

## Assessment of functional conditions of basketball and football players during the load by applying the model of integrated evaluation

Renata Žumbakytė-Šermukšnienė<sup>1,2,3</sup>, Alma Kajėnienė<sup>1,3</sup>, Alfonsas Vainoras<sup>1</sup>,  
Kristina Berškienė<sup>1</sup>, Viktorija Augutienė<sup>1</sup>

<sup>1</sup>Kaunas University of Medicine, <sup>2</sup>Lithuanian Academy of Physical Education, <sup>3</sup>Kaunas Sport Medicine Center

**Key words:** functional state; integrated evaluation; bicycle ergometry test; athlete.

**Summary.** We consider the human body as an adaptable, complex, and dynamic system capable of organizing itself, though there is none, the only one, factor inside the system capable of doing this job. Making use of the computerized ECG analysis system “Kaunas-load” with parallel registration of ECG carrying out body motor characteristics, ABP, or other processes characterizing hemodynamics enable one to reveal and evaluate the synergistic aspects of essential systems of the human body what particularly extends the possibilities of functional diagnostics.

The aim of the study was to determine the features of alterations in the functional condition of basketball and football players and nonathletes during the bicycle ergometry test by applying the model of evaluation of the functional condition of the human body.

**Material and methods.** The study population consisted of 266 healthy athletes and nonathletes. Groups of male basketball players, male football players, male nonathletes, female basketball players, and female nonathletes were studied. A computerized ECG analysis system “Kaunas-load” that is capable of both registering and analyzing the power developed by the subject and 12-lead ECG synchronically were used for evaluating the functional condition of the CVS. The subject did a computer-based bicycle ergometry test. The following ECG parameters at rest and throughout the load – HR, JT interval, and the deduced JT/RR ratio index that reflects the condition between regulatory and supplying systems – were evaluated. After measuring ABP, the pulse amplitude (S–D) was evaluated. The pulse blood pressure ratio amplitude (S–D)/S that depicts the connection between the periphery and regulatory systems was also evaluated. Speeds of changes in physiological parameters during physical load were evaluated too.

**Results.** Heart rate and JT/RR ratio of athletes at the rest and during load were lower, and JT interval of rest was longer and became shorter more slowly during load, compared to that of healthy nonathletes.

The pulse arterial blood pressure amplitude of men at rest and during load was higher than that of women. The pulse ABP amplitude of athletes was higher than that of nonathletes.

The relative pulse ABP amplitude in the state of rest in the groups of men was higher than in groups of women. The relative pulse amplitude of female basketball players at rest and during load was higher than that of female nonathletes.

Significant differences in the dynamics of speed of changes in HR, the pulse ABP amplitude, and the relative pulse ABP amplitude of male and female basketball players, male football players, as well as male and female nonathletes were observed.

**Conclusions.** The newly deduced parameters, namely, speeds of changes in the parameters with changes in the phase of the load reflect very well peculiarities of functional condition of the human body during bicycle ergometry test.

The sum total of those newly deduced parameters and customary parameters reveals new functional peculiarities of the human body.

### Introduction

Functional changes in the human body during physical load are a sequence of complex interrelated processes. The physiological essence of body adaptation is acquiring such functionality of the body that would distinguish itself by a greater tolerance to physical load, a

greater amount of energy resources at the disposal of the body, and perfection of regulatory mechanisms (1, 2). A frequent phenomenon among athletes is overtraining (deadaption) that can be caused by the absence of proper balance between training load and recovery, as well as by training sessions that are too frequent and

Correspondence to R. Žumbakytė-Šermukšnienė, Jankaus 2, 50275 Kaunas, Lithuania. E-mail: renuksz@gmail.com

Adresas susirašinėti: R. Žumbakytė-Šermukšnienė, Jankaus 2, 50275 Kaunas. El. paštas: renuksz@gmail.com

too long and by additional tension due to a forthcoming contest or due to other causes (3–5). The aim of complex research is to evaluate the reserve possibilities of the athlete's body and to reveal the factors, if any, that limit the realization of reserve possibilities of the athlete (6).

We consider the human body as an adaptable, complex, and dynamic system capable of organizing itself, though there is none, the only one, factor inside the system capable of doing this job (7, 8). When assessing only a single system of the human body during physical load, we could not assess the response of the whole body to load, since the condition of the body, being a dynamical system, is under the influence of several attractors and it returns to a stable condition spontaneously (8). Therefore, in estimating the function of particular systems of the human body, it is essential to study not only the changes in separate parameters, but also to involve such parameters that indicate the interrelationship of the various systems of the human body (9).

