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Change of Cortisol and Insulin Content in Blood under Influence of Special Workability Recreation System for Students with High Motor Functioning Level.

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ABSTRACT

To show dynamic of adaptation hormones content in blood under influence of specific factors of workability recreation in students with high motor functioning level. In the research 43 students with high motor functioning level participated. All students were informed about sense of experiment and gave written consent for participation. The students were divided into six groups (3 control groups and 3 experimental groups) by pair-wise selection by individual features of adaptation systems' functioning. For dividing of students into groups we used hierarchic cluster analysis. For recreation of workability we applied natural methods (medicinal plants). The research took 4 months. Medicinal plants were used in four cycles (21 days each with 7 days' pauses). Application of medicinal plants facilitated normalization of cortisol and insulin in blood and reduction of index of adaptation system's tension. We showed the role of the worked out recreational methodic as modulator of organism's adaptation systems. Changes of adaptation systems' tension index and β -endorphins' content witness about role of the applied recreation system as modulator of adaptation processes. We showed optimization of cortisol and insulin content in blood under influence of special workability recreation methodic. It witnesses about purposefulness of analysis of blood hormonal content for determination of level of long term adaptation to stresses. We also showed possibilities of medicinal plants' application for recreation of students' physical workability.

Keywords: blood, cortisol, insulin, workability, recreation, medicinal plants.

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INTRODUCTION

The relevance of the research is conditioned by the fact that at present time effectiveness of application of different workability recreation indicators is under discussion [1–5]. In many researches, devoted to workability recreation after physical loads [6–10] the most mobile parameters are taken as the tested ones: heart beats rate; blood pressure and other [11–15]. These indicators reflect organism's reaction to load just after the load: the so-called "urgent" adaptation of organism to load. One of indicators of long-term adaptation is hormonal changes in organism [16–19]. For example, cortisol is a stress hormone [12]. Its content in blood can be substantially influenced by general psycho-somatic state (stress, depression, heavy comorbidities, intoxication) [20–22]. That is why usage of cortisol content indicator as indicator of organism's adaptation to stress factors is rather relevant. It permits to determine effect of long term adaptation (no less than three weeks). Application of cortisol as indicator of "urgent" adaptation is less effective. It can explain results of researches by Buchheit M. et al. [23]. These authors found that training load, heart beats rate and indicators of health were simple indicators for control of sportsmen training's quality in training camp. Cortisol in this case is less effective indicator because of complexity of procedure of its determination [24]. However, application of cortisol as indicator of long term adaptation is relevant. The same principles are suitable for insulin content in blood [25–29].

That is why determination of dynamic of cortisol, insulin and peptide beta-endorphine concentration in blood has theoretical significance for identification of organism's reaction to stress of hormonal system. With it, it is necessary to consider influence of stress factors in combination with effectiveness of recreational processes. Besides, such researches are interesting from practical point of view. For example for determination of effectiveness of different factors, increasing organism's adaptation potentials. It is known that for man the most stress factor is physical loads. In this connection analysis of cortisol, insulin and peptide beta-endorphin concentration in blood of students with high level of motor functioning is of theoretical and practical significance. Influence of cortisol and insulin content in blood on special factors of workability recreation is reflected also in researches on sports medicine [30–33]. Modern process of sport training requires maximal tension of sportsmen's organisms. It is noted in many works: influence of training load and organism's response to it on workability level [34–36]; control of physical load and fatigue influence on indicators of sportsmen's fitness [23, 37–40]; control of young sportsmen's changes of physical workability and heart beats rate [41–43]; effectiveness of sportsmen's adaptation to physical loads by indicators of heart rhythm variability [44–46]; recreation of sportsmen's workability with the help of medicinal plants [47–51].

Recreational processes take central place in sportsmen's trainings [48, 52, 53]. They require application of effective and practical methods, which do not cause side effects [47, 54–57]. Natural recreation methods, which have been used since ancient time in practice of folk medicine, are exactly these methods [58–60]. Their combination with effective training programs meets the requirements of modern sports. Experimental proof of this principle is especially relevant in modern sports and in sports of the future.

