THE EFFECTS OF GRADE CHANGE ON THE LACTATE PROFILE DURING SKATE ROLLER-SKIING

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Abstract

The goal of this study was to distinguish the differences between two roller-ski treadmill protocols on lactate profile and oxygen consumption (VO_2). Eleven, collegiate, elite cross-country skiers served as subjects. Subjects completed two skate roller-skiing treadmill protocols. One protocol increased intensity by speed and the other increased in grade. VO_2 was assessed by open-circuit spirometry and blood lactate (LA) values were determined at the end of each stage (3 min. 20s.). Lactate threshold (LT) was determined using computer analysis of the log-log plots of heart rate (HR) and VO_2 vs. LA. The protocols were compared to determine if differences exist in LA, HR, or VO_2. The mean value ±sd for VO_2 at LT during the elevation protocol was 46.3mlkg^{-1}min^{-1} ±2.8mlkg^{-1}min^{-1}. The mean VO_2 at LT during the speed protocol was significantly higher at 49.1mlkg^{-1}min^{-1} ±1.6mlkg^{-1}min^{-1} (p=0.0036). The mean HR at LT during the elevation protocol was 155 beats•min^{-1} ±6.8beats•min^{-1} which was significantly lower than the HR at LT during the speed protocol of 162 beats•min^{-1} ±9.1beats•min^{-1} (p=0.0011). LA values at similar intensities, prior to LT, and the HR/VO_2 relationship were not different between protocols. The results indicate that during graded skate roller-skiing, LA concentration was higher for a given intensity as compared to level skiing.

Introduction

Once the technical skills of cross-country skiing are mastered, physical fitness becomes the limiting factor to race performance. One method of dry-land training involves the use of "sport specific" roller-skis (Figure 1.). Training pace can be controlled by exercising at heart rates above, at, or below lactate threshold, consequently controlling training intensity. Upper body exercise has been shown to produce higher lactate concentrations for a given workload than lower body exercise. Increased upper body activity encountered during inclined ski-skating may increase blood lactate concentrations for a given intensity as compared to skiing on the level. Variations in lactate dynamics with changes in grade will hinder the accurate establishment and implementation of training intensity zones. Quantification of the differences observed between graded and level skiing may help coaches and physiologists understand how workload distributed between the upper and lower body affects metabolic measures.

Figure 1. Skate roller-skis used for dry-land training

Purpose

It was the purpose of this study to provide information regarding differences in the physiological responses to roller-skiing on graded versus level terrain. Specifically, differences in heart rate, VO_2, and blood lactate values were assessed.

Significance

Currently, there is a gap between the knowledge of exercise physiologists and the practical expertise of coaches. Therefore, knowledge gained about the integration of physiological testing and exercise prescription is essential to optimal performance in sport. Little information exists about the relationship between the mode of workload change and the blood lactate/heart rate and blood lactate/VO_2 relationships during skate skiing. Information obtained in a controlled laboratory environment will provide better understanding of the physiological responses encountered during skiing and roller-skiing.

Methods

Participants

Eleven, elite, male, college aged, cross-country skiers served as subjects. All had national or international level race experience.

(n=11)	Mean	SD
Age (years)	20.8	± 1.2
Mass (kg)	71.0	± 5.4
% Fat	6.1	± 1.1
Hours trained week^{-1}	10.7	± 2.9
Avg. VO_2peak (mlkg^{-1}min^{-1})	64.6	± 1.8
Avg. HRpeak (beats•min^{-1})	192.6	± 5.8

Table 1. Subject characteristics

Procedures

Heart rate, VO_2 and blood lactate were measured during two submaximal skate roller-skiing protocols. One protocol increased intensity by grade and the other by speed. A blood sample was collected via finger stick at the end of each stage for lactate determination (3min. 20s.). Peak VO_2, peak HR, and peak lactate were determined using a separate protocol. VO_2 was determined using indirect, open-circuit spirometry, lactate was measured using a *YSI* 2300 lactate analyzer and heart rate was recorded using *Polar* heart rate monitors. Roller-ski ergometry was completed on a 2.4m. X 3.0m. motorized treadmill equipped with a nonslip belt that allowed secure skating and poling (Figure 2.).

Figure 2. Laboratory setup

Statistical Analysis

Significant differences between the two protocols were determined using the students paired t-test with significance set at $p<0.05$. A Bonferroni adjustment was used to modify the α level to account for the increased probability of committing a type I error during multiple test study designs. For the four tests, the adjusted "p" value was $p<0.0125$.

Results

The mean value (±sd) for the HR at LT during the elevation protocol was 154.9 beats•min^{-1} (±6.8 beats•min^{-1}) which was significantly lower than the mean value for HR at LT during the speed protocol (162 beats•min^{-1}, ±9.1 beats•min^{-1}, p=0.0011) (Figure 3.). The mean value for the VO_2 at LT during the elevation protocol was 46.3mlkg^{-1}min^{-1} (±2.8mlkg^{-1}min^{-1}). The mean value for the VO_2 at LT during the speed protocol was significantly higher at 49.1mlkg^{-1}min^{-1} (±1.6mlkg^{-1}min^{-1}, p=0.0036) (Figure 4.).

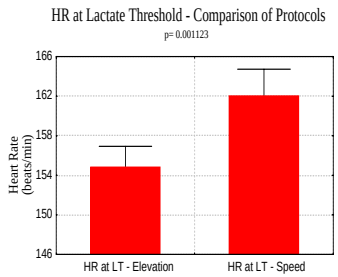

Figure 3.

= mean + SE

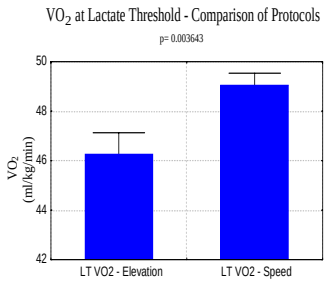

Figure 4.

Discussion

In summary, muscular, nervous, and metabolic differences between the upper and lower-body may account for increased blood lactate concentrations during upper body exercise compared to lower body exercise. Biomechanical research has demonstrated that the role of the upper-body increases with grade during ski-skating. An increase in upper-body utilization during graded skiing may account for the differences seen between protocols. The current study demonstrated a reduction in HR at LT and VO_2 at LT during uphill skiing as compared to level skiing. There were no differences in the HR/VO_2 relationship or pre-threshold lactate values between protocols. Although this investigation demonstrated differences in metabolic variables between level and graded ski-skating, further research is needed to determine the mechanisms responsible for these changes.

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