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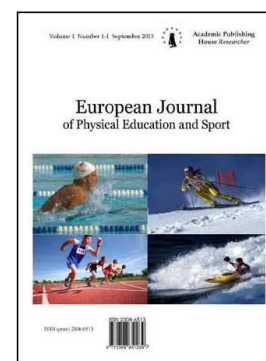
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## The Functional State of the Cardiovascular System of Students with Different Levels of Physical Fitness

Aiman E. Konkabaeva <sup>a,\*</sup>, Maral Rasol <sup>a</sup><sup>a</sup> E.A. Buketov Karaganda State University, Kazakhstan

### Abstract

In this article the current functional state of the cardiovascular system of the body of students that regularly go in for sport and those that are not involved in sports is studied. The cardiovascular system was estimated by recording the heart rate variability, and by defining a work capacity of a man by Rufe method. A complex estimation of heart rate variability by index of activity of the regulatory systems of the body was carried out. It was found that students involved in sports had a moderate and expressed stress on regulatory systems observed in 55 % of cases that composed more than half of the surveyed students. It may be due to inadequate physical load placed on the current functional state of the body.

**Keywords:** adaptation, cardiovascular system, nervous system, students, cardiac rhythm, regulator system, health, operability.

### 1. Introduction

In the life of a certain part of the students sport, which to some extent is an anti-stress factor, takes an important place. Physical activity plays an important role in the formation of body's functional reserves. At the same time in Universities training and competitive activity alongside with the academic load places high demands on the functionality of the body, which is especially typical for sport games. Any discrepancy between the volume as well as intensity of physical activity and adaptive capabilities of the organism can cause a number of changes in functional systems on homeostatic level, change the regulatory-adaptive status of the body, predetermining the further course of adaptation (Bersenev, 2008).

Body's resistance to the sports' training and competition loads, sports results, maintenance of the favorable dynamics of health state are determined depending on the nature of the mechanisms of regulation, the level of physiological reserves and physiological price of adaptation of the basic adaptive systems of the body. The complex of functional systems, providing final sports' results, first of all include the cardiovascular system (CVS), which is the most mobile system in the process of urgent and long-term adaptation to the muscular load of varying intensity and duration, and according to the concept of Baevsky R.M. (2005), is an indicator of adaptive reactions of the whole body (Makarenko et al., 2001: 52-57; Sostojanie..., 1978: 105).

\* Corresponding author

E-mail addresses: [aiman54@mail.ru](mailto:aiman54@mail.ru) (A.E. Konkabaeva)

Sports training loads, in their turn, have a significant impact on the morphofunctional development of the circulatory apparatus and, in particular, of the heart, as well as the usefulness of the mechanisms of its regulation (Tihvinskij, 1991). However, the specialized literature does not cover issues concerning the dependence of the level of physical fitness on the autonomic regulation of the heart rate, sports qualification and specialization of athletes, and doesn't identify informative criteria for estimation of the functional state of the cardiovascular system. The lack of data on this issue made it possible to determine the priority areas for further research. The development of criteria for estimation of the functional state of the cardiovascular system will improve the efficiency of the training process at stages of long-term improvement, the system of selection of athletes to the national team to participate in the main events of the season.

Inconsistency level of athletes load requests leads to the development surge cardiovascular system, the emergence of pre- and pathological changes in organs and systems (Il'in and Krivoruchenko, 2006). Therefore, the purpose of our research is to study the dynamics of functional state of the mechanisms of regulation of cardiac activity, level of work capacity of students with different levels of physical fitness.

