DYNAMICS OF CENTRAL AND PERIPHERAL CARDIOVASCULAR INDICES WHILE PERFORMING REPETITIVE DOSED EXERCISE TEST

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ABSTRACT

Research background and hypothesis. Various physical loads require a different level of activation of various physiological systems and physiological mechanisms, which can highlight the synergetic interaction between central and peripheral mechanisms.

Research aim. The aim of this study of this study was to identify and compare the central and peripheral reactions of cardiovascular system while performing repetitive dosed exercise test.

Research methods. The participants in the study (15 persons in each of the four groups: non-athletes males; non-athletes females; well-trained endurance runners and well-trained sprinters) performed three Roufier exercise tests, i. e. 30 squats per 45 s with two minutes of rest between exercising. 12-leads ECG was registered and the heart rate (HR), the duration of interval JT were measured and analysed. Changes of oxygen saturation (StO_2) in m. vastus leteralis were measured by near-infrared spectroscopy.

Research results. One time performance of the physical load may not reveal any central and peripheral synergic peculiarities as adaptation to physical loads in cumulative. For non-athletes the performance of repetitive Roufier tests every two minutes produced the fatigue summation effects which were typical of central and peripheral indices; for well-trained athletes we observed the stability of central reaction and fatigue effects in peripheral responses.

Discussion and conclusions. A lot of cardiovascular indices may indicate the summation effects of fatigue while repeatedly performing a Roufier Test with two minutes of rest between exercising. The peripheral changes start first and they impact the central cardiovascular changes.

Keywords: electrocardiogram, dosed exercise test, oxygen saturation.

INTRODUCTION

While performing different movement tasks the activity of various functional systems are energized in different degrees and ways. The activity of controlling mechanisms appears in hierarchic interaction, thus providing information about the functional state of the system or the whole body (Grassi et al., 1996; Hughson, 2007; Jones, Pople, 2007). Cardiovascular system plays one of the most important roles in the constitution of the supplying systems, and the recognition of the processes taking place in the cardiovascular system is important while performing the testing procedures aimed at estimating the adaptation of the body functions to workloads or peculiarities of the recovery process (Perkiomaki, 2003; Vainoras, 2004). There are many studies designed for the assessment of central and peripheral mechanisms of regulation of muscular blood flow and oxygen supply to muscles and for better understanding of the interaction of the central and peripheral mechanisms; however, there is a great demand for the studies on the sequence and interaction of various mechanisms when physical exercises are performed under various conditions and at different intensities of exercising (Tschakovsky, Joyner, 2008).

The hypothesis of the present study was formulated taking into account the fact that various physical loads requiring a different level of activation of various physiological systems and physiological mechanisms may highlight the synergetic interaction between central and peripheral mechanisms. The aim of this study was to identify and compare the central and peripheral reactions of cardiovascular system while performing repetitive dosed exercise test.

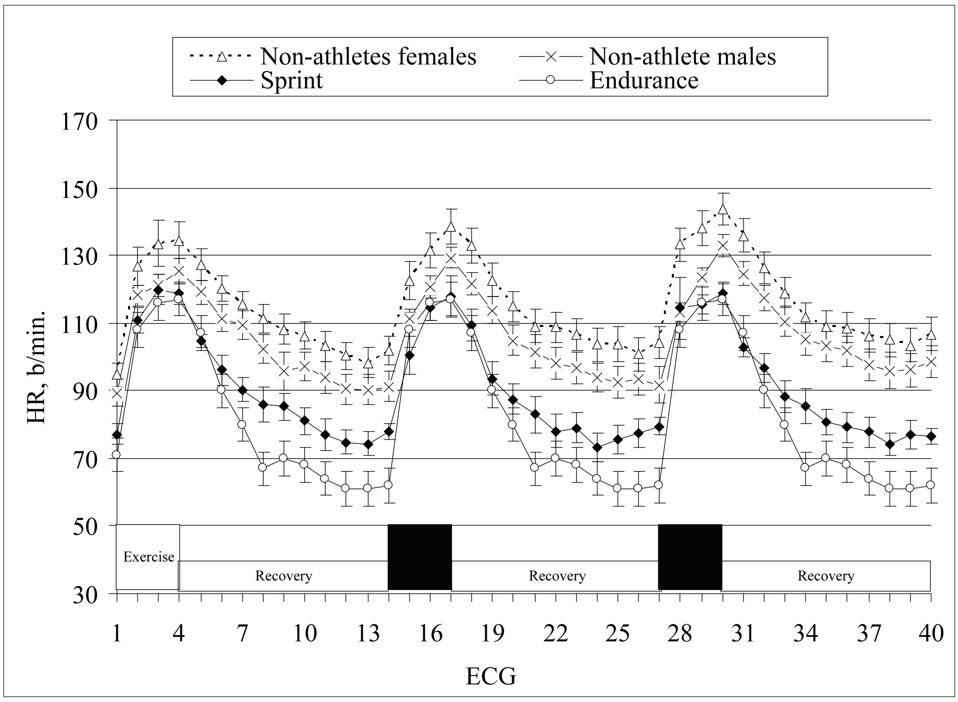
RESEARCH METHODS

Four groups of research participants in the study 15 persons in each group (*non-athletes males; non-athletes females; well-trained endurance runners and well-trained sprinters*) were engaged in to experiment. All participants performed three Roufier exercise tests, i. e. 30 squats per 45 s with two minutes of rest between each exercise. During the exercising and recovery the 12-leads ECG was registered using the computerised system "Kaunas-load". The heart rate (HR), the duration of interval JT of ECG, the ratio JT/RR were measured and analysed. Indirect ABP measurements were taken from the arm with a sphygmomanometer and standard-size arm cuff before the exercise test and after exercising during the first two minutes of recovery. Changes of oxygen saturation (StO_2) in a thigh muscle (*m. vastus leteralis*) were measured by near-infrared spectroscopy (*Hutchinson Technology Hutchinson*, Minnesota, USA device, Model 325). The increase of StO_2 after each repetitive workload in various cohorts was normalized, i. e. the baseline of StO_2 registered before exercise tests was set equal to 100 percent. The significance of the difference between values obtained at each testing was evaluated by computing t criterion; the paired and unpaired t-tests were used. The difference was considered statistically reliable, when p was < 0.05 (95 CI).

RESEARCH RESULTS

The results obtained during this study showed that the performance of repetitive exercising, i. e. while performing aerobic dosed workload produced different reactions which were dependant on the adaptation to exercising. Figure 1 presents the dynamics of HR in four experimental cohorts while performing 3 dosed exercise tests with 2 minutes of recovery between them. Presented HR curves showed that in the non-athlete female cohort the specific feature was the highest values

Figure 1. **Dynamics of HR in four experimental cohorts while performing 3 dosed exercise tests with 2 minutes of recovery between them**



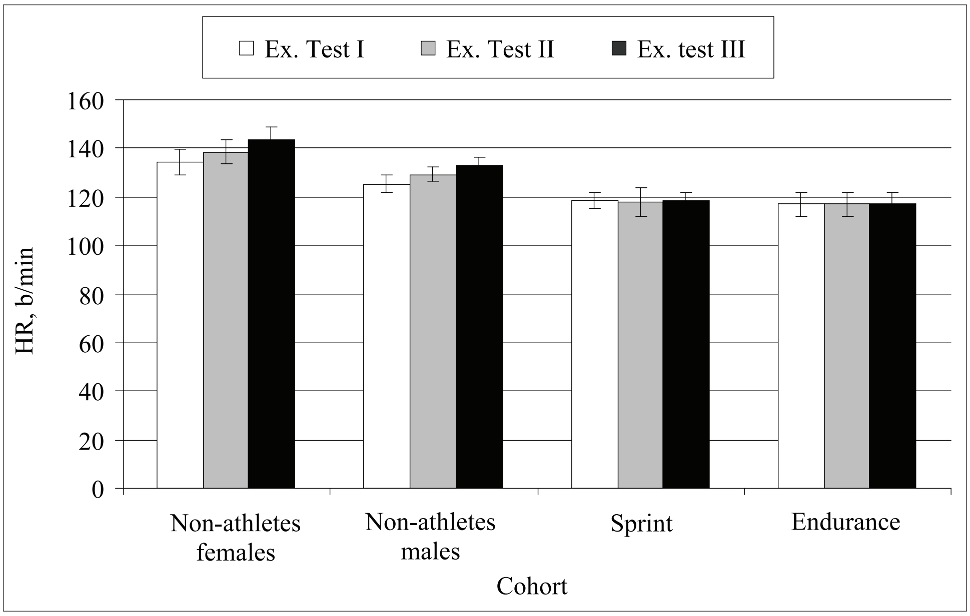


Figure 2. **Maximal values of HR registered at the end of exercise test in four experimental cohorts while performing 3 dosed exercise tests with 2 minutes of recovery between them**

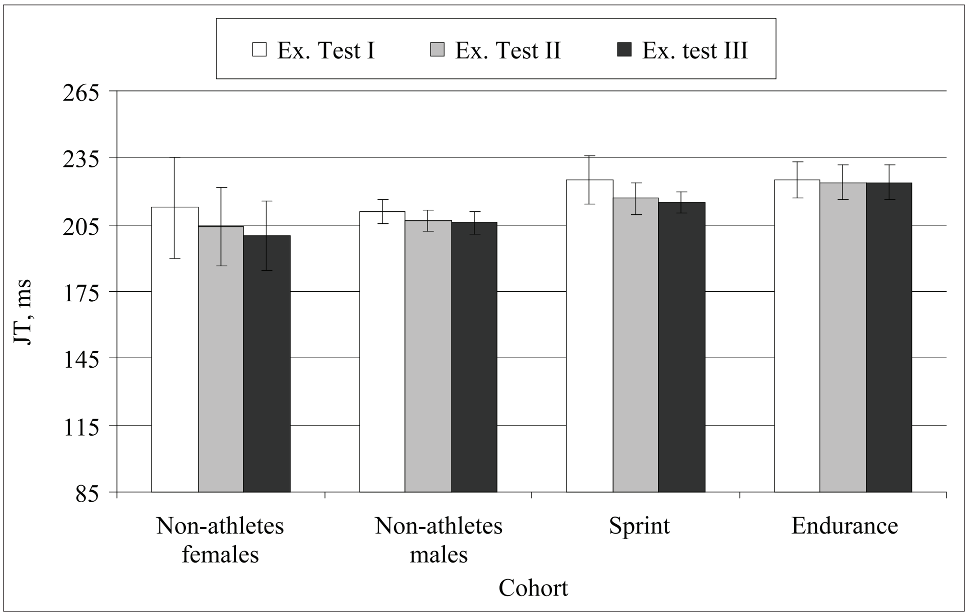


Figure 3. **Maximal values of JT interval registered at the end of exercise test in four experimental cohorts while performing 3 dosed exercise tests with 2 minutes of recovery between them**

of HR at the rest (94.6 ± 3.35 b/min – in non-athlete female cohort; 89.4 ± 4.06 b/min – in non-athlete male cohort; 77.2 ± 2.93 b/min – in well-trained sprinters cohort and 71.2 ± 3.01 – in well-trained endurance runners cohort). The same peculiarities, i. e. the highest HR values in the non-athlete female cohort remained during the workloads. At the end of the first testing workload HR increased up to 134.3 ± 5.04 b/min in non-athlete female cohort; up to 125.4 ± 3.3 b/min – in non-athlete male cohort; up to 118.6 ± 3.9 b/min – in well-trained sprinters cohort and up to 117.2 ± 3.00 b/min – in well-trained endurance runners cohort. The same dynamics of HR was observed performing the second and the third testing workloads.

Figure 2 presents the maximal values of HR registered at the end of the exercise test in four experimental cohorts while performing 3 dosed exercise tests with 2 minutes of recovery between them. Presented data indicate that there was no increase in maximal values of HR in two well trained athlete cohorts while performing repetitive exercises, i. e. there was no summing effect of fatigue taking into account the central reactions of the cardiovascular system. The results of other two cohorts (non-athlete males and non-athlete females) showed that HR increased with every second period of exercising, i. e. the summation of fatigue was evident. The same tendency was observed in the dynamics of JT interval (Figure 3). The decrease of JT interval at the end of workloads had the tendency to be bigger in both non-athlete groups and there were no significant changes between the shortest JT interval values in both athlete groups while performing Roufier test-workloads in a repetitive way.

Figure 4. **Dynamics of StO_2 in four experimental cohorts while performing 3 dosed exercise tests with 2 minutes of recovery between them**

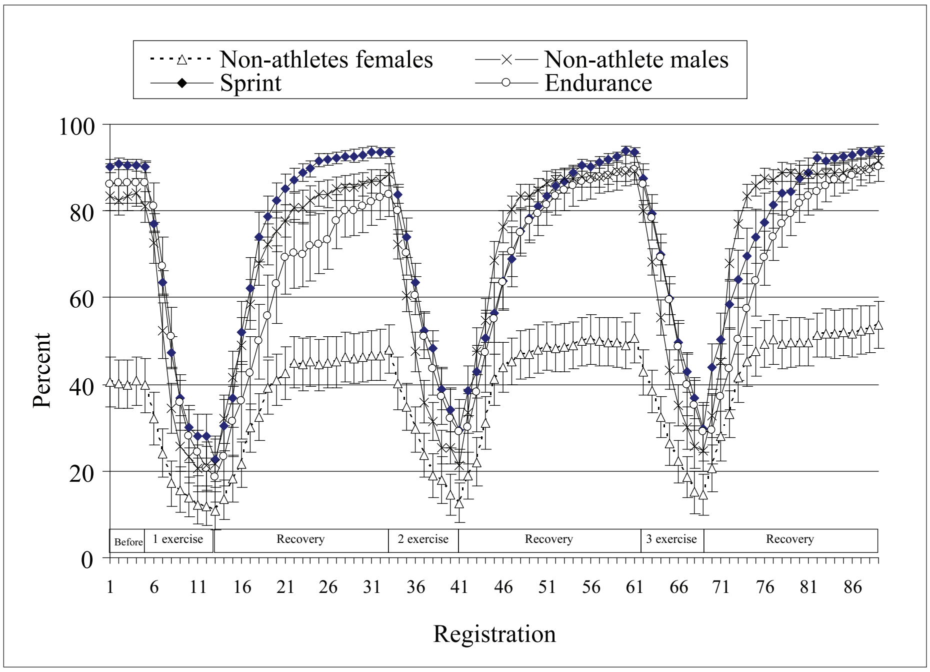
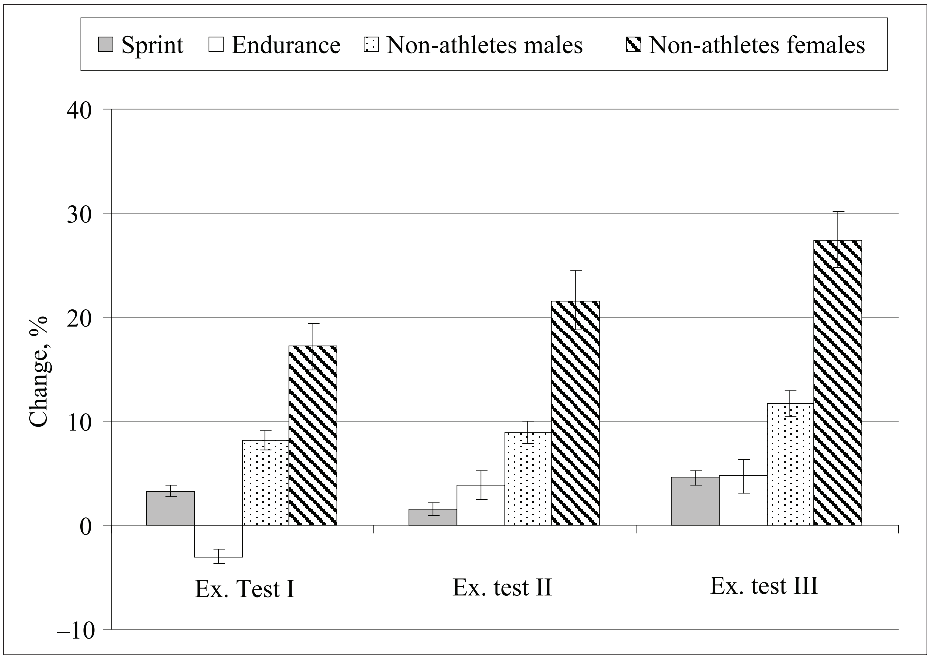


Figure 5. **Increase in StO_2 after 2minutes of recovery after exercising in four experimental cohorts**



Note. Initial value of StO_2 registered before an experiment is accepted as 100%.

Figure 4 shows the average dynamics of StO_2 during exercising and the recovery in four experimental cohorts. The data obtained during the study showed that non-athlete female cohort was characterized by lower baseline values of StO_2. Figure 5 shows the increase in StO_2 after 2 minutes of recovery after exercising in four experimental cohorts (the initial value of StO_2 registered before an experiment were accepted as 100%). The presented data showed that the effect of summation was observed in all four cohorts. The slowest increase was observed in the endurance cohort; a greater increase was found in the sprint cohort; still greater increase – in non-athlete male cohort and the greatest increase – in non-athlete female cohort.

DISCUSSION

Consideration of the interrelations of the factors affecting cardiovascular changes may lead to a better understanding of the regulation of muscle blood flow and the mechanisms, which may explain the sequence of changes of various cardiovascular indices at onset of exercising. Research literature contains some hypothesis concerning the possible leading triggers of cardiovascular changes at the onset of exercising but most of these possible explanations related to the intracellular signalling from blood vessels (Wernbom et al., 2008).

At the onset of exercise the cardiovascular system adapts with a series of integrated responses to meet the metabolic demands of exercising muscles (Hughson, Tschakovsky, 1999). Regulatory mechanisms of the systemic blood circulation are oriented to sustain a gradient of pressure necessary to insure the needed blood circulation intensity in organs and active muscles. This happens in the combination of the heart work indexes and changes in the total peripheral resistance (Ahlborg et al., 1996; Ursino, Magosso, 2003). Systematic research is needed in order to define the central and local mechanisms underlying cardiovascular responsiveness during exercising. Such information is important for designing future interventions aimed at improving muscle blood supply and functional capacity (Koch et al., 2005). Moreover important question is about the trigger of these changes, i. e. if peripheral or central changes start first.

The results obtained during the analysis of ECG indices showed only the difference between cohorts in the adaptation to exercising, i. e. there was no summation in fatigue in well trained athlete's cohorts, and the fatigue summation effect was evident in both non-athlete cohorts. On the basis of these results and the indices of central reactions of the cardiovascular system we could not came up to the conclusion what was the most important trigger. The results about the peripheral changes are needed, and it is important to find out if the peripheral or the central changes start first.

Post exercise hyperemia reflects the biological cost of performed workload, i. e. the changes in muscular tissue (Osada et al., 2003; Vinet et al., 2011). The results obtained during the study showed the increase in StO_2 at the second minute after testing workloads, i. e. the peripheral changes were observed in all four cohorts. This suggests and supports the notion that peripheral changes start first and they impact the central cardiovascular changes.

The non-athlete female cohort was characterized by lower baseline values of StO_2 which may be explained as an artefact of measurement technique, i. e. reduced by sub-subcutaneous fat layer, which was is a typical difference for this female cohort.

One time performance of the physical load may not reveal central and peripheral synergic peculiarities as adaptation to physical loads is cumulative. For non-athletes the performance of repetitive Roufier tests every two minutes produced the fatigue summation effects, which were typical of central and peripheral indices; for well-trained athletes we observed stability of central reaction and fatigue summation effects in peripheral responses.

CONCLUSIONS AND PERSPECTIVES

A lot of cardiovascular indices may indicate the summation effects of fatigue while repeatedly performing a Roufier Test with two minutes of rest between exercising. The peripheral changes start first and they impact the central cardiovascular changes.

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PERIFERINĖS BEI CENTRINĖS ŠIRDIES IR KRAUJAGYSLIŲ SISTEMOS FUNKCINIŲ RODIKLIŲ KAITA ATLIEKANT KARTOTINIUS DOZUOTO FIZINIO KRŪVIO MĖGINIUS

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SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Atliekant įvairius fizinius krūvius, nevienodai aktyvuojamos organizmo fiziologinės sistemos ir mechanizmai, todėl tokios studijos gali atskleisti sinerginę centrinių ir periferinių mechanizmų sąveiką.

Tikslas: nustatyti ir palyginti centrinės bei periferinės širdies ir kraujagyslių sistemos funkcinių rodiklių kaitos ypatybes atliekant kartotinius dozuoto fizinio krūvio mėginius.

Metodika. Buvo tiriamos keturios grupės (po 15 tiriamųjų kiekvienoje) nesportuojančių merginų, nesportuojančių vaikinų ir dvi didelio meistriškumo sportininkų (sprinto ir ištvermės). Tiriamieji atliko tris dozuoto fizinio krūvio mėginius (Rufjė testą, t. y. 30 pritūpimų per 45 s, darant dviejų minučių poilsio pertrauką tarp krūvių). Dvylika standartinių derivacijų buvo nenutrūkstamai registruojama elektrokardiograma (EKG) įvertinant ŠSD ir EKG JT intervalo pokyčius. Deguonies įsotinimo šlaunies raumenyje kaita registruota neinvazinės artimosios spektroskopijos metodu.

Rezultatai. Atliekant vienkartinį dozuotą fizinį krūvį, daugelis sinerginių centrinių ir periferinių ŠKS ypatybių gali neišryškėti, nes individualūs ir adaptacijos prie fizinių krūvių rodikliai sumuojasi. Kas dvi minutes atliekant kartotinius Rufjė fizinio krūvio mėginius, psireiškia nesportuojančių asmenų nuovargio sumavimosi efektai; vidutinio meistriškumo sportininkų – centrinių ŠKS funkcinių rodiklių reakcija į pirmą pratimo kartojimą; didelio meistriškumo sportininkų – funkcinių rodiklių atkartotinumas (reakcijų stabilumas).

Aptarimas ir išvados. Kas dvi minutes atliekant kartotinius Rufjė fizinio krūvio mėginius, daugumos ŠKS funkcinių rodiklių kaita rodo suminį fizinio krūvio efektą. Periferinių funkcijų pokyčiai pasireiškia pirmiau ir veikia kitus centrinės ŠKS funkcinius rodiklius.

Raktažodžiai: elektrokardiograma, dozuoto krūvio mėginiai, deguonies pasisavinimas.

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