A number of studies dealing with a complex effect of physical load have been published during recent years (10). Making use of the automatic ECG analysis system "Kaunas-load" with parallel registration of ECG carrying out body motor characteristics, ABP, or other processes characterizing hemodynamics enable one to reveal and evaluate the synergistic aspects of essential systems of the human organism what particularly extends the possibilities of functional diagnostics.

According to physiologic changes in human organism during load, the main systems responsible for organism functionality could be working muscles (P); responsible for energy supply, cardiovascular system (H); for oxygen supply, lungs (L); and coordinating all that systems function together, regulatory system (R) (in which central nervous system, periphery nervous system, humoral regulation, etc. as one could be accounted). Two systems responsible for suppl – cardiovascular and respiratory – could be reduced to one supplying system (H) (Fig. 1).

During load, let's say usual bicycle ergometry, computerized system after test, measure about 10 000 initial parameters, every process is measured in details, and maximal decomposition of situation is achieved. The parameters were joining according to physiologic sense. The group of complex parameters has only about 100 parameters. Part of them is used to build the integral evaluation – one parameter, which assumes main organism changes.

Having applied a model of estimating the functional condition of the human organism and having done a bicycle ergometry test, research in the parameters reflecting the functional properties of both male and female basketball players and male football players has been undertaken in this study.

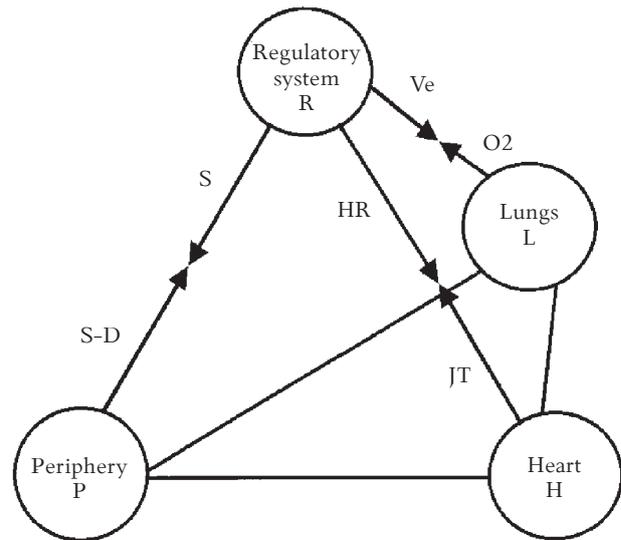


Fig. 1. Used model in the system "Kaunas-load"

### Material and methods

The contingent of subjects consisted of 266 healthy athletes and nonathletes who had no complaints about their health and whose ECG was without any pathological changes. Subjects were divided into the following groups: 113 male basketball players (MB), 55 male football players (MF), and 30 male nonathletes (MN-A), as well as 38 female basketball players (WB) and 30 female nonathletes (WN-A).

*The methods of the research. Bicycle ergometry.* "Kaunas-Load," an automatized ECG analysis system, created at the Institute of Cardiology of Kaunas University of Medicine, that is capable of both registering and analyzing the power developed by the subject and 12-lead ECG synchronically (11, 12), has been used for evaluating the functional condition of the CVS. The subject did a computer-based bicycle ergometry test. A short-term provocative protocol was used (13). The initial power of the load applied to everybody was 50 W, and it was increased for healthy WN-A group by 25 W every minute, and in the case of the others, by 50 W till submaximum power developed. The frequency of pedaling was 60 rotations per min. Usually the power is limited by clinical symptoms that are regarded as absolute and relative indications of discontinuing the load.

The arterial blood pressure (ABP) was measured by auscultation of Korotkoff's tones with a stethoscope in the humeral artery area. ABP was measured in sitting position at rest the last 15 s of every step of physical load test.

*Electrocardiography.* During a bicycle ergometry, 12-lead ECG was registered synchronically the last 10 s of each minute. The following ECG parameters at rest, throughout the load, and during recovery were evaluated: HR, JT interval, and the deduced JT/RR ratio index that reflects the condition between regulatory and supplying systems.

During bicycle ergometry, research parameters reflecting several basic interrelated systems of the human body, i.e. the executive (PS), the supplying and regulatory systems, were registered. Making use of the integral model of evaluation (11, 12), both separate and integrated functions of the systems mentioned were evaluated. The interrelationship among the systems functioning in the human body is described in a similar way by other authors too (14).