## 2. Research materials and methods

The study involved two groups of 1st year students, male, without bad habits, aged 19-21 years old. The first group consisted of students studying at the Faculty of Physical Education and Sports, the second – a control group consisted of students from the Faculty of Biology and Geography, who are not involved in sports. Current functional state was estimated according to the heart rate variability. Heart rate variability was examined using a computerized complex «Varikard» (Russia). Estimation of heart rate variability was made using method of mathematical statistics of Baevsky R.M. (1997). Recording Mode - a short-term, in the supine position (5-minute recording). The article contains the most informative parameters of heart rate variability (HRV): total power spectrum (TP), the balance of departments of the autonomic nervous system (ANS) (LF / HF), the index of regulatory systems tension (SI), the index of centralization (VLF + LF) / HF (IC) and the structure of the spectral power (HF, LF, VLF). Statistic data processing was performed on a PC using Excel program.

## 3. Results and discussion

Specialists in the field of sports physiology and medicine proved that the cardiovascular system (CVS) limits the development of adaptive reactions of the organism, and that the performance of the muscular system depends on its state. Specification of Quetelet index revealed drop of indicators below normal in 10 % of cases, 90 % of surveyed students had normal indices (Figure 1). However, the students from the control group had normal Quetelet index in 59 % cases, below the normal – 29% and 12 % of students had indicators above normal. Students that do not go in for sports, had downward and upward deviations in fatness. Only 59 % of students in the control group had normal indicators, while the majority of students regularly involved in sports, had a normal index of fatness.

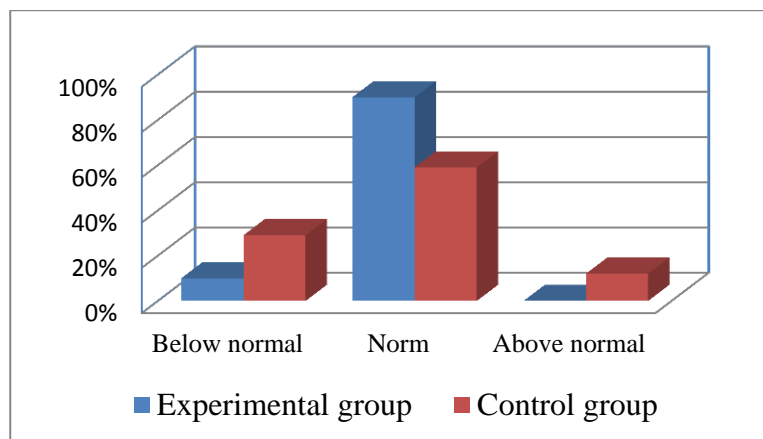


Figure 1. Quetelet index in the experimental and control groups of students

Study of indicators of work capacity revealed that the group 12 % of students who regularly go in for sport had a good work capacity, and 88 % – average work capacity (Figure 2). In the control group indicators of work capacity by Ruffier test were as following: good work capacity was observed at 20 % of students, the average work capacity is not found, satisfactory work capacity – at 10 % and poor work capacity was observed at 70 % of the surveyed students.