Medicinal plants take one of central places in natural means of workability recreation [58, 59, 61–63]. At present, not medical recreational means have acquiring still higher popularity. Among them medicinal plants, which are non traditional natural recreational means, are the most interesting. Their effectiveness has been proved by thousands years' practice of their application.

Positive influence of natural means on workability recreation is noted in many researches: immersion in cold water (15°) for up to 10 minutes (several series) is the most optimal for recreation of workability after physical loads [64]; physical condition of junior schoolchildren depends on alternation of loads and rest [54, 65]; determination of hemoglobin level for optimization of respiratory function [66]. In general recreation is conditioned by many physiological processes and depends on different factors. Giorgi et al. [67] studied functional recreation (on example of heart beats rate) of 8 years' age and 20 years' age Judo wrestlers. The authors found that in older age (20 years) more by 49.3% work is fulfilled, comparing with younger age (8 years). Recreation degree in older age is by 14.8% higher in comparison with young Judo wrestlers. Functional recreation of organism is more influenced by age than coefficient of quantity of fulfilled work.

Thus, it can be assumed that application of special factors of workability recreation in students with increased motor functioning will permit:

- 1) Determine dynamic of cortisol, insulin and peptide beta-endorfine concentraion in blood;
- 2) Find out specific features of organism’s long term adaptation to physical loads;
- 3) Create view of mechanisms of adaptation to physical loads;
- 4) Determine effectiveness of special methodic of workability recreation with the help of medicinal plants.

In this connection the chosen direction of the research is relevant and timely.

The purpose of the works is to show dynamic of adaptation hormones content in blood under influence of specific factors of workability recreation in students with high motor functioning level.

The research was approved by ethic Committee of Kharkov national pedagogic university. Written consents of students for participation in this experiment were also received.

MATERIAL AND METHODS

In the research 43 students with high motor functioning level participated. All students actively practice game kinds of sports. All they are students of physical education faculty. The students were divided into six groups (3 control groups and 3 experimental groups) by pair-wise selection by individual features of adaptation systems’ functioning. For dividing of students into groups we used hierarchic cluster analysis. (see table 1).

Table 1. Distribution of the tested into groups as a result of cluster analysis of heart beats rate indicators and cortisol and insulin concentration in blood

Group	Initial data	Experimental effect
1 control	High concentration of cortisol and low concentration of insulin in blood. High activity of sympathetic division of nervous system	Ordinary training process
1 experimental		Non traditional recreational methods
2 control	Low concentration of cortisol and high concentration of insulin in blood. Low activity of para-sympathetic division of nervous system	Ordinary training process
2 experimental		Non traditional recreational methods
3 control	Average concentration of cortisol and average concentration of insulin in blood. Average activity of sympathetic division of nervous system	Ordinary training process

Experimental and control groups number 1 consisted of the tested with high content of cortisol (500–650 nmol/L). These groups were assessed as groups with too high activity of adaptation systems, connected with any stresses. Experimental and control groups with low cortisol content (220–350 nmol/L) had number 2 and were assessed as groups with inhibited adaptation systems, resulted from over-fatigue or avitaminosis. The rest tested were in experimental and control groups number 3 – with average concentration of cortisol (see table 1). In the tested with high content of cortisol we registered low content of insulin. These tested, with high cortisol and low insulin content, were characterized by high activity of sympathetic part of vegetative nervous system. The tested, who had high insulin and low cortisol content, demonstrated increased activity of para-sympathetic part of vegetative nervous system.

The received data confirm the known fact about reflection of activity of nervous system’s sympathetic part by level of cortisol concentration as well as about reflection of nervous system’s para-sympathetic part by level of insulin concentration. Level of β -endorphin concentration reflects activity of regulatory mechanisms of organism’s adaptation system’s functioning. The highest level of β -endorphin concentration was found in groups, in which indicators of cortisol and insulin concentration confidently differed from average values.