While evaluating the alterations in the selected parameters, their interrelationship and the sum total results of all alterations having taken place, we are able to characterize the adaptation of the human organism to the load applied and to give our own recommendations for the optimum load to be assigned. This model also enables to evaluate the visible response of the human organism after the applied individualized influence based on alterations in parameters, their ratio, etc.

After measuring ABP, the pulse amplitude (S-D) was evaluated. The amplitude of pulse blood pressure reflects the periphery system. The amplitude of pulse blood pressure ratio (S-D)/S that depicts the connection between the periphery and regulatory systems was also evaluated. The amplitude of pulse ABP ratio and the pulse amplitude were registered at rest, during load and recovery.

Speeds of changes in physiological parameters during physical load were evaluated too. The parameter was calculated according to the formula:

$$f_i = [f(N_{i+1}) - f(N_i)] / (N_{i+1} - N_i),$$

where  $f_i$  indicates speed of changes in physiological parameter during load;  $i = 1, 2, 3, 4, 5, 6$ , the 1st, 2nd, etc. minute of load;  $N = 0, 50, 100, 150, 200, 250, \text{ and } 300$ , when the subject is an athlete (woman and man) or a male nonathlete until submaximal power achieved by him, whereas  $N = 0, 50, 75, 100, 125, 150, \text{ and } 175$ , when the subject is a female non-athlete until submaximal power achieved by her.

**Statistical analysis of the data.** The values are presented as arithmetical means (M)  $\pm$  standard deviation (SD) of the sample. Statistical significance of differences was calculated using Student  $t$  test for independent and dependent samples. The difference of less than 0.05, with respect to error probability, was regarded as statistically significant.

## Results

**Alterations in heart rate and its speed of changes during load in the groups studied.** Heart rate (HR) of healthy athletes at rest was slower, and during load, it increased more slowly than that of nonathletes. It was found that heart rate of MB was significantly lower throughout the load ( $P < 0.05$ ), that of MF at

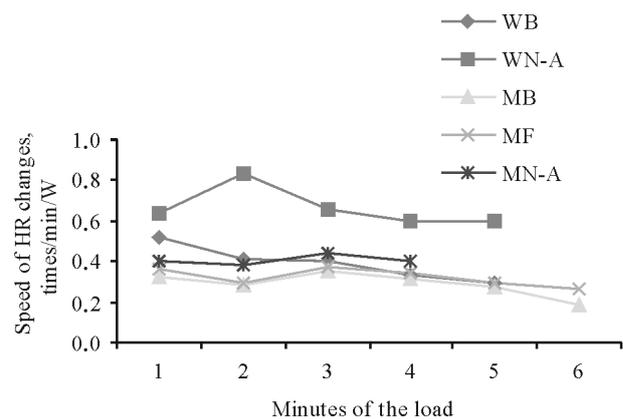


Fig. 2. Alteration in speed of HR changes each minute of physical load test in all the groups

rest and in the warming-up phase of physical load test (PLT) until 150 W of the load ( $P < 0.05$ ), compared to HR of MN-A. HR of WB was also significantly lower at rest and at every step of PLT, compared to that of WN-A ( $P < 0.05$ ). A comparison of HR changes in MB and MF during PLT revealed no significant differences between them.

The dynamics of speed of changes in HR can be seen in Fig. 2. It was showed that speed of changes in HR of nonathletes during PLT was higher than that of athletes. Speed of HR changes of WN-A was significantly higher at all phases of PLT, compared to that of WB ( $P < 0.05$ ). Speed of HR changes of MB and MF was lower at all phases of PLT, compared to that of MN-A. Speed of HR changes of MB was found to be significantly lower ( $P < 0.05$ ) during the warming-up phase of PLT, whereas that of MF at the second minute of PLT ( $P < 0.05$ ) as compared to MN-A.

There were differences in the dynamics of speed of HR changes of men and women. Thus, maximum speed values in all groups of men were observed at the third minute of the load, in WN-A at the second minute, and in WB at the first minute of the load.

