

THE RESIDUAL EFFECT OF PRIOR DROP JUMPS ON CARDIO RESPIRATORY PARAMETERS DURING MODERATE CYCLING IN YOUNG WOMEN

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ABSTRACT

Research background and hypothesis. Unaccustomed prior drop jumps (PDJ) can cause muscle damage with concomitant delayed onset muscle soreness (DOMS) and decreased concentric contraction performance efficiency, but the residual effect of PDJ on cardio respiratory system parameters during moderate cycling exercise (MC) remains equivocal. We suppose that DOMS, induced of PDJ, has altered cardio respiratory system parameters during MC exercises.

Research aim of the study was to assess the residual effect of 100 prior drop jumps on cardio respiratory system parameters kinetics during moderate cycling exercise.

Research methods. On four different days 10 women performed one increasing and three (control, 45 min and 24 h after 100 drop jumps) MC (Ergoline-800, Germany) exercises. The cadence of cycling was 70 rpm. The oxygen uptake ($\dot{V}O_2$), carbon dioxide output ($\dot{V}CO_2$); minute ventilation (V_E) and heart rate (HR) were continuously recorded during MC. Subjects rated their perceived exertions at the end of MC, and the DOMS was rated 24 h after PDJ.

Research results. After 24 h the subjects felt moderate DOMS (5.0 (2.79)) according to 10 point scale. The $\dot{V}O_2$; $\dot{V}CO_2$ and HR kinetics were unaltered by moderate DOMS after 45 minutes and 24 hours, but V_E tended to increase 45 minutes after PDJ. The negative correlation between DOMS and $\dot{V}O_2$ ($r = -0.52$) was observed.

Discussion and conclusion. Prior drop jumps seem not to have significant residual effect on cardio respiratory parameters kinetics after 45 minutes or 24 hours, but they tend to increase V_E after 45 minutes of recovery during moderate cycling exercise in young women.

Keywords: delayed onset muscle soreness, oxygen uptake, constant load.

INTRODUCTION

Unaccustomed eccentric exercise, which involves active lengthening of muscle, induce delayed muscle soreness (DOMS) with concomitant damage and disarrangement of muscle fibers (Hortobagy et al., 1998; Stupka et al., 2000; Laanksonen et al., 2006; Malm, Yu, 2012), elevates creatine kinase activity (Gleeson et al., 1995; Stupka et al., 2000; Skurvydas et al., 2010; Chen et al., 2011) and reduces muscle force production and performance (Laanksonen et al., 2006; Semmler et al., 2007; Chen et al., 2010; Gorianovas et al., 2010; Skurvydas et al., 2010).

Residual effect of prior drop jumps (PDJ) as a form of eccentric – concentric exercise on cardio respiratory system parameters during constant cycling remains equivocal. No residual effect of PDJ has been observed on $\dot{V}O_2$, minute ventilation (V_E) and heart rate (HR) during the steady state phase of moderate cycling (70 W), but increased $\dot{V}O_2$ and V_E during the steady state phase of heavy cycling one hour after PDJ have been reported in men (Ratkevičius et al., 2006). Moreover, the moderate DOMS induced of bench stepping exercise did not appear to impact $\dot{V}O_2$ during

heavy cycling 48 and 72 h after eccentric exercise in women (Schneider et al., 2007) or eccentric squatting exercises in men (Gleeson et al., 1995; Moysi et al., 2005; Twist, Eston, 2009). Contrary, significant increases in $\dot{V}O_2$ during steady state of moderate intensity running performed one hour after prior drop jumps with straight legs have been found in women (Zaičėnkovienė, Stasiulis, 2010) as well as increased V_E during moderate and severe cycling performed 48 hours after comprising squats in men (Davies et al., 2009). Nevertheless, we could not find data about the residual effect of prior eccentric-concentric exercises on cardio respiratory parameters within 24 hours of recovery during moderate intensity cycling exercise (MC) in women.

