

Express Assessment of the Students' Adaptive Abilities and Revealing of the Risk Group

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Abstract

The educational process in the higher educational establishments should contribute to the formation of the independent, initiative, creative and healthy personality. However, some students have different functional disturbances during the education, their health can worsen. The aim of this investigation is the express assessment of the regulatory body systems conditions of the students of different year in Vladimir State University and revealing of the risk group of students, who are exposed to the adaptive processes disorders, basing on the heart rate variability analysis. The students of different specializations at the age of 17 to 22 from Vladimir State University were examined. Total amount was 200 people, among which there were: 100 girls and 100 boys. Software and hardware complex "Zdorovie-express" was used; there were determined heart rate variability values, which were used to calculate the complex index of the regulatory body systems activity as well as to assess general cardiac output using the indices of the heart rate, pulse and cardiac muscle. The conducted investigations show high effectiveness of use of regulatory body systems activity index for the express assessment of the students' adaptive abilities and revealing risk groups. The acquired results speak for the fact that the load, suffered by the students in the process of education in the university, is a sufficient stressor and can result in the significant strain of the regulatory body systems for the most part of students (67%) and 14% of students are in the risk group which is characterised by the overstrain of the regulatory body systems and different stages of adaptation failure. Aggravation of the adaptation mechanism was noted by the 4th year of study. These results can be used for optimization of the educational process in the higher educational establishments as well as for the organization of the preventive works among students, correct organization of the sanitary measures.

Keywords: adaptation, heart rate variability, regulatory body systems activity index, students

1. Introduction

In modern higher educational establishments one can observe continuous intensification of the educational process, complication of its content, implementation of new informational methods of training, which increase the strain on students. The educational process should contribute to the formation of the independent, initiative, creative and healthy personality. But some students have different functional disturbances during the education and their health can worsen (Ryumina et al., 2012; Davidenko et al., 2005; Gevorkyan & others, 2003; Yusoff, 2010).

That's why the analysis of the young people adaptive abilities in the higher educational establishments and revealing risk groups of students having high probability of functional disturbances development is of urgent character (Stewart et al., 1996; Агаджанян, 1994). Adaptive processes activate when the habitual conditions are changing and it becomes necessary to accommodate to the new situations. It is the thing that the students face starting from the 1st year of study, when their lifestyle and education system are changed. In the process of adaptation the students suffer difficulties, for example, accommodation to the new study schedule; the emotions connected with the leaving of the habitual school group of people; apprehension of the career choice etc (Mazumdar, 2012; Ansari, 2011; Blom, 2009). In the previous investigations it was noted that the adaptive processes are more difficult for the students who live far away from their parents, who moved home. Students' adaptation is a complex process which is affected by a lot of different factors. It includes the changes of the level

of separate systems functioning and the strain of the regulatory systems. In case of failures in the work of these systems there appear functional and organic changes in the human body. Decrease of the students' adaptive potential is considered as a risk factor of diseases development since even an insignificant aggravation of adaptive abilities can lead to the serious health problems (Gavrilova, 2004; Altynova, 2009).

The most sensitive indicator of adaptive processes is the cardiovascular system, Heart rate and force which are controlled by the sympathetic and parasympathetic divisions of the autonomic nervous system, immediately respond to any changes of the environment and are widely used for the characterisation of the adaptive reserves, regulatory mechanisms and stress level (Ihlen, 2009; Ситдиков, 2001.) Nowadays the most convenient index of the interaction effectiveness of the cardiovascular system and other body systems is the heart rate variability (Бабунц, 2002). The method of heart rate variability analysis becomes popular and is widely used in the functional diagnostics due to the fact that it is operational and non-invasive. This analysis allows to give a general assessment of the human state, since it characterises vital indices of the body physiological functions control (functional reserves and autonomic balance) (Baevskiy, 2001; Bailóna et al., 2010; Malik, 1998).