**Alterations in the JT interval and speed of its changes during load in the groups.** The duration of the JT interval of WB at rest was found to be  $0.270 \pm 0.024$  s, whereas that of WN-A significantly shorter, i.e.  $0.255 \pm 0.020$  s ( $P < 0.05$ ), compared to the respective values of WB. The duration of the JT interval in the group of MN-A at rest ( $0.246 \pm 0.028$  s) was significantly shorter than that of MB and MF ( $P < 0.05$ ). The duration of the JT interval of MB at rest was  $0.263 \pm 0.029$  s and that of MF was  $0.266 \pm 0.031$  s. The duration of the JT interval of WB was registered as a longer one at each step of PLT and during the warming-up phase as significantly longer comparing to that of WN-A ( $P < 0.05$ ). The duration of the JT interval of MN-A during the warming-up phase of the load was found to be significantly shorter than in the group of MB and MF ( $P < 0.05$ ). No significant difference in the duration of the JT interval

between the groups of MB and MF during the load was observed.

Speed of changes in the JT interval was not consistent and its dynamics was peculiar to men and women (Fig. 3). Speed in the duration of changes in the JT interval of WN-A was significantly higher during warming-up at the second minute of the load, compared to that of WB ( $P < 0.05$ ). The highest value of alteration speed in the duration of the JT interval of WN-A was registered at the second minute of the load, whereas in the case of WB during the warming-up phase at the first 3 minutes of the load, and in groups of men – the third minute of the load. Higher speeds in changes of the JT interval were observed in groups of women, compared to those of men.

*Changes in the JT/RR ratio and alteration in speed of its changes during load in the groups.* Changes in the JT/RR, which indicate the connection between the regulatory and supplying systems during load, were evaluated. A higher index of repolarization ratio, i.e., ratio of the JT interval and RR, in WN-A at rest and throughout the load was observed and at the beginning of the warming-up phase, at the load of 50 W, it was found to be higher as compared to that of WB ( $P < 0.05$ ). The JT/RR ratio of MN-A at rest and at all steps of the load was established to be higher than that of MB or MF, and during the warming-up phase, at the loads of 50 W and 100 W, this difference between MN-A and MF was significant ( $P < 0.05$ ).

An observation of alteration in speed of the changes in JT/RR ratio that indicate the connection between the regulatory and supplying systems (Fig. 4) revealed that at the first minute of the load, maximum value of speed of the changes in the JT/RR ratio was observed in all the groups of men and women studied. Speed of changes in JT/RR ratio throughout the load was found to be higher among WN-A than that of WB.

*Alteration speed of changes in the systolic blood pressure during load in the groups.* Differences in the dynamics of speed of changes in systolic blood pressure (S) in the groups of men and women studied were observed (Fig. 5). It was characteristic of women that speed of changes in S was lower at the first minute of the load, and then an increase occurred and the maximum speed value was reached at the third minute of the load. There was a decrease in speed of changes in S at the second minute of the load among men, and then the speed increased until it reached its maximum value at the fourth minute of the load.

The speed of changes in S of WN-A was found to be higher throughout the load, and it was significantly higher at the second and third minute of the load as compared to that of WB ( $P < 0.05$ ).

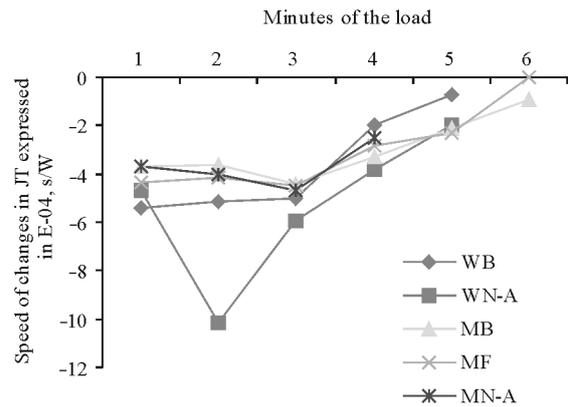


Fig. 3. Alteration in speed of changes of the JT interval duration during each minute of physical load test in the groups

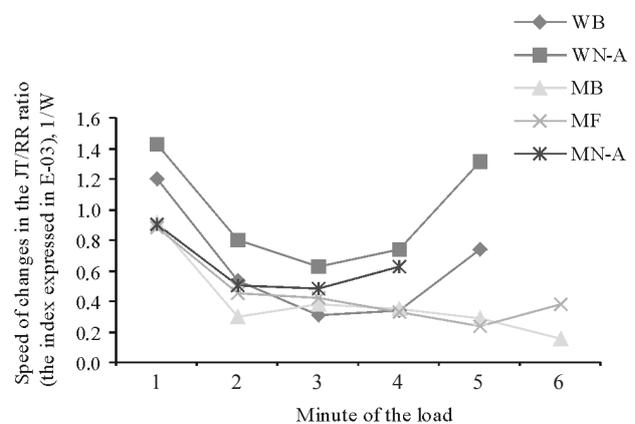


Fig. 4. Alteration in speed of changes in the JT/RR ratio index during each minute of the physical load test in the groups

