RELATIONSHIP BETWEEN LABORATORY MEASURES AND 5-KILOMETER SKI SKATING PERFORMANCE

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Abstract

The goal of this study was to determine if laboratory ski performance measures were related to on-snow race performance. Ten, NCAA Division I, collegiate, cross-country skiers served as subjects. Subjects completed a skate roller-skiing treadmill protocol to determine lactate threshold (LT) and VO_2 peak and also completed an arms-only roller-skiing treadmill protocol to determine upper-body VO_2 peak. VO_2 was assessed by open-circuit spirometry and blood lactate values were determined at the end of each stage (3 min. 20s.). Double-pole upper-body power was also determined using an electronically braked power ergometer. Two weeks after testing, subjects participated in an NCAA sanctioned 5-kilometer (5-K) ski-skate race. Multiple regression analysis revealed that ski-skating VO_2 peak, ski-skating time to exhaustion, double-pole time to exhaustion, upper-body VO_2 peak and upper-body power explained 93% of the variance in 5-K ski time (r =0.962, p=0.023). 5-K ski time was most related to double-pole time to exhaustion (r =-0.74, p=0.007) and ski-skating VO_2 peak (r =-0.73, p= 0.008). Heart rate and VO_2 at LT during treadmill skate roller-skiing were not significantly related to ski performance (r =-0.08, p=0.86; r =-0.28, p=0.47 respectively). Upper-body peak power was moderately related to double-pole time to exhaustion and upper-body VO_2 peak (r =0.57, p=0.042; r =0.59, p=0.035 respectively). These data support the validity of the use of ski-specific laboratory tests for training and research purposes.

Introduction

Cross-country ski racing taxes many aspects of human performance, including: strength, power, speed, muscular endurance, coordination, and aerobic capacity. To monitor the effects of training and to track the performance of athletes, periodic laboratory testing of physiological variables is conducted. For a laboratory test to be useful, it must reliable, valid and strongly related to ski racing performance. Laboratory tests have been carefully designed to specifically mimic the on-snow demands of cross-country ski racing or to test the specific physiological constructs associated with peak skiing performance. For laboratory testing to be practical and efficient, the tests that are most related to skiing performance need to be used.

Purpose

The goal of this investigation was to determine which frequently utilized laboratory tests were most related to 5-K ski skating performance.

Methods

Participants

Ten, NCAA div. I, male, college aged, cross-country skiers served as subjects. All had national or international level race experience.

Table 1. Subject characteristics

(n=10)	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_2 peak (ml • kg^{-1} • min^{-1})	64.6	±1.8
Avg. HR peak (beats•min^{-1})	192.6	±5.8

Procedures

Heart rate, VO_2 and blood lactate were measured during a submaximal skate roller-skiing protocol. A blood sample was