In the course of some years the authors assess physical state and adaptive abilities of students, reveal students with the decreased adaptive potential as well as study the influence of different factors on the human health (Ryumina et al., 2012; Trifonova et al., 2012)

The aim of this investigation is the express assessment of the regulatory body systems conditions of the students of different year in Vladimir State University and revealing of the risk group of students, who are exposed to the adaptive processes disorders, basing on the heart rate variability analysis.

2. Objects and Methods of Investigation

The students of different specializations at the age of 17 to 22, studying under the Vladimir State University were examined. Total amount was 200 people, among which: 100 girls and 100 boys. The students, who took part in the experiment, were not subject to regular medical check-up concerning any chronic conditions. The examination was conducted during the education process in 2013. For this purpose the hardware-software complex "Zdorovye-express" was used. This complex is designed for the screening-assessment of the psycho-physiological and somatic health level, body reserves and physical development parameters. Basing on the acquired data the complex displays individual recommendations for the state correction and healthy lifestyle choice (www.mks.ru/dev/functionaltest/healthexpress). Two modules of the hardware-software complex "Zdorovye-express" - "Cardiovisor" and "Heart rate variability" - were used. The output data for these modules was the record of the ECG extremity lead signals which lasted for 3 minutes. Cardiovisor analyses micro-alterations of the ECG line signal. As the result there appears the map of the dispersive heart changes in the form of the heart portrait. A range of other characteristics is also calculated. Among these we used such as "**Cardiac muscle**", "**Rate**" and "**Pulse**" **Indices**. They characterise the total value of the dispersive abnormalities and are changing in the range of 0% - 100%. The more is the index value, the more is abnormality.

"Heart rate variability" module records the duration of R-R intervals of the electrocardiogram (also called R-R intervals), builds dynamic raw of R-R intervals (cardio interval graphic) and performs mathematical analysis of the acquired data, with the help of which it assesses the human state and his/her adaptive reserves.

Table 1. Algorithm of the index of activity of the regulatory systems (IARS)

Regulatory system characteristics	Criteria for their assessment
A. Total effect of regulation	rNN -average value of the RR-intervals, s
B. Heart automatism	SDNN -standard abnormality of all RR – intervals dX- range, s CV - variation coefficient, %
C. Autonomic homeostasis (balance of the sympathetic and parasympathetic influences)	dX- range, s AMo-mode amplitude, % IN - regulatory systems strain index
D Regulation stableness	CV - variation coefficient, %
E. Subcortical nerve centres activity	VLF/TF ; LF/TF ; HF/TF, where VLF- is a power of high-frequency conten of the spectrum, ms ² ; LF is a power in the low frequency range, ms ² ; HF is power of the high-frequency part of the spectrum, ms ² ; TF= VLF+ LF+ HF

In order to perform the complex analysis of the heart rate variability parameters we used the *index of activity of the regulatory systems (IARS)* calculation method, suggested by Baevskiy R. M. (www.zdex.ru/support/manuals; Baevskiy, 2000; Баевский, 1997). This method is based on the fact that different states and functional characteristics of the regulatory systems can be assessed by one or several heart rate variability parameters. IARS was calculated for each student with the help of the hardware-software complex using the special algorithm which takes into account statistic indices, histogram values and R-R intervals spectrum analysis; each criterion is assessed in points, the sum for the module is calculated as follows:

$$IARS=|A|+|B|+|C|+|D|+|E|$$

The algorithm of the IARS components and criteria characteristics calculation is presented in Table 1.

IARS takes values from 1 to 10 and allows to differentiate various stages of regulatory systems strain (Table 2).

Table 2. Interpretation of the index of activity of the regulatory systems (IARS)

IARS meaning	Regulatory systems strain level	Functional status
1	Optimal level	
2	Normal level	Normal
3	Moderate functional strain	
4	Obvious functional strain	
5	Full-blown functional strain	Donozological state
6	Regulatory mechanisms overstrain	
7	Full-blown overstrain	Premorbid states
8	Regulatory systems deterioration	
9	Full-blown deterioration	Adaptation failure
10	Regulatory mechanisms failure	

This classification of functional states characterizes four health levels, four levels of adaptive abilities of the body. An important thing here is that the uncertain notion of in-between states acquires some sense on the basis of concepts of adaptation and homeostasis. Within the framework of this simplified pattern the differentiated 10-points scale of functional states ("states ladder") was created. This scale allows assessing and forecasting functional states of the body, which are in between the norm and the pathology, in terms of regulatory systems strain degree.