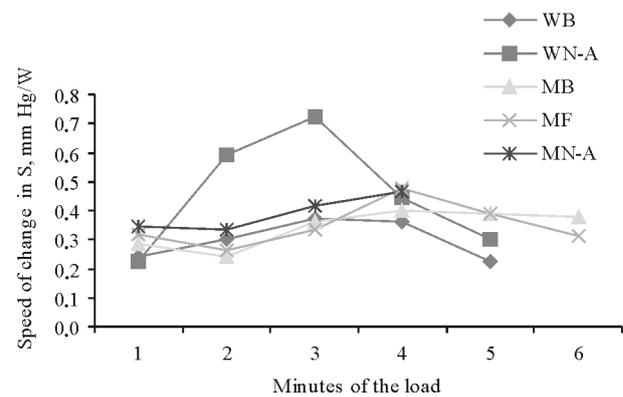


Fig. 5. Alteration in speed of changes in systolic blood pressure during each minute of physical load test in groups

The speed of changes in S of MN-A was observed to be higher than that of male athletes, and during warming-up at the second minute of the load, it was significantly higher than that of MB ( $P < 0.05$ ). This parameter of MF at the end of the warming-up phase, i.e. at the fourth minute of the load, was significantly higher than that of MB ( $P < 0.05$ ).

Changes in the amplitude of pulse blood pressure ( $S-D$ ) and alteration speed of its changes during load in the groups studied. The pulse ABP amplitude of WN-A was  $36.06 \pm 1.70$  mm Hg and that of WB was  $40.45 \pm 1.31$  mm Hg. This parameter in the case of WN-A was significantly lower than that of WB ( $P < 0.05$ ). The pulse ABP amplitude of MB was  $51.85 \pm 1.23$  mm Hg, that of MF was  $50.18 \pm 1.50$  mm Hg, and that of MN-A was  $51.87 \pm 2.44$  mm Hg. The pulse ABP amplitude of men at rest and during load was higher than that of women. The pulse ABP amplitude of both MB and MF at the end of the warming-up phase, i.e. at the load of 200 W, was found to be statistically significantly higher than that of MN-A ( $P < 0.05$ ). There were no changes in the pulse ABP amplitude in the group of MF at the load of 300 W, but a consistent increase in the amplitude of MB at this stage of the load was observed.

A lower pulse ABP amplitude of WN-A, compared to that of WB, was observed during the load, and a significant difference in this parameter in the warming-up phase, as well as in the steady state was

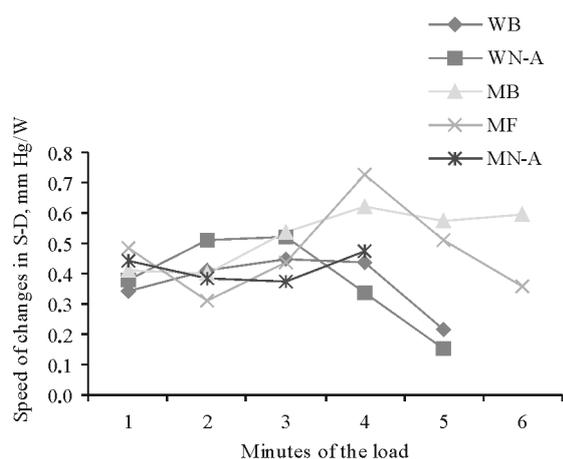


Fig. 6. Alteration in speed of changes in the pulse arterial blood pressure amplitude during each minute of physical load test in the groups

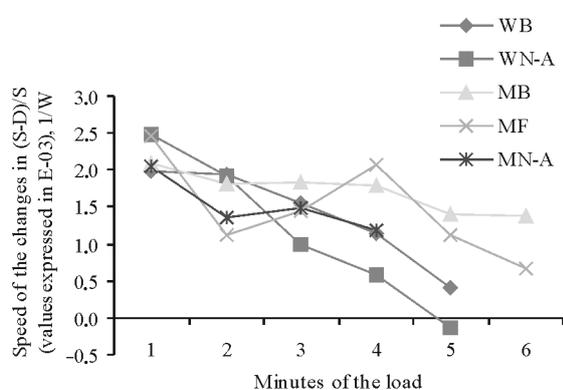


Fig. 7. Alteration in speed of changes in the relative pulse ABP amplitude during each minute of physical load test in all the groups

determined ( $P < 0.05$ ). The load of WB during PLT was limited by overloading of the periphery system at the last step of the load during mobilization of resources. No signs of overloading of the periphery system at the last step of the load in the group of WN-A were observed.

