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Original Research Article

Gender differences in residual effect of prior drop jumps on oxygen uptake during heavy cycling exercise

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ABSTRACT

Background and objective: Unaccustomed eccentric or eccentric–concentric exercise leaves us stiff and sore the next day and can cause muscle damage. The data about the residual effect of prior eccentric–concentric exercises on oxygen uptake (VO_2) during constant cycling exercise in women or the data about differences of such effect between genders are scarce. Therefore, the aim of this study was to assess differences of the residual effect of PDJ on VO_2 during HCE and indirect muscle damage parameters between women and men.

Materials and methods: The study aimed to assess differences of the residual effect of prior drop jumps (PDJ) on VO_2 during heavy cycling exercise (HCE) and indirect muscle damage parameters between men ($n = 8$) and women ($n = 11$). On four different days participants performed one incremental cycling exercise and three HCE (control [CON], 45 min [45' PDJ] and 24 h [24 h PDJ] after 100 drop jumps). The intensity of HCE was set to work rate corresponding to 50% of the difference between the second and the first ventilatory thresholds which were determined analyzing pulmonary gas exchange parameters during incremental cycling exercise. Capillary blood samples were collected in order to measure blood lactate concentration immediately after HCE and serum creatine kinase (CK) activity 24 h after PDJ. Subjects rated perceived exertion and delayed onset muscle soreness (DOMS) using 20 and 10 point scales, respectively.

Results: VO_2 at 3–6 min of HCE performed 45' after PDJ was significantly increased as compared to CON HCE only in the male group. Both men and women felt moderate muscle pain. CK activity was significantly increased 24 h after PDJ in the male group. Both during HCE 45' PDJ and 24 h PDJ, the significant positive correlation was observed between relative changes of VO_2 during steady state of HCE and CK activity only in the male group.

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Conclusions: Prior eccentric–concentric exercise of thigh muscles (100 drop jumps) accelerates VO_2 kinetics at the start and increases VO_2 during steady state of heavy cycling only in the male group. So, prior exercise of such type has a higher negative impact on cycling economy in men than in women and this might be related to greater muscle damage and fatigue in physically active male persons after plyometric exercise.

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1. Introduction

It is well established that unaccustomed eccentric or eccentric–concentric exercise leaves us stiff and sore the next day and can cause muscle damage. Muscle damage is characterized by delayed onset muscle soreness (DOMS), muscle fiber disarrangement and inflammatory cell infiltration, increased serum creatine kinase (CK) activity, decreased muscle force production, and decreased concentric contraction performance efficiency [1,2]. Repetitive prior drop jumps (PDJ) from 0.4 to 0.5 m height induce long lasting (within 24–48 h of recovery) muscle fatigue with concomitant signs of muscle damage [3].

The data about gender differences in exercise induced muscle damage are contradictory. The CK activity and DOMS rating have been found both similar [4] or higher in women [5] or in men [6] during different periods after eccentric–concentric exercise. The decrease in elbow flexors maximal voluntary force has been similar in women and men after eccentric exercise [7]. In contrast, a larger leg strength decrease has been observed in women at 48 h after stepping exercise [5]. Several studies have not found differences in muscle Ca^{2+} content [5] and Z-disks streaming [8] between women and men after eccentric–concentric exercise. Gender-related differences in muscle injury, oxidative stress, and apoptosis have been demonstrated after eccentric exercise of the knee extensor [9].

Several repeated activities with short time interval in between are sometimes performed in sports competitions and while testing of athletes. It may cause non-metabolic fatigue associated with muscle damage and delayed onset muscle soreness. This may be of particular importance if prior activities are conducted in unaccustomed conditions, e.g., unfamiliar covering of sports facilities. In such cases muscles may work in different regimens as compared to the training process. Prior heavy exercise may alter oxygen uptake (VO_2) kinetics and metabolic costs during subsequent constant exercise [10]. Data about residual effect of prior eccentric–concentric exercise on VO_2 during constant cycling exercise remains equivocal. Increased VO_2 during steady state phase of constant cycling exercise with no significant alteration on VO_2 slow component 1 h after PDJ has been reported [11]. On the contrary, no changes in VO_2 and gross cycling efficiency have been observed 48 and 72 h after prior bench stepping in women [12] or eccentric squatting exercises in men [13]. We could not find data about the residual effect of prior eccentric–concentric exercises on VO_2 during constant cycling exercise in women or data about differences of such effect between genders. The hypothesis of our study was that VO_2 changes after PDJ would

be different between women and men during heavy constant cycling exercise (HCE) 45 min and 24 h after prior PDJ.

The purpose of the present study was to assess differences of the residual effect of PDJ on VO_2 during HCE and indirect muscle damage parameters between women and men.

2. Materials and methods

2.1. Subjects

A total of 11 healthy women and 8 healthy men volunteered to participate in this study after giving written informed consent. The inclusion criteria were as follows: physically active (physical education students), age of 18–25 years, body mass index of >18.5 and <27.5 kg/m^2 , no smoking, and no joint problems or other contraindications to exercise. The exclusion criteria included the following: being an athlete or participation in any formal physical exercise or sport program, chronic diseases, or any contraindications to exercise. The experimental protocol was approved by the Lithuanian Ethical Committee of Kaunas University of Medicine (No. BE-2-68) and conducted in accordance with the Declaration of Helsinki.

2.2. Peak oxygen uptake and ventilatory thresholds

The first and the second ventilatory thresholds (VT_1 and VT_2 , respectively) and peak oxygen uptake ($\text{VO}_{2\text{peak}}$) were evaluated using an incremental cycling exercise test ($2 \text{ W } 5 \text{ s}^{-1}$) on an electronically braked cycle ergometer “Ergometrics-800S” (Ergo Line, Medical Measurement Systems; Binz, Germany) at a pedal cadence of 70 rpm. The test was started with 3 min of baseline pedaling at 20 W and continued until the intensity of cycling could not be maintained at the required level for longer than 10 s. The subjects breathed through low resistance mouthpiece and gas exchange (VO_2 ; pulmonary ventilation V_E ; RER, respiratory exchange ratio) was measured breath-by-breath using wireless portable spirometric system “Oxycon mobile” (Viasys Healthcare; California, USA). Prior to each exercise session, the spirometric system was calibrated. The average value of VO_2 over the last 30 s of cycling was referred to as peak VO_2 and the VT_1 and VT_2 were determined from the result of the incremental cycling exercise. 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. Heart rate (HR) was continuously calculated with a wireless Polar monitoring system (S810 Polar, Finland).

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