Experimental groups were trained with application of individual means of workability recreation. In control groups the worked out methodic was not used. The research took 4 months. Medicinal plants were used in four cycles (21 days each with 7 days’ pauses).

Medical plants were used in the following composition: *Méntha piperíta*, *Verónica officinalis*, *Oríganum vulgáre*, *Crataégus sanguínea*, *Melilótus officínalis*, *Tília cordáta*, *Thýmus serpyllum*, *Tussilágo*

fárfara, Hypéricum perforátum, Artemísia vulgáris, Rhodióla rósea, Urtíca dióica [59].

For determination of organism’s adaptation potentials we used bio-chemical methods of blood extended test. As indicators we chose: concentration of cortisol and peptide of β -endorphin, regulating functioning of organism’s adaptation systems; concentration of insulen and hemoglobin.

Besides, we calculated index of adaptation systems’ tension by formula [48]:

$$IN_{\kappa/i} = \frac{x_2 \times 100\% \div x_1}{y_2 \times 100\% \div y_1};$$

Where $IN_{\kappa/i}$ – index of adaptation systems’ tension;
 x_1 – mean value of cortisol concentration in group before experiment;
 x_2 – mean value of cortisol concentration in group after experiment;
 y_1 – mean value of insulen concentration in group before experiment;
 y_2 – mean value of insulen concentration in group after experiment.

As it is known, index κ/i (in this research it is index of adaptation systems’ tension) – is relation of percentage of values of cortisol and insulen normal values. The lower it is the higher organism’s reserve potentials are [44, 68, 69]. We also determined relation of β -endorphin content afre experiment to concentration of β -endorphin before experiment. Indicator higher than “1” witnessed about increase of organism’s adation systems’ activity. Indicator lower than “1” witnessed about weakening of organism’s adaptation systems’ activity.

RESULTS OF THE RESEARCH

Results of the research showed that the worked out recreation system was a stimulator of activity of organism’s adaptive and regulatory systems. It is witnessed by change of indicators of cortisol, insulen and β -endorphin concentration in control and experimental groups.

In the first experimental group we noticed: confident reduction of cortisol concentration ($p < 0.001$); confident increase of insulen concentration ($p < 0.001$); confident increase of β -endorphin concentration ($p < 0.05$) (see table 2, fig.1).

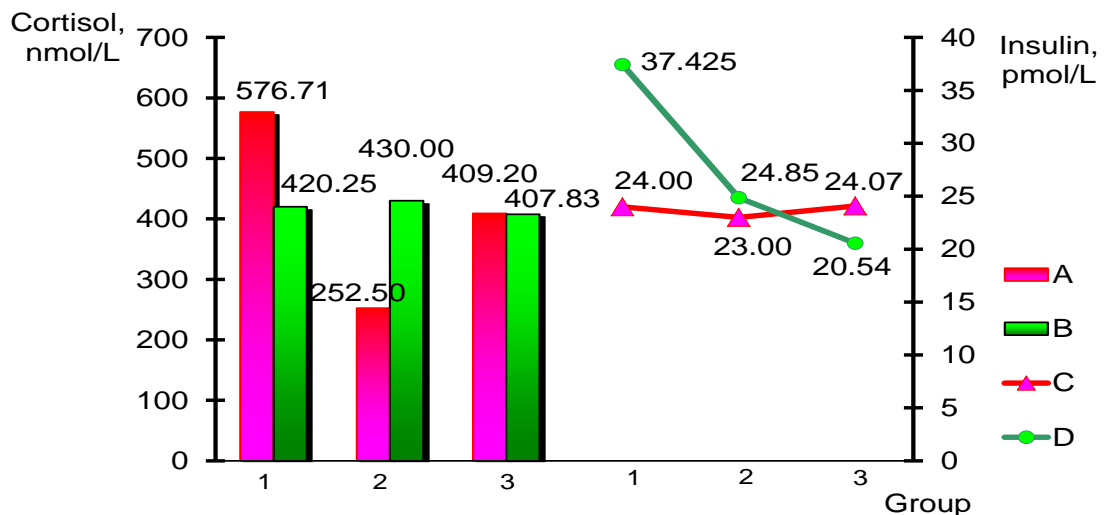


Figure 1. Indicators of cortisol and insulin content in blood in experimental groups before and after experiment:

- A – Content of cortisol in blood before experiment;
- B – Content of cortisol in blood after experiment;
- C – Content of insulin in blood before experiment;
- D – Content of insulin in blood after experiment.

