of creative thinking [10]; analysis of the response of the heart to local load. As a local load, the subjects were tested on the hand dynamometer at a force of 1/3 of the maximum at a given level until fatigue (the inability to maintain a given force) [9]. Heart rate and blood pressure were measured according to the Korotkov’s method. The cardiointervalogram was recorded before, during and after stress tests. Assessment of the regulatory processes of the heart was performed according to the variability of heart rhythm on the cardiointervalogram [1]. To study the adaptive
responses of the body and assess the functional status of the heart, we calculated the statistical indicators of heart rhythm: Mo (the most common value of the duration of cardio intervals), Δx (variation range, Δx=(R–R)max–(R–R)min); AMo (amplitude of the mode of cardiac intervals in %), SI (stress index of regulatory systems. It is determined by the formula: SI = AMo/2MoΔx in c.u.). Computer electroencephalography included spectral analysis of electroencephalograms (EEG). EEG recording was carried out with the help of 8 cup electrodes connected to ear electrodes and localized strictly in accordance with the 10–20 system.

The academic performance was analyzed by the average scores for the exams: “satisfactory” (3.2 ± 0.2), “good” (3.9 ± 0.3), “excellent” (4.8 ± 0.2).

The result processing was done by means of Statistica 6.0 suite (StatSoft, the USA) and SPSS suite. We calculated the arithmetic mean (M) of the ordered sample, the standard error of the mean (m), and the Student’s t-calculated the arithmetic mean (М) of the ordered sample, the standard error of the mean (m), and the Student’s t-calculated the arithmetic mean (М) of the ordered sample, the standard error of the mean (m).

III. RESULTS AND DISCUSSION

Local static work on the wrist dynamometer showed an increase in systolic (ADs) and diastolic blood pressure (ADD) in all subjects, with the most pronounced response in untrained young men (Table 1). After mental activity in young athletes, heart rate (HR) and blood pressure indicators changed less than in other groups, and in female athletes, the response of blood pressure indicators to mental load was greater than to local muscle work.

The reaction to the local load was similar in all subjects. However, in athletes the increase in blood pressure was higher.

Table 1 - Change in heart rate and blood pressure in students before and after mental and local static muscle work

<table>
<thead>
<tr>
<th>Group</th>
<th>HR (bpm)</th>
<th>BL</th>
<th>HR (bpm)</th>
<th>BL</th>
<th>HR (bpm)</th>
<th>LL</th>
<th>Sys. press. mm Hg</th>
<th>BL</th>
<th>Diastolic press. mm Hg</th>
<th>LL</th>
<th>Sys. press. mm Hg</th>
<th>ML</th>
<th>Diastolic press. mm Hg</th>
<th>ML</th>
<th>Sys. press. mm Hg</th>
<th>LL</th>
<th>Diastolic press. mm Hg</th>
<th>LL</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA</td>
<td>65.2±2.2</td>
<td>67.4±2.9</td>
<td>58.2±2.9</td>
<td>58.2±2.9</td>
<td>70±2.3</td>
<td>72±3.1</td>
<td>107±3.1</td>
<td>107±3.1</td>
<td>129±3.1</td>
<td>129±3.1</td>
<td>85±2.3</td>
<td>85±3.1</td>
<td>1.4*</td>
<td>1.4*</td>
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<tr>
<td>MN</td>
<td>68.5±1.9</td>
<td>70±2.9</td>
<td>83±1.0*</td>
<td>83±1.0*</td>
<td>103.7±4.4</td>
<td>108±2.8</td>
<td>73.7±3.1</td>
<td>127±3.1</td>
<td>78±2.8</td>
<td>1.3*</td>
<td>1.3*</td>
<td></td>
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<tr>
<td>FA</td>
<td>69.5±1.3</td>
<td>75±2.1*</td>
<td>74±3.1</td>
<td>74±3.1</td>
<td>99.4±2.1</td>
<td>109.3±1.3*</td>
<td>76.8±1.7*</td>
<td>108±2.0*</td>
<td>74±1.6*</td>
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</tr>
<tr>
<td>FN</td>
<td>70.8±3.5</td>
<td>80.6±1.9*</td>
<td>87±3.9</td>
<td>87±3.9</td>
<td>73.5±1.9</td>
<td>116.5±2.2*</td>
<td>78±3.2</td>
<td>110±3.8</td>
<td>74±1.9</td>
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</table>

Note: * - significant differences compared to initial values (P<0.05); ML – mental load; LL – local load; BL – before load; MA, FA – male and female athletes; MN, FN – male and female non-athletes.

Analysis of heart rhythm also indicates similar changes in the mechanisms of heart regulation in both activities. The values of heart rate variability at rest indicated greater central sympathetic influences on the heart in untrained subjects compared to athletes.

After mental load, an increase in the stress indicators of the central regulatory mechanisms (AMo and SI) was observed, especially in untrained students. Similar changes occurred after local muscle activity, however, the increase of central influences on the heart was higher. Indicators of heart rhythm also had differences in subjects with different levels of motor activity (Table 2).