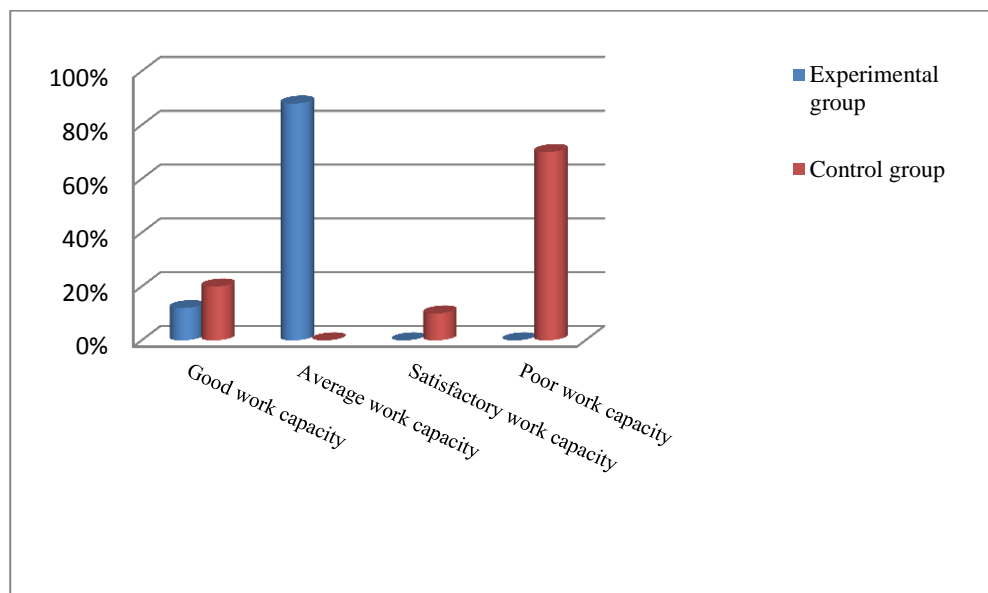


Figure 2. Indicators of Ruffier test

Thus, students that are not involved in sports, according to the results of our research, had deviations in the degree of fatness in 41 % of cases, which correlated with a decrease in work capacity (in 70 % of cases) of surveyed students. Alongside with this, the students that regularly go in for sports tended to have a normal fatness (in 90 % of cases), which was accompanied by a good and normal work capacity.

These results indicate that adaptation to physical activity is a dynamic process, which is based on the formation of a new program of physical development and health. This ability to adapt to the conditions of a regular training activity depends not only on the existing constitutional reserves, but also on the volume of training loads of students involved in cyclic sports, the adequacy, efficiency and stress of regulation mechanisms of the body of students.

Improving the efficiency of the training process of athletes is impossible without improving the system of estimation of the functional state of the cardiovascular system of students [5]. To estimate the cardiovascular system a number of parameters is used: frequency of heart contraction (FHC), heart rate, quantity of a minute and pulsatile blood volume, blood pressure, phase analysis of systole. Of all these indicators the most widely used in the sports practice is the analysis of FHC and heart rate. Mathematical and statistical characteristics of heart rate have individual specificity that allows early diagnosis of fatigue and monitor of the adaptation process of each athlete, to predict sport results, hold the sport selection, as well as use in the management of the training process in order to optimize the mode of training sessions. Therefore, we examined the heart rate variability (HRV) of students in the two groups.

In the experimental group average frequency of heart contraction (FHC) of students at rest was  $57 \pm 4,1$  cont./min., it was significantly ( $p < 0.05$ ) lower than the average FHC in the control group ( $77 \pm 7,8$  cont./min.).

The total power spectrum (TP) in the experimental group of athletes was high and amounted to  $5328,3 \pm 2813,1$  ms<sup>2</sup>/Hz. In the control group TP was equal to  $7208.1 \pm 2813.1$  ms<sup>2</sup>/Hz. Characteristic features of the cardiac rhythm during a 5 min. record was following (Table 1).

**Table 1.** Values of structure of the total power spectrum of HRV of students- athletes.

	TP, ms <sup>2</sup> /Hz		HF,%		LF,%		VLF, %		LF/HF	
	Experi- mental group	Control group	Experi- mental group	Control group	Experi- mental group	Control group	Experi- mental group	Control group	Experi- mental group	Control group
Median	6792,8	3067,8	34,3	36,3	53,3	41,2	25,5	24,5	2,29	1,79
25 percentile	1901,5	1266,0	12,7	16,2	22,3	22,4	5,1	16,4	0,29	0,53
75 percentile	9487,5	25669,5	76,9	42,4	86,4	56,7	48,2	58,7	6,81	3,02

In estimation of indicators we used the median and interquartile range. The latter is pointed in 25 % and 75 % percentile. Average value of TR indicators, reflecting the current functional status of the body was substantially above normal value in both the experimental and the control groups.