The aim of the study was to assess the residual effect of 100 prior drop jumps PDJ on oxygen uptake ($\dot{V}O_2$), carbon dioxide output ($\dot{V}CO_2$); minute ventilation (V_E) and heart rate (HR) during moderate cycling exercise MC in young women.

RESEARCH METHODS

Participants. Ten healthy young women (anthropometry and physical characteristics are presented in Table 1) volunteered to participate in this study after giving written informed consent. The subjects were physically active but did not take part in any formal physical exercise or sport program. The experimental protocol was approved by the Lithuanian Ethical Committee of Kaunas University of Medicine and conducted in accordance with the Declaration of Helsinki.

Ergometer cycling and data collection. The electronically braked cycle ergometer “Ergometrics–800S” (*Ergo Line, Medical Measurement Systems; Binz, Germany*) was used. The pedal cadence was 70 repetitions per minute. Subjects breathed through low resistance mouthpiece and pulmonary gas exchange parameters ($\dot{V}O_2$; $\dot{V}CO_2$; V_E) were measured breath-by-breath using wireless portable spirometry system “Oxycon mobile” (*Viasys Healthcare; California, USA*). Subjects’ HR was recorded simultaneously by HR monitor (S810

Polar, Finland). The seat and handlebar positions on the cycle ergometer were adjusted for each subject prior to initial exercise test and maintained in that position for the subsequent exercise tests.

Incremental cycling exercise. The first and the second ventilation thresholds (VT_1 and VT_2 , respectively) and peak oxygen uptake ($\dot{V}O_{2peak}$) were evaluated using an incremental cycling exercise (ICE) test (two watts (W) every five seconds). The test was started by three min of baseline pedalling at 20 W and continued until the intensity of cycling could not be maintained at the required level for longer than 10 s. The average value of $\dot{V}O_2$ over the last 30 s of cycling was referred to as $\dot{V}O_{2peak}$ and the VT_1 and VT_2 were determined from the result of the ICE.

Moderate cycling exercise. The intensity of MC test was 80% of VT_1 . The MC was preceded by three min of baseline pedalling at 20 W, then six min MC and three min baseline (20 W) were performed.

Cardiorespiratory system parameters kinetics analysis. Cardio respiratory system parameters ($\dot{V}O_2$; $\dot{V}CO_2$; V_E ; HR) kinetics during MC were determined using a mono – exponential model with independent time delays. The following equation was used to model mono – exponential response kinetics:

$$y(t) = y(b) + A(1 - e^{-t/\tau}),$$

where $y(t)$ represents the variable of $\dot{V}O_2$; $\dot{V}CO_2$; V_E and HR at any time (t); $y(b)$ is the baseline (average value of last 30 s during cycling at 20W) of $\dot{V}O_2$; $\dot{V}CO_2$; V_E and HR ; A is the phase II component amplitude of y response, and $(1 - e^{-t/\tau})$ is the exponential function describing the rate at which y is rising towards the phase II component amplitude. In the exponential function, t is time; τ is the phase II component time constant. $\dot{V}O_2$; $\dot{V}CO_2$ and V_E data were fit from the phase II response (phase I – “cardiodynamic” increase were removed) to the end of MC, (Rossiter et al., 1999). HR data were modeled mono – exponentially from the onset to the end of MC.

Table 1. Subject’s descriptive characteristics. Values are means (SD)

Subjects (n = 10)	Age, yrs	Weight, kg	Height, m	Free fat mass, kg	Maximal power, W	VO_{2peak} , ml/kg/min
Mean (SD)	21.7 (1.9)	61.1 (4.6)	1.71 (0.06)	45.1 (2.3)	199 (21)	35.03 (3.84)

Note. VO_{2peak} – relative peak oxygen uptake.

Prior drop jumps. Subjects performed 100 drop jumps from a 0.47 m stage with 20 s of recovery between every drop jump. After drop the subject got to amortization phase while the knee joints were flexed at the angle of 90° when a vertical jump (hands on hips) was performed.