3. Results

For the preliminary assessment of the general functional state of the heart we used "*Pulse*", "*Cardiac muscle*" and "*Rate*" indices, acquired with the help of the Cardiovisor module (Table 3). Average indices of cardiac muscle (15.95 ± 4.07 , normal value is less than 15%), pulse (85.58 ± 11.12 , normal value is 60-80 beats/minute) and rate (26.83 ± 16.09 , normal value is less than 15%) are a little bit higher for all the selection and are noted by the significant data scatter. The results mean that on an average the students have normal functional characteristics of the heart, but their regulatory mechanisms are activated. The examined group of students is very inhomogeneous. That's why we performed the analysis of percentage ratio of students with different indices.

Functional state according to the "Cardiac muscle" index is normal for the most part of the students. Only 7% of students have abnormalities which need dynamics control and, perhaps, additional examination in case of repeating abnormalities. The students of different years of study have no significant differences.

The "Rate" index is one of the markers for adaptive abilities of the body. Index value of more than 80% which could speak of the serious disturbances and obvious stress, was not found among the students. The most part of students (93%) have the "Rate" index in the state of physiological norm, 7% have in-between state. The students of different years of study have no significant differences. It is necessary to point out that the 2nd year students more frequently have in-between states comparing to the other students.

Pulse indicator is dynamic. We cannot make any general conclusion according to the results of one or two measurements, but we can speak of the state of a human in the given time. During the examination 54% of students have normal pulse, 22% have moderate tachycardia and 22% have obvious tachycardia.

Table 3. Percentage ratio of students with different values of indices of rate, cardiac muscle and index of activity of the regulatory systems (IARS)

Indicators	1st year		2nd year		3rd year		4th year		total	
	boys	girls	boys	girls	boys	girls	boys	girls	boys	girls
Rate index, %										
No significant abnormalities (less than 15%)	25	19	9	23	39	17	25	19	24	20
Slight abnormalities (15-50%)	72	78	86	60	56	75	64	81	70	73
In-between state (50-80%)	3	3	5	17	5	8	11	0	6	7
Obvious abnormalities (more than 80%)	0	0	0	0	0	0	0	0	0	0
Cardiac muscle index, %										
No significant abnormalities (less than 15%)	41	25	18	27	33	33	25	23	30	26
In-between state (15-19%)	53	63	77	70	61	59	61	77	62	68
Slight probability of pathology development (20-22%)	0	0	0	0	6	0	7	0	3	0
Probable pathology development, dynamics control needed (22-27%)	3	6	5	3	0	8	0	0	2	4
Pathological abnormalities, additional examination needed (more than 27%)	3	6	0	0	0	0	7	0	3	2
IARS (index of activity of the regulatory systems) , %										
Physiological norm	28	31	0	23	6	25	14	15	14	24
Donozological state	35	22	36	40	39	41	22	35	32	33
Premorbid state	31	34	50	27	33	17	50	27	41	28
Adaptation failure	6	13	14	10	22	17	14	23	13	15

For the assessment of the students' adaptive status the characteristics of heart rate variability were determined (Table 4). **Index of activity of the regulatory systems (IARS)** was calculated. This index was the main one in the course of analysis of adaptive abilities and was the main criterion of students' assignment to the risk group. Average IARS value corresponds to the obvious functional strain of the regulatory systems both of boys (IARS=5.67±1.70) and girls (IARS=5.23±1.95).

Percentage ratio of students with different regulatory systems states is shown on Figure 1 and in Table 4.