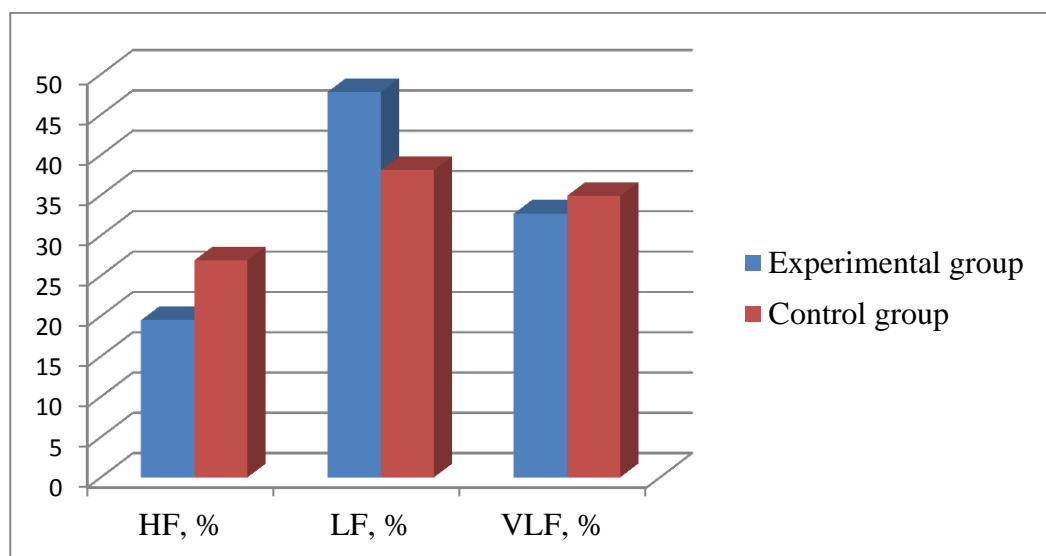


Figure 3. Indicators of the heart rate variability of trained and not trained students

The structure of the spectral power of HRV during registration of students at rest was distributed as follows: the most lowered component at athletes is high-frequency component (HF-component), reflecting modulating influence of the parasympathetic department of the ANS on heart rhythm. The predominance of LF and VLF-component in the structure HRV at athletes indicates the influence of long physical activity, aimed to form stamina, as well as the diminution of physical fitness. In the control group there is a higher total power spectrum and increase the share of VLF-component, reflecting the transition from the vegetative level of regulation to a slower humoral-metabolic one. LF/HF index, which characterizes the balance of the ANS departments, indicates the predominance of the activity of the sympathetic-adrenal system at athletes (2.29) as compared with the control group (1.6) (Figure 3).

Complex assessment of heart rate variability can be done according to the index of activity of regulatory systems (IARS). Analysis of the functional state of regulatory systems revealed that state the optimal stress of regulatory systems (physiological norm) was observed at 50 % of students in the experimental group and at 25 % of students in the control group (Figure 4).