Blood lactate concentration. Blood sample (25 µl) for the measurement of blood lactate concentration ([La]) (Accutrend Portable Lactate Analyzer, Roche, Germany) was taken from fingertips.

Muscle soreness and perceived exertion rating. DOMS was reported subjectively performing one squat using a visual scale of 0–10 points in which 0 represented no pain and 10 represented intolerably intense pain.

The subject was asked to rate their perceived exertion (RPE) using the Borg scale, ranging from 6 to 20 (7 – very, very light; 19 – very, very heavy).

Experimental protocol. Subjects reported to the laboratory on four separated days within a two-three week period. Exercise testing was performed at approximately the same time of day for each subject. The first session was used to familiarize subjects with the testing equipment and procedures. In the same session, each subject performed an ICE test (after five min warm up and five min rest). Subsequently, subjects performed control (CON) MC in the second session (no sooner than after 48 hours of rest after ICE). On the third occasion subject performed PDJ and after 45 minutes (45'PDJ) they performed the same MC. On the fourth occasion subject performed MC 24 hours after PDJ (24h PDJ). The DOMS was rated 24 h after PDJ. The [La] was taken and each subject was asked to rate her perceived exertion at the end of MC tests.

Statistical analysis. $\dot{V}O_2$ and V_E were analyzed using two-way repeated measures ANOVA design evaluating time and testing conditions (CON; 45'PDJ; 24h PDJ) as the main effects. $\dot{V}O_2$; $\dot{V}CO_2$; V_E and HR parameters kinetics was analyzed using paired one – way ANOVA (CON; 45'PDJ; 24h PDJ). Significant results were further analyzed using Bonferroni corrections. Statistical significance was accepted when $p < 0.05$. All data are reported as the means (SE).

RESEARCH RESULTS

The power output of MC was 82 (16) W, which corresponds to 40.7 (5.1) percent of maximal power of ICE. There were no significant differences in perceived exertion rating during MC under 45'PDJ (11.7 (1.4) and 24 h PDJ (11.4 (1.1)) compared with CON – (11.7 (1.5)).

The absolute $\dot{V}O_2$ (Figure 1) unaltered during MC under different testing conditions (CON; 45'PDJ; 24h PDJ). The V_E (Figure 2) increased during 45'PDJ compared with CON, but the elevation was not statistically significant ($p = 0.51$).

Table 2 shows mean values of base line (b), fast components A and τ of $\dot{V}O_2$, $\dot{V}CO_2$, V_E and HR respectively, during MC, but there were no significant differences under different testing conditions (CON; 45'PDJ; 24h PDJ). The [La] did not differ 45'PDJ (3.43 (0.98) mmol/L) and 24h PDJ (3.67 (0.98) mmol/L) compared with CON (3.47 (0.69) mmol/L) at the end of MC. Negative moderate, but not statistically significant ($p = 0.13$) relationships between $\dot{V}O_2$ during 45' PDJ and DOMS (Figure 3) and $\dot{V}O_2$ during 24h PDJ and DOMS (Figure 4) were observed. The mean value of DOMS was 4.8 (2.5) points on a 10 point scale.