Table 2. Hormonal indicators of adaptation systems' work of students with high motor functioning before and after application of special workability recreation methodic

Indicators	Group	Before experiment	After experiment	t	p	IT*	β_1 / β_2^{**}
Cortisol, nmol/L	1 C	569.7±15.42	540.6±14.26	3.05	<0.05	0.93	
	1 E	576.71±23.24	420.25±18.45	9.54	<0.001	0.42	
	2 C	269.8±13.14	310.2±13.28	3.78	<0.05	1.11	
	2 E	252.5±15.47	430±12.45	12.95	<0.001	1.6	
	3 C	415.1±25.13	410.1±14.52	0.74	>0.05	1.24	
	3 E	409.2±23.14	407.83±16.57	0.05	>0.05	1.25	
Insulin, pmol/L	1 C	24.8±0.05	25.4±0.08	0.56	>0.05		
	1 E	24±0.16	37.43±0.07	11.23	<0.001		
	2 C	22.9±0.11	23.2±0.13	0.09	>0.05		
	2 E	23±0.08	24.85±0.14	3.86	<0.05		
	3 C	23.8±0.04	18.8±0.16	2.95	<0.05		
	3 E	24.07±0.09	20.54±0.18	2.84	<0.05		
Beta endorphins, pmol/L	1 C	24.01±0.12	24.5±0.07	2.84	<0.05		1.02
	1 E	23±0.11	24.82±0.09	3.25	<0.05		1.08
	2 C	23.17±0.18	24.8±0.05	3.21	<0.05		1.07
	2 E	20±0.19	25.2±0.06	3.75	<0.05		1.26
	3 C	24.02±0.08	22.1±0.15	2.85	<0.05		0.92
	3 E	23.6±0.09	19.35±0.08	2.98	<0.05		0.83

Notes:

*IT – index of tension of adaptation systems;

** β_1 / β_2 – relation of β -endorphins after experiment to concentration of β -endorphins before experiment;

C – control group;

E – experimental group.

In first control group we also noticed the same tendency (see table 2), that witnesses about modulatory role of regular trainings themselves. This effect is increased at the account of application of the worked out complex recreation methodic. In first control group reduction of cortisol concentration was not very expressed, comparing with experimental ($p < 0.05$) (see table 2). Increase of insulin was not confident (see table 2). Increase of β -endorphins was also less expressed, comparing with experimental group (see table 2).

In experimental and control groups number 2 we registered increase of cortisol and reduction of insulin concentration. In experimental group these changes were more expressed. In experimental group number 2 increase of cortisol was confident ($p < 0.001$). In control group number 2 increase of cortisol was confident with $p < 0.05$. Reduction of insulin in experimental group number 2 was confident with $p < 0.05$. In control group this change was not confident (see table 2, fig.1).

Increase of β -endorphins' concentration in control and experimental groups number 2 was confident with $p < 0.05$. In experimental group this changes were more expressed (see table 2). In experimental and control groups number 3 change of cortisol concentration was not confident (see table 2, fig.1). It can be explained by initial values of its concentration, which were close to average normal value as well as by absence of demand in such changes. Concentration of insulin changed (reduced) in the following way: in control group stronger than in experimental group (see table 2, fig.1). Concentration of β -endorphins also reduced. It witnesses about weakening of activity of regulatory mechanisms of adaptation systems (see table 2). The received data also witness that regular trainings to some extent facilitate harmonization of adaptation systems' functioning. However, such changes are manifested only as tendency. At the same time application of complex recreation system significantly rise level of optimization of organism's adaptation systems' functioning. It is witnessed by the following:

1. Confident increase of cortisol content in cases with its low content;
2. Inhibition of adaptation systems, resulted from over-fatigue, avitaminosis or other factors;

3. Reduction of cortisol concentration in cases with its high content and hyper-activity of adaptation.

In group with average cortisol concentration there were no changes. Less expressed β -endorphin content in experimental group, comparing with control group witnesses about stabilizing effect of complex recreational methodic (in case if adaptation hormones' content is close to normal). Index of adaptation systems' tension also witnesses about modulatory role of the worked out recreational system (see table 2). In first experimental group it is much less than "1" (0,42): concentration of cortisol reduced and concentration of – increased. In second experimental group index of adaptation systems' tension is much higher than "1" – (1,6): concentration of cortisol increased and cocentration of insulin – reduced. In third experimental group index of adaptation systems' tension is a little higher than "1": changes of the mentioned hormones' concentration were insignificant. In this case we observed stabilizing role of the worked out recreational methodic.

Correlation of β -endorphins concentrations berfore and after experiment also witnesses about modulatory role of the woked out recreational system (see table 2). In first and second experimental groups this value is higher than "1". It witnesses about increase of β -endorphins concentration as a result of experiment. Just in hese groups change of cortisol and insulin concentrationswere higher. In third group this value is less than "1". It shows weakening of adaptation systems' regulatory mechanisms in connection with absence of demand in any changes in organism: values of these indicators were close to normal. Changes of this correlation in control groups were expressed less than in experimental. It says about modulatory function of the worked out recreational system.

DISCUSSION

The received results witness about effectiveness of application of medicinal plants for strengthening of organism's adaptation systems' functioning. Application of medicinal plants in health related and sports practice is often more preferable than application of synthetic medicine. In this case there are no side effects [12, 49, 56]. Herbs are closer to live organisms (including human being) by chemical composition. That is why they are metabolized better in comparison with synthetic medicine. Besides, most of synthetic medications are active substances, extracted from medicinal plants [58, 59, and 62]. Specialists in herbal medicine note [12, 58, 59], that effectiveness of medicinal plants' application is connected with holistic impact on organism. Medicinal plants contain complex of biologically active substances, naturally interconnected with each other. To achieve such effect synthetically is much more difficult. That is why treatment by medicinal plants was and remains to be effective mean of workability recreation.

At present medicinal plants are selected for recreation of workability on the base of chemical composition. With it, the most difficult is to combine different herbs. It is connected with the fact that some substances can strengthen or inhibit effect of other substances. It is very difficult to scientifically explain the methods of medicinal plants' selection. That is why scientific methods of research are used for generalization and analysis of experience of ancient folk medicine in respect to medicinal plants' application [51]. That means that the prospect is combination of scientific analysis and folk medicine art.

Especially difficult is selection of medicinal plants for sportsmen. It is connected with the fact that herbs can manifest their effect differently. That is why application of medicinal plants is mainly based on intuitive knowledge of separate specialists. In this connection, in our work we made an attempt to combine scientific knowledge and folk medicine art. It permitted to work out system of workability recreation for students with high motor functioning level in sports.

As a result of conducted researches we found that medicinal plants in the described composition have modulation effect. From the point of view of natural factors' positive influence (as recreational mean) the conducted by us research confirms the data of other authors. From the point of view of individual selection of medicinal plants (for recreation of workability) and modulation effect we received original data for practice of sports training.

CONCLUSIONS

The conducted research showed the role of the worked out recreational methodic as modulator of organism's adaptatiuon system. It is witnessed by increase of cortisol content (in case of its low initial content) and reduction of this indicator (in case of its initial increased content). The same changes are characteristics for insulin content. Changes of index of adaptation systems' tension and content of endorphins also witness about importance of the applied recreational system as modulator of adaptation processes.

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