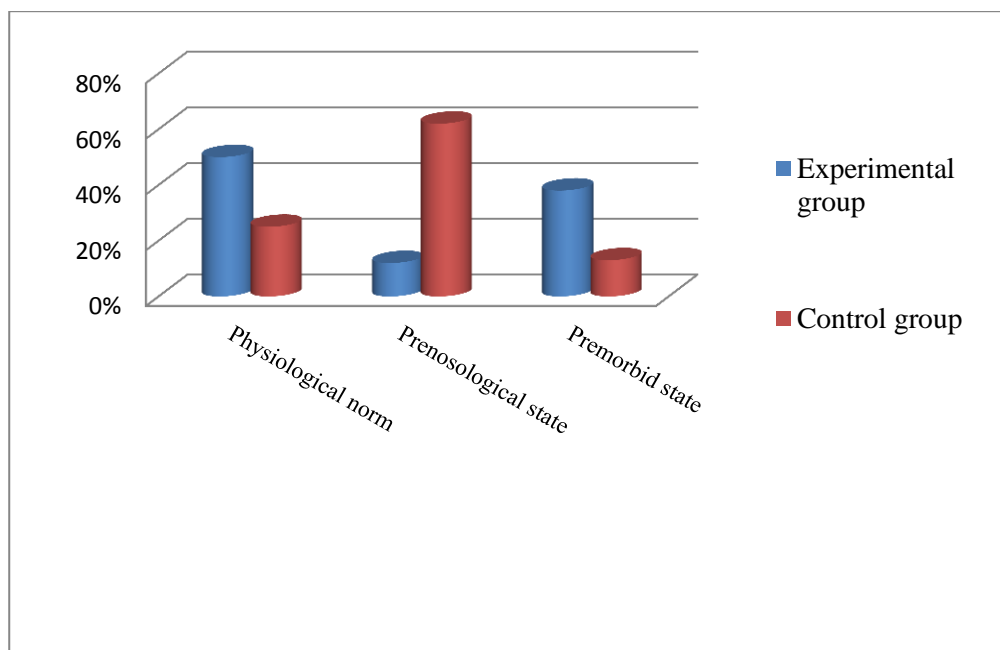


Figure 4. Complex assessment of heart rate variability by IARS

State of a moderate stress of regulatory systems (prenosological state), when in order to adapt to environmental conditions a body requires additional functional reserves, in the process of adaptation to work, under emotional stress or under influence of un favorable environmental factors, was observed at 12 % of the students in the experimental group and at 62 % of students in the control group. State of expressed stress of regulatory systems (premorbid state) that is associated with the active mobilization of protective mechanisms, including increased activity of the sympathetic-adrenal system and pituitary-adrenal gland system was found at 38 % of the students in the experimental group and at 13 % of the surveyed students in the control.

The gathered data attest that moderate and expressed stress of regulatory systems in the experimental group was observed in 55 % of cases, that is more than half. It can be explained by the inadequacy of the current physical load placed on the functional state of the body. In this case, as a rule, the main burden falls on the regulatory mechanisms, on account of stressing them adaptation of physiological responses and CVS metabolism to increasing physical activity is fulfilled. Studies have demonstrated the need for regular monitoring of the process of physical exercise with a purpose of its optimization. The survey of students in the control group who are not involved in sports, revealed changes in the degree of fatness, the low level of work capacity, expressed level of stress of regulatory systems (75 % of students), indicating diminution of reserve capacity of the body.

In addition, studies have shown that in the experimental group with higher adaptive capacity of CVS all indicators of physical development and health were higher. Further stress of regulatory adaptive mechanisms of CVS of students in the control group and some students of the experimental group may lead to the development of disadaptation processes of the body. Thus, despite the fact that the major physiological systems providing working in athletic activities are oxygen transport system, the central nervous system plays an important pole too.

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УДК 612

### Функциональное состояние сердечно-сосудистой системы у студентов с различным уровнем тренированности

Айман Ережеповна Конкабаева<sup>a,\*</sup>, Марал Расол<sup>a</sup>

<sup>a</sup> Карагандинский государственный университет им. академика Е.А. Букетова, Казахстан

**Аннотация.** Изучено текущее функциональное состояние сердечно-сосудистой системы организма у студентов регулярно занимающихся спортом и не занимающихся спортом. Состояние сердечно-сосудистой системы оценивалось с помощью регистрации вариабельности сердечного ритма, определения работоспособности по Руфье. Была проведена комплексная оценка вариабельности сердечного ритма по показателю

\* Корреспондирующий автор

Адреса электронной почты: [aiman54@mail.ru](mailto:aiman54@mail.ru) (А.Е. Конкабаева)

активности регуляторных систем организма. Выявлено, что у студентов, занимающихся спортом умеренное и выраженное напряжение регуляторных систем наблюдалось в 55 % случаев, что составило более половины обследованных, это может быть обусловлено неадекватностью предъявляемых физических нагрузок текущему функциональному состоянию организма.

**Ключевые слова:** адаптация, сердечно-сосудистая система, студенты, сердечный ритм, регуляторная система, здоровье, работоспособность.