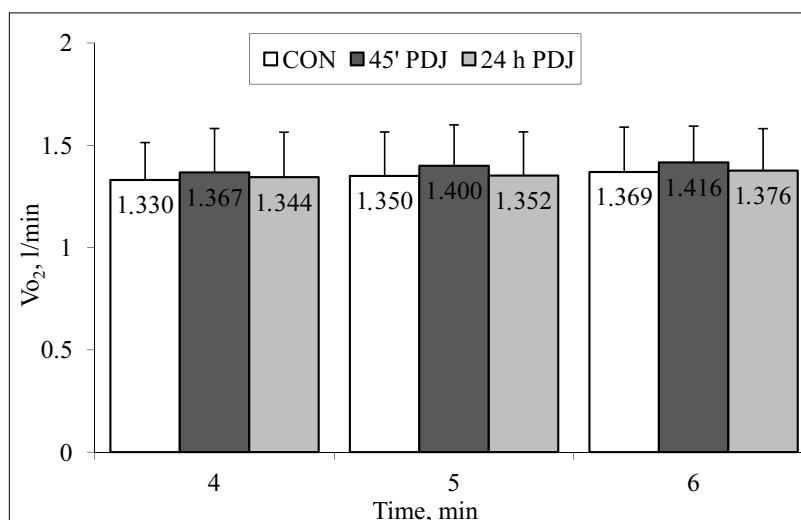


Figure 1. Group mean response of oxygen uptake ($\dot{V}O_2$) during moderate cycling exercise steady state (4 – 6 minutes) under control condition (CON); 45 minutes (45'PDJ) and 24 hours after prior drop jumps (24h PDJ)

Table 2. Cardiorespiratory parameter responses to moderate intensity cycling exercise under control 45 min and 24 hours after prior drop jumps

Parameters	Control conditions	45 min after prior drop jumps	24 h after prior drop jumps
$\dot{V}O_2$ baseline, $l \cdot min^{-1}$	0.700 (0.071)	0.692 (0.041)	0.714 (0.061)
A $\dot{V}O_2$, $l \cdot min^{-1}$	0.630 (0.170)	0.700 (0.170)	0.640 (0.184)
$\tau_1 \dot{V}O_2$, s	32.65 (8.33)	32.85 (9.73)	29.22 (8.75)
$\dot{V}CO_2$ baseline, $l \cdot min^{-1}$	0.550 (0.064)	0.554 (0.056)	0.563 (0.069)
A $\dot{V}CO_2$, $l \cdot min^{-1}$	0.74 (0.17)	0.80 (0.18)	0.76 (0.19)
$\tau \dot{V}CO_2$, s	58.25 (10.41)	53.8 (23.00)	56.9 (21.18)
V_E baseline, $l \cdot min^{-1}$	18.82 (2.64)	19.03 (2.77)	19.01 (2.73)
A V_E , $l \cdot min^{-1}$	19.74 (4.68)	21.96 (4.46)	19.82 (5.38)
τV_E , s	77.34 (18.18)	68.62 (19.45)	76.04 (34.59)
HR baseline, $l \cdot min^{-1}$	103.4 (13.0)	104.0 (10.1)	98.7 (8.3)
A HR, $l \cdot min^{-1}$	40.4 (4.7)	43.7 (5.0)	39.7 (5.3)
τHR , s	61.52 (12.12)	57.59 (15.11)	55.65 (12.51)

Note. Values are means (SD). $\dot{V}O_2$ – oxygen uptake; $\dot{V}CO_2$ – carbon dioxide output; V_E – pulmonary ventilation; HR – heart rate; A – fast component amplitude; τ – fast component time constant.

Figure 2. Group mean response of pulmonary ventilation (V_E) during moderate cycling exercise steady state (4–6 minutes) under control condition (CON); 45 minutes (45'PDJ) and 24 hours after prior drop jumps (24h PDJ)