Table 4. Average value of the students' heart rate variability indices

Index	boys		girls	
	Value	Normal	Value	Normal
SDNN -standard abnormality of all RR – intervals, ms	59.44±26.09	28.5 – 71.6	50.92±17.96	30.5 – 71.9
SI, stress index	118.30±131.37	32 - 283	128.67±79.21	37 - 216
IC, centralization index	4.10±2.84	1.05 – 5.04	3.82±4.63	0.99 – 2.52
RMSSD, square root of the average sum of squares of differences between the adjacent RR -intervals, ms	41.25±22.86		38.74±20.23	
VLF, power in the very low frequency range, %	20.63±12.17	7.6 – 23.8	19.21±11.36	8.4 - 24
HF, power of the high-frequency part of the spectrum %	25.54±12.90		31.59±17.29	
LF, power in the low frequency range, %	54.03±14.61	36.8 – 66.8	49.19±15.21	30.4 – 57.1
TP, spectrum power, ms ²	3576.25±3533.89		2452.86±1996.13	
LF/HF	2.94±2.02		2.68±3.05	
TPVLF, spectrum power, ms ²	580.66±686.85		360.38±359.57	
TPLF, spectrum power, ms ²	1493.45±1156.69		922.00±734.45	
AMo, mode amplitude, %	39.00±14.10	20.4 – 58.4	41.47±11.86	23.6 – 44.1

4. Results Discussion

The acquired results correspond to the many of literature data about the fact that the heart rate variability parameters as well as the results of their mathematical processing are reliable and informative indices for the assessment of the regulatory systems state, adaptive abilities and susceptibility to the stress influences (Antonio Luque-Casado, 2013; Luft, 2009). The investigations in this sphere have been conducting for a long time using different, constantly improving methods (Lombardi & Mortara, 1998; Ravenswaaij et al., 1993; Berntson et al., 1997, Berger et al., 1986).

Almost all the measurements of the heart rate variability indices correspond to the normal data according to the average norm (Table 3). It was noted while performing similar investigations by the other authors (Lutsenko & Gabelkova, 2013; Chuyan et al., 2008).

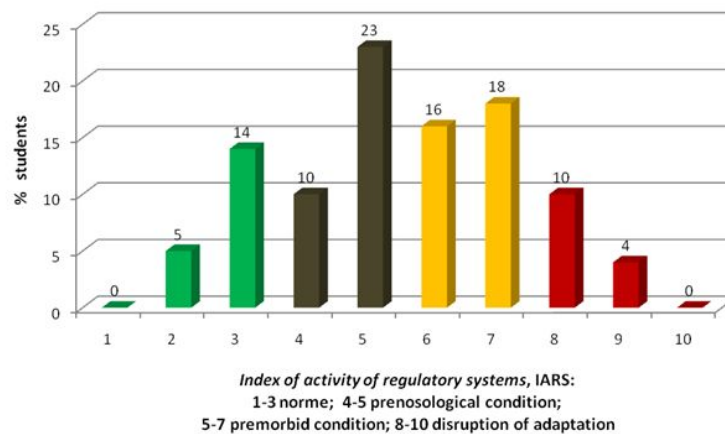


Figure 1. Students' body regulatory systems activity index (the whole selection)

The calculated averaged complex index of IARS shows the functional strain of regulatory systems, but it doesn't show the number of students with normal indices and students having abnormalities of different degree. That's why we performed the analysis of percentage ratio of the investigated students with different characteristics.

The analysis of the percentage ratio of students having different character of adaptive processes development according to the IARS showed the absence of the investigated people with both highly unfavourable and optimal states. There are no students with the IARS 10 index (Figure 1), i.e. in the state of the maximum stress and complete disturbance of adaptive processes. However, 14% have significant deterioration of adaptive resources (IARS = 8-9). Also there are no students with the most optimal state of the regulatory systems; there are few students, both among boys and girls, with the index 2, which corresponds to the peaceful state.

Most of the students are on different levels of functional strain (IARS is from 4 up to 7). This state can be considered as a normal adaptive response of the healthy organism to the stress influences, which in this case are the education conditions; it should not lead to the disease development in the future. The ranges of investigations show that the second phase of stress not necessarily transfers to the deterioration phase and develops into the adaptation failure. The organism in the state of regulatory systems strain is characterised by the high resistance to the diseases on the account of sympathetic and sympathoadrenal activations. To prevent stress from changing into distress it is important to orient students of this group to the healthy behaviour and cognitive activity (Lutsenko & Gabelkova, 2012; Michie, 2012).