There were great differences in alteration in speed of changes in the pulse ABP amplitude between men and women (Fig. 6).

Alterations in the relative pulse arterial blood pressure amplitude  $[(S-D)/S]$  and the speed of its changes during load in the groups. The relative pulse ABP amplitude was higher in groups of men than that in groups of women. The relative pulse ABP amplitude of WB at rest was also higher than that of WN-A, and this difference was significant ( $P < 0.05$ ). The relative pulse ABP amplitude of WB during load was higher at all stages of the load, compared to that of WN-A, and this difference between the two groups of women during warming-up and steady state was significant ( $P < 0.05$ ).

There were differences in alteration in speed of changes in the relative pulse ABP amplitude between men and women during physical load (Fig. 7).

## Discussion

The aim of the study was to assess functional status of the basketball and football players and persons without physical activity by applying the model of integrated evaluation (11, 12) and to describe physiological characteristics and speed of alteration of them during physical load.

Dynamic systems theory offers a variety of techniques that allows expressing the behavior of the nervous and muscular systems of short-period phases and provides information on the system organization (8, 15). According to the modern theory of dynamical systems, some principles could be applied to sports medicine: at first for analysis of human motion (8), as well as motion control and learning (7, 8), body posture (16, 17) and the athlete's body physiological studies (18, 19), for improvement of sports training methods (8, 20–22).

In our study, the indexes of body systems most involved into intensive physical load and their interrelationships were analyzed; the attention to body self-organization during physical load was paid.

A total of 266 bicycle ergometry tests were performed. The alteration of simple ECG indices and relative indicators was analyzed. With the intention of an accurate assessment, calculations of these indicators of the rates of change per load watts to every minute of physical load were made.

We registered slower heart rate of healthy athletes at rest. During load, it increased more slowly than in nonathletes group. We follow the same phenomenon described by the other investigators that

heart rate of the athletes at rest is slower (23) and during exercise increases more slowly than nonathletes (9, 24). This is explained by the fact that the body adaptation to physical load increases the activity of the parasympathetic nervous system (25) and therefore reduces HR.

It has been established that speed of changes in HR of nonathletes during PLT was higher than that of athletes. It could be displayed by worse adaptation of nonathletes to physical load and more active implication of regulatory systems during exercise in comparison with athletes. Significant differences in HR alteration speed between basketball and football players were not observed. It reveals a tendency for basketball players HR alteration speed during exercise to be lower than in the football players. This phenomenon would show a better adaptation to physical activity, a lower activity of the parasympathetic nervous system of basketball players.

Significant differences in the dynamics of speed of HR changes of men and women were found. This difference in activities of regulatory systems is likely to be determined by a more marked humoral control typical for the body of women.

As the HR of basketball and football players of almost all the PLT was significantly lower than those of nonathletes, the JT interval of athletes was found to be significantly longest in warming-up period in comparison to nonathletes. No significant difference in the duration of the JT interval between the groups of MB and MF during the load was observed. Jaruševičius (26) registered a moderate correlation between JT interval duration and HR at the maximum of physical exertion in healthy individuals in the mean group ( $r=-0.38$ ) and strong correlation ( $r=-0.56$ ) in the athletes' group. It is obvious that a shorter JT interval that indicates a stronger recruitment of the heart was observed, namely, among less trained persons.

The speed of changes in the JT interval was not consistent, and its dynamics was peculiar to men and women. It is clear that higher speed in changes of the JT interval indicates worse slow adaptation to load.

Changes in the JT/RR that indicate the connection between the regulatory and supplying systems during load were evaluated. It is clear that the long-term physical loads decrease the HR and increase duration of interval JT, reduce cardiac load. Obviously, a relative indicator of the JT/RR decreases. Šilanskienė (9) discussed about this phenomenon in more detail. The fact that relative rate of JT/RR decreases in the long-term slow adaptation to physical activity was documented in our study. The JT/RR of female nonathletes was higher at rest and under stress conditions than in the basketball players and in male nonathletes, higher than in football or basketball players.