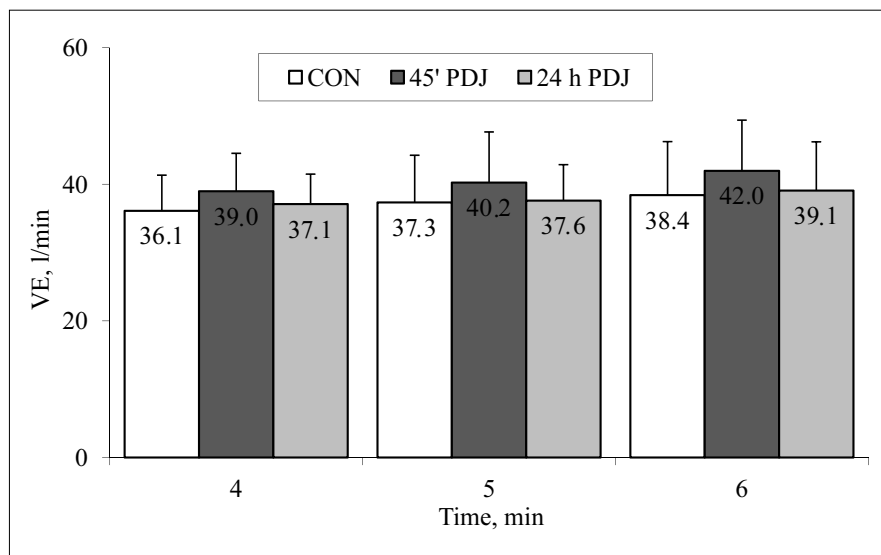
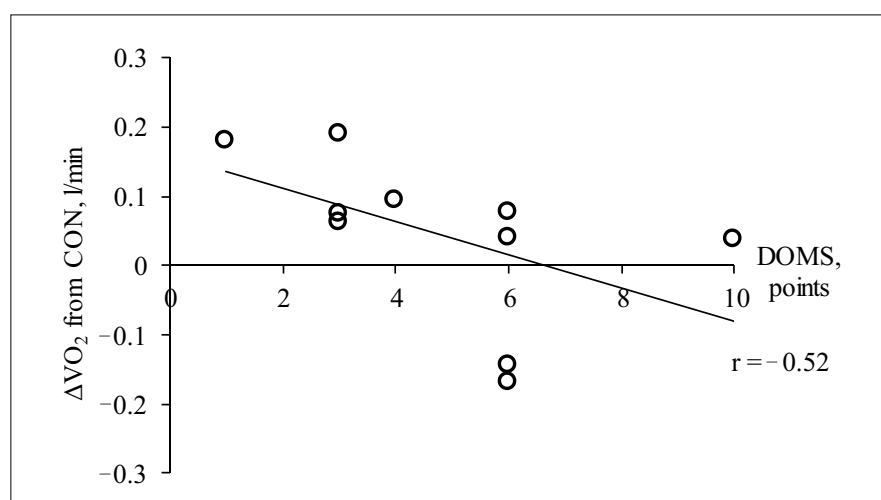


Figure 3. The correlation between changes (from control moderate cycling conditions (CON)) on oxygen uptake (ΔVO_2) during moderate cycling 45 minutes after prior drop jumps and delayed onset muscle soreness (DOMS) 24 hours after prior drop jumps



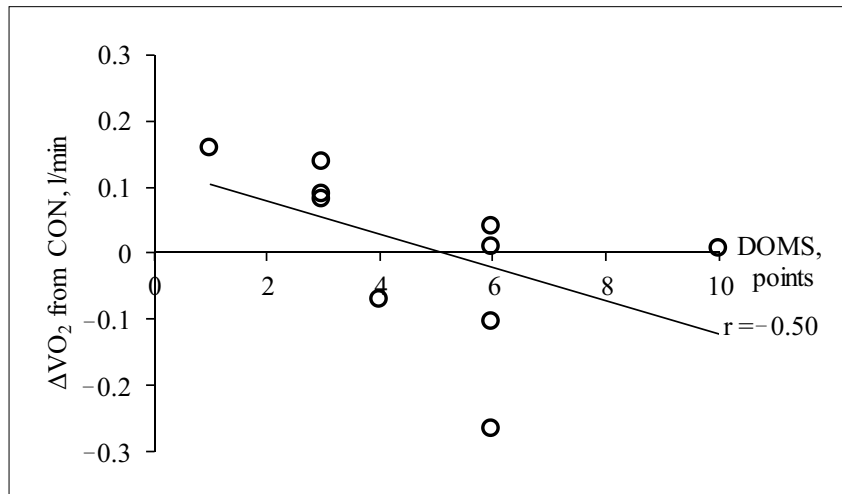


Figure 4. The correlation between changes (from control moderate cycling conditions (CON)) on oxygen uptake ($\Delta\dot{V}O_2$) during moderate cycling 24 hours after prior drop jumps and delayed onset muscle soreness (DOMS) 24 hours after prior drop jumps

DISCUSSION

This is the first study examining cardiorespiratory parameters response to PDJ 45 minutes and 24 hours after PDJ during MC in young women. The main finding of this study is that PDJ does not change the steady state of $\dot{V}O_2$ and cardiorespiratory parameters phase II kinetics, but has a tendency to elevate V_E during moderate cycling 45 minutes after PDJ.