The results of the Spilberg-Hanin test showed an average level of personal anxiety in most students. The initial indicators of situational anxiety were lower among young athletes (34.0 ± 3.1) and untrained girls (39.4 ± 3.1), and after completing the cognitive test they increased in all subjects, especially in untrained girls (43.5 ± 3.7). The indicators of personal anxiety in young athletes were lower, and situational anxiety was higher than in untrained students; in girls, these data were opposite.

After a local load, indicators of personal anxiety decreased, and situational anxiety increased, especially in untrained girls (52.2 ± 3.6). According to the changes in these indicators, the reserves of the central nervous system are higher for athletes than for untrained students, both with mental and local physical exertion.

Table 2 - Change in heart rhythm after mental load in students

<table>
<thead>
<tr>
<th>Group</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mo s</td>
</tr>
<tr>
<td>MA</td>
<td>0.85±0.1</td>
</tr>
<tr>
<td>FA</td>
<td>0.75±0.5</td>
</tr>
<tr>
<td>MN</td>
<td>0.80±0.1</td>
</tr>
<tr>
<td>FN</td>
<td>0.7±0.07</td>
</tr>
</tbody>
</table>

Note: * - significant differences compared to initial values; ** - between athletes and untrained subjects (P<0.05); the rest are as in table 1.

High ability to mobilize resources provides higher academic performance in athletes compared to untrained students. Performance analysis showed that in the group of non-athletes, 8 out of 11 had an average score of “satisfactory”, 7 - “good”, 2 - “excellent”. For untrained girls, 6 out of 20 had an average score of “satisfactory”, 9 - “good”, 5 - “excellent”.

Among the group of athletes, 5 people had an average score of “excellent”, 12 - “good”, 8 - “satisfactory”. 6 girls athletes had excellent performance, 6 a good one, 3 - satisfactory.

EEG analysis showed that in athletes during recording with open eyes, the presence of alpha activity is typical.
Alpha activity is characterized by a significant rhythm index in the anterior hemispheres. In untrained students, alpha activity is registered in the occipital regions; in most of the leads - in the left hemisphere.

When performing a local load, the average dominant frequency of alpha activity in both groups was from 8 to 10 Hz. The greatest increase in the spectral power of alpha waves was observed in the frontal leads in both groups, in the central leads in untrained students, in the central occipital leads in the group of athletes. With the development of fatigue, an increase in the spectral power of slow alpha and theta rhythms is noted in both groups, although in the group of athletes these changes occur later and are less pronounced than in the group of untrained students (Fig. 1).

It can be assumed that low-intensity loads and local work should not cause pronounced changes in the most important functional systems of the body. However, our data indicate the functional stress of the heart and central nervous system with local and mental stress in all subjects, including athletes.

The greatest pressor response to local work was found in untrained students. At the same time, in athletes, the increase in blood pressure was higher. This is explained by the reflex redistributive response of vessels to any kind of physical activity in athletes. An analysis of heart rhythm also indicates similar changes in the mechanisms of heart regulation to both types of activity. After local work, the degree of increase in SI was higher in all female subjects. Thus, local loads lead to an increase in the activity of the central mechanisms of heart regulation not only in untrained students, but also in athletes, especially girls. These results indicate a high ability to mobilize resources. This ensures high performance in a greater number of athletes compared to untrained students, but also in athletes, especially girls. These results indicate a high ability to mobilize resources. This ensures high performance in a greater number of athletes compared to untrained students, but also in athletes, especially girls. These results indicate a high ability to mobilize resources. This ensures high performance in a greater number of athletes compared to untrained students. Obviously, a certain level of functional stress is necessary for successful sports and creative activities.

Indicators of the psychophysiological status in athletes demonstrate great potential in cognitive activity, which can be realized with a well-structured educational process.

The data of EEG studies confirm the central nature of adaptive responses both to mental and local muscle activity. One of the main factors determining the success of training is the plasticity of the psychophysiological processes in the brain. The plasticity of these processes positively correlates with high values of the alpha rhythm index. The authors [2] also found that groups of highly creative subjects were characterized by higher alpha-rhythm power compared to low-creative individuals.

With respect to the nature of functional stress under academic loads, such means as relaxation, music, and aromatherapy can be used as prevention of overstrain. The course of relaxation exercises [4] among students resulted in a decrease in the activity of sympathetic and central nervous systems and an increase in the parasympathetic system.

IV. CONCLUSION

Thus, the academic loads at university contribute to the development of functional stress in student athletes. Widespread loads on hand muscles (typing and writing) also have a specific effect, causing an increase in blood pressure. These factors, combined with changes in the regimen of sleep, rest, and nutrition, often lead to health disorders.

For students combining sports and academic loads, correction of the psychophysical status is necessary using, for example, relaxation techniques. Given the high performance of cognitive tests, we can talk about good cognitive abilities in swimmers. However, further research is needed on the scientific justification for their curricula. A possible option in this case could be the reservation of academic places for highly qualified athletes and other changes in training schedules for athletes.

Conflict of interest: none declared.

REFERENCES