An observation of alteration in speed of the changes in JT/RR ratio revealed that the first minute of the load, the maximum value of speed of the changes in the JT/RR ratio was observed in all the groups of men and women studied. This maximum value of the JT/RR ratio index was higher among women than men, and in the case of WN-A, it was higher than that of WB. If at the beginning of the load speed of changes in JT/RR ratio had maximum values and speed of changes during load decreased in all the groups studied, then at the maximum of the load, i.e., during mobilization of reserves, the values of speed of changes in the JT/RR ratio index increased again. We think that an increase in speed of changes in JT/RR in the last step can indicate the "limit" of functional possibilities of the individual, i.e., this increase shows the limit of regulatory and supplying systems during mobilization of reserves. Possibly, this index might be regarded as indicating the point at which the load during PLT should be restricted.

Differences in the dynamics of speed of changes in systolic blood pressure in the groups of men and women were observed. Such differences in alteration in speed of changes in S between men and women were likely to be determined by different control of regulatory systems in organisms of men and women.

The speed of changes in S of MF at the end of the warming-up phase, i.e., at the fourth minute of the load, was significantly higher than that of MB. Thus, we believe, therefore, the regulatory system of MF to be more disbalanced in this phase of load and to react more actively to the same physical load performed, compared to MB. The higher rates of S alteration speed in the groups of nonathletes demonstrate lower adaptation to physical load and more active reaction of regulatory system.

The pulse ABP amplitude of men at rest and during load was higher than that of women. The higher the pulse amplitude (within certain limits), the better blood flow in working muscle (1). German sports medicine physicians (27) found that athletes during exercise significantly reduced diastolic blood pressure. Exactly for this reason the ABP pulse amplitude had possibility for increasing (1).

There were great differences in alteration in speed of changes in the pulse ABP amplitude between men and women. Lower speed of changes in this parameter observed in the groups of women at the first minute of load gradually increased already at the second minute of the load and having reached maximum speed values within several minutes, started to decline again. The second minute of the load marked the beginning of the first stage of intensification of blood circulation in muscles, as recorded by Poderys (1). It was difficult to evalu-

ate this phenomenon estimating only the changes in the pulse amplitude without registering speed of its changes. At all stages of speed of changes in this parameter, the speed in WN-A was higher than that of WB. Higher speed of changes in the pulse ABL amplitude observed in the groups of men already at the first minute of the load later tended to decrease and rise again and after reaching maximum values, decreased again. We think the highest speed of this parameter in the groups of men at the first minute of the load indicates the first stage of intensification of blood circulation in the muscles during warming-up, whereas the second increase in speed at the fourth minute is likely to indicate the second stage of intensification of blood circulation in the muscles. We have noticed that speed of changes in the pulse ABP amplitude of MF had higher alteration amplitudes than that of MB. These "waves" of alterations in speed in the group of MF are likely to reflect greater recruitment of the periphery system, i.e., activation associated, obviously, with the increased production of lactate. Thus, in the groups of women, one stage of intensification of blood circulation in the muscles and in the groups of men, two stages of intensification are observed. Evidently, the stages of intensification of blood circulation in the muscles of men and women differ in time.

The relative pulse amplitude of blood pressure indicates the ratio of difference between systolic and diastolic blood pressure and systolic blood pressure  $[(S-D)/S]$ . According to the model of integrated evaluation (11, 12), it is applicable as an indicator describing the relationship between a regulatory system (R) and working muscles (P). This indicator displays the change as a function of peripheral activation during exercise. The relative pulse amplitude at rest in male groups was found to be higher than in female groups. This index was higher in the

group of female basketball players under the same conditions in comparison with female nonathletes. We have opinion that the alterations of relative pulse amplitude depend on person's adaptation to physical load and physical capacity.

The speed of changes in the relative ABP amplitude in all the groups of subjects studied tended to be higher at the first minute of the load, compared to that of the last minute of the load. A sharp decrease in speed of changes in the relative pulse ABP amplitude was observed among women. The values of this parameter of WN-A were lower each minute of the load throughout the PLT, compared to those of WB. Meanwhile in the groups of men, a decrease by "jumps" was observed in this parameter. The first jump down was typical for all the groups of men at the second minute of the load, and the second jump up in the group of MN-A was observed at the third minute, in MF and MB groups at the fourth minute of the load, whereas later speeds decreased again. In our opinion, MF group was more overstrained and overtrained, and therefore, greater fluctuations in speed of changes in the relative pulse ABP amplitude of MF were registered during PLT, compared to the respective indices of MB and MN-A. Alteration in speed of changes in the relative pulse ABP amplitude is likely, therefore, to depend on gender, adaptation to physical loads, physical capacity, and even on the kind of sports practiced.