The 10-point scale is reasonable to be used in individual analysis of the students' state. For the sake of convenience of the mass data the indices can be combined in 4 classes according to the scheme, offered by its creators (Table 2). We used this scheme in the comparative characteristic of the students of different years of study (Figure 2).

We did not notice any significant difference among the students of different years of study. Regulatory systems activity is far better during the 1st year of study. 30% of students are in the state of physiological norm. Their state aggravates by the 3rd and 4th year of study. Only 13% of students have physiological norm, 20% have adaptive processes failures.

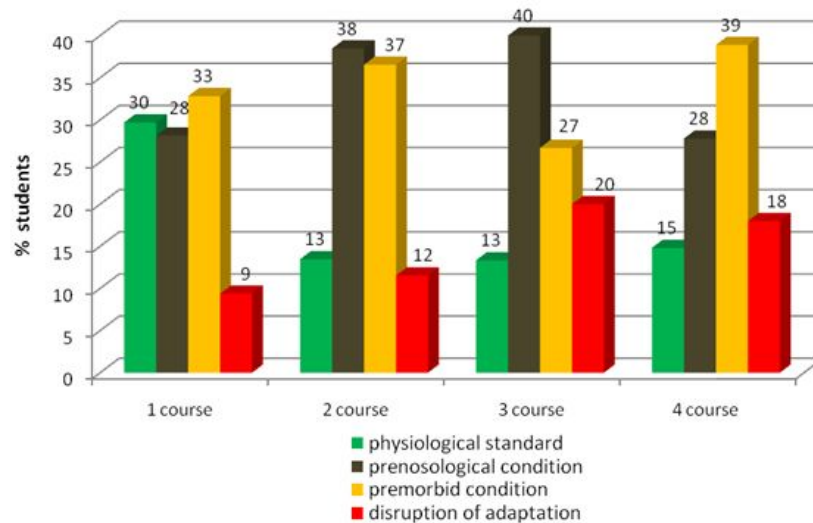


Figure 2. Adaptive mechanisms state of students of different years of study

The investigators points out the necessity of students' examination aimed at revealing regulatory systems disorders starting from the 1st year of study. The examination is aimed at preventing regulatory systems overstrain and optimization of educational process (Poborskiy, 2007). Taking this fact into account we used the index of activity of the regulatory systems for the revealing of the risk groups of students. To this group we referred students who were healthy at the moment of examination but had high probability of diseases development due to the probable regulatory systems deterioration. 14% of students (total amount of students were 28: 13 boys and 15 girls) were in the risk group; their IARS index was more than 8 and they had a slight probability of adaptive failure. As an example of abnormalities which were observed for the students of this group, we can take a student with the IARS index = 9; he had serious abnormalities according to 4 of 5 characteristics, which include heart automatism, autonomic homeostasis, regulation stableness, subcortical centres activity.

Persons of the risk group are recommended to have additional examination, to correct their lifestyle and to have medical supervision.

5. Report

Thus, the conducted investigations show high effectiveness of use of regulatory body systems activity index for the express assessment of the students' adaptive abilities and revealing risk groups. The acquired results speak for the fact that the load, suffered by the students in the process of education in the university, is a sufficient stressor and can result in the significant strain of the regulatory body systems for the most part of students (67%) and 14% of students are in the risk group which is characterised by the overstrain of the regulatory body systems and different stages of adaptation failure. Insignificant aggravation of the adaptation mechanism was noted by the 4th year of study.

These results can be used for optimization of the educational process in the higher educational establishments as well as for the organization of the preventive works among students, correct organization of the sanitary measures. These results have certain restrictions in usage since no differentiation of students according to the academic progress and lifestyle was made. The investigations are to be continued in order to find certain reasons which cause regulatory systems overstrain as well as revealing different adaptive responses among students of different specialities (humane and technical).

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