As expected, moderate DOMS was induced in thighs muscles after 24 hours in the present study. Drop jumps from a 0.4–0.5 m high platform (Nielsen et al., 2005; Ratkevicius et al., 2006; Skurvydas et al., 2007; Gorianovas et al., 2010) either bench stepping exercise (Gleeson et al., 1995; Schneider et al., 2007) or squats with a load corresponding 70–150 percents of body mass (Moysi et al., 2005; Davies et al., 2009) are commonly used to induce DOMS, which is first felt 6–10 hours post exercise and peaks between 24 and 78 hours post exercise. Unfortunately, changes in force generating capacity of thigh muscles and CK activity in blood were not measured in our study, but our experiment was performed like in the previous study and represented maximal voluntary contraction (MVC) decrease by ~20% as measured one hour post-exercise (Skurvydas et al., 2000) and still shows deficit within 72 hours and CK activity increase within 24–48 hours of recovery (Nielsen et al., 2005; Skurvydas et al., 2007; Gorianovas et al., 2010). Thus, it is reasonable to assume that muscle damage was induced in the present study.

Previously study results showed no residual effect of on $\dot{V}O_2$ during heavy (Gleeson et al., 1995; Moysi et al., 2005; Schneider et al., 2007) and

moderate (Davies et al., 2009) cycling performed 24–72 hours after eccentric exercise in men or women. However, in contrast, increased $\dot{V}O_2$ has been reported during steady state phase at three different cycling intensities (~40; 50 and 65% of $\dot{V}O_{2peak}$) in men (Ratkevicius et al., 2006) and during moderate running in women one hour after eccentric exercise (Zaičenkoviėnė, Stasiulis, 2010). Sustaining these findings, it is possible to suppose that prior eccentric exercises elevate $\dot{V}O_2$ of steady state phase during constant cycling and running one hour after DOMS inducing exercise, but in the present study unaltered absolute $\dot{V}O_2$ of steady state phase during MC performed 45 minutes after PDJ is in contrast with this assumption. However, unaltered $\dot{V}O_2$ during MC performed 24 h after PDJ concurs with previous studies, demonstrating no residual effect on $\dot{V}O_2$ during constant cycling within 24–72 hours post eccentric exercises (Gleeson et al., 1995; Moysi et al., 2005; Schneider et al., 2007; Davies et al., 2009). Moreover, in the present study, negative insignificant correlation which has been observed between DOMS and $\dot{V}O_2$ (see Figures 3 and 4) did not confirm DOMS negative impact on $\dot{V}O_2$. Hence we may infer that eccentric exercise has slight residual effect within the first hour of recovery, with no alteration on $\dot{V}O_2$ 24–72 during constant cycling. However, elevated V_E and [La] and HR have been previously observed (Gleeson et al., 1995; Schneider et al., 2007; Davies et al., 2009) with increases in ratings of perceived exertion during constant exercise (Gleeson et al., 1995; Zaičenkoviėnė, Stasiulis, 2010) 1–48 hours after eccentric exercise. In the present study, V_E tended to increase after 45 minutes, but [La] and RPE were unaltered after PDJ 45 minutes and 24

hours of recovery. Increases in V_E observed whilst exercising with DOMS have been associated with the additional recruitment of type II fibers and a concomitant rise in the rate of glycogenolysis (Chein et al., 2007) and in turn increased RPE (Davies et al., 2009). Contrary, increases in RPE with no alteration in V_E have been found (Zaičėnkoviėnė, Stasiulis, 2010) during moderate running, conversely, elevated V_E with no changes in a sense of effort have been observed during moderate exercise one hour after PDJ in the present study. The concert between V_E , [La] and RPE are still contradictory. Despite the unclear reason of elevation in V_E , it is one of the most sensitive cardiorespiratory parameters which could be altered by eccentric exercise.

CONCLUSIONS AND PERSPECTIVES

In conclusion, prior drop jumps have induced delayed onset muscle soreness after 24 hours of recovery. The delayed onset muscle soreness does not change during the steady state of oxygen uptake, carbon dioxide output and heart rate phase II kinetics both after 45 minutes and 24 hours after prior drop jumps, but it tends to elevate ventilation 45 minutes after prior drop jumps during moderate cycling exercise. The delayed onset muscle soreness does not alter blood lactate concentration and perceived exertion ratings during moderate cycling exercise in young women.

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ŠUOLIŲ PRIEŠKRŪVIO POVEIKIS MERGINŲ KVĖPAVIMO BEI ŠIRDIES IR KRAUJAGYSLIŲ SISTEMŲ RODIKLIŲ KAITAI ATLIEKANT VIDUTINIO INTENSYVUMO KRŪVĮ VELOERGOMETRU

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SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Neįprasti nušokimai vertikaliu šuoliu (NVŠ) sukelia raumenų pažeidimą, lydima vėluojančio raumenų skausmo ir sumažėjusio koncentrinė susitraukimų atlikimo veiksmingumu, tačiau nėra aišku, koks NVŠ liekamasis poveikis širdies ir kraujagyslių bei kvėpavimo sistemų rodikliams, jų kaitai atliekant vidutinį krūvį veloergometru (VK). Manoma, kad atliekant VK po ekscentrinė pratimų pakis širdies ir kraujagyslių bei kvėpavimo sistemų funkcijų rodikliai.

Tikslas – nustatyti 100 NVŠ poveikį širdies ir kraujagyslių bei kvėpavimo sistemų funkcijų rodiklių kaitai atliekant VK.

Metodai. Skirtingų testavimų metu 10 merginų atliko vieną nuosekliai didinamą krūvį, per kitus tris kartus (kontrolinį, praėjus 45 minutėms ir 24 valandoms po NVŠ) – VK veloergometru („Ergotone-800“, Vokietija). Mynimo dažnumas – 70 k./min. VK metu buvo registruojamas deguonies suvartojimas ($\dot{V}O_2$), anglies dioksido išskyrimas ($\dot{V}CO_2$), minutinė plaučių ventilacija (V_E) ir širdies susitraukimų dažnis (ŠSD). VK pabaigoje buvo vertinamos subjektyviai suvokiamos pastangos. Praėjus 24 valandoms po NVŠ, tiriamosios vertino skausmą.

Rezultatai. Tiriamosios jautė vidutinį šlaunies raumenų skausmą praėjus 24 valandoms po NVŠ (5,0 (2,79) balų). Praėjus 45 minutėms ir 24 valandoms po VK, $\dot{V}O_2$, $\dot{V}CO_2$ ir ŠSD nepakito, tačiau V_E po 45 minučių didėjo, bet nereikšmingai. Buvo nustatytas neigiamas koreliacinis ryšys tarp VRS ir $\dot{V}O_2$ ($r = -0.52$).

Aptarimas ir išvados. Apibendrinant galima teigti, kad 100 nušokimų vertikaliu šuoliu, praėjus 45 minutėms 24 valandoms po jų, neturi reikšmingo poveikio moterų kvėpavimo ir širdies bei kraujagyslių sistemų rodiklių kaitai, tačiau turi tendenciją padidinti V_E praėjus 45 minutėms po NVŠ, kai atliekamas vidutinio intensyvumo krūvis veloergometru.

Raktažodžiai: vėluojantis raumenų skausmas, deguonies suvartojimas, pastovus krūvis.

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