### Conclusions

The newly deduced parameters, namely, speeds of changes in the parameters with changes in the phase of the load, reflect very well peculiarities of functional state of the human body during bicycle ergometry test.

The sum total of those newly deduced parameters and customary parameters reveals new functional peculiarities of the human body.

## Krepšininkų ir futbolininkų funkcinės būklės ypatybės fizinio krūvio metu naudojant integraliojo vertinimo modelį

Renata Žumbakytė-Šermukšnienė<sup>1,2,3</sup>, Alma Kajėnienė<sup>1,3</sup>, Alfonsas Vainoras<sup>1</sup>,  
Kristina Berškienė<sup>1</sup>, Viktorija Augutienė<sup>1</sup>

<sup>1</sup>Kauno medicinos universitetas, <sup>2</sup>Lietuvos kūno kultūros akademija, <sup>3</sup>Kauno apskrities Sporto medicinos centras

**Raktažodžiai:** funkcinė būklė, integralusis vertinimas, veloergometrinis fizinio krūvio mėginys, atletas.

**Santrauka.** Žmogaus organizmą vertiname kaip adaptyvią, kompleksinę, dinaminę sistemą, kuri pati save organizuoja, tačiau šį darbą atliekančio vienintelio veiksnio sistemos viduje nėra. Naudodami automatizuotą EKG analizės sistemą „Kaunas–Krūvis“ ir registruojant lygiagrečiai su elektrokardiograma kūno judėjimo charakteristikas (išvystomą darbo galingumą), arterinį kraujo spaudimą ar kitus hemodinamiką charakterizuojančius procesus, galime atskleisti ir vertinti esminių žmogaus organizmo sistemų sinergetinius aspektus, kas labai praplečia funkcinės diagnostikos galimybes.

**Tyrimo tikslas.** Pasinaudojant organizmo funkcinės būklės vertinimo modeliu, nustatyti krepšininkų, futbolininkų bei nesportuojančių asmenų organizmo funkcinės būklės kaitos ypatybes veloergometrinio mėginio metu.

*Tiriamųjų kontingentą* sudarė 266 sveiki sportuojantys ir nesportuojantys asmenys. Tirtos krepšininkų, futbolininkų ir nesportuojančių vyrų grupės bei krepšininkų ir nesportuojančių moterų grupės. Širdies ir kraujagyslių sistemos funkcinėi būklei vertinti naudota automatizuota EKG analizės sistema „Kaunas–Krūvis“. Tiriamiesiems atliktas kompiuterizuotas veloergometrinis fizinio krūvio mėginys naudojant trumpalaikį-provokacinį tyrimo protokolą. Buvo vertinami šie EKG rodikliai ramybės sąlygomis ir viso mėginio metu: širdies susitraukimų dažnis, intervalas JT ir išvestinis rodiklis JT/RR. Išmatavus AKS, buvo vertinama pulsinė amplitudė (S–D). Taip pat vertintas santykinis rodiklis (S–D)/S – santykinė pulsinė amplitudė. Vertinti fiziologinių rodiklių kitimo greičiai fizinio krūvio metu.

*Rezultatai.* Sportuojančių asmenų ramybės ir krūvio metu širdies susitraukimų dažnis ir santykis JT/RR yra žemesnis, o ramybės JT intervalas ilgesnis ir lėčiau trumpėja krūvio metu nei sveikų nesportuojančių asmenų.

Vyrų pulsinė kraujospūdžio amplitudė ramybės ir krūvio metu yra aukštesnė nei moterų. Sportuojančių asmenų pulsinė amplitudė yra didesnė nei nesportuojančių.

Vyrų grupėse santykinė pulsinė amplitudė ramybėje yra aukštesnė nei moterų grupėse. O moterų krepšininkų ramybės ir krūvio metu santykinė pulsinė amplitudė yra didesnė nei nesportuojančių moterų.

Nustatyta reikšmingų skirtumų vyrų ir moterų krepšininkų, futbolininkų bei nesportuojančių vyrų ir moterų širdies susitraukimų dažnio, pulsinės amplitudės, santykinės pulsinės amplitudės kitimo greičių dinamikoje.

*Išvados.* Organizmo funkcinės būklės kaitos ypatybes veloergometrinio mėginio metu apibūdina nauji išvestiniai rodikliai: tiriamojo rodiklio kitimo greitis keičiantis krūvio pakopoms. Išvestinių ir įprastinių rodiklių visuma atskleidžia naujas organizmo funkcines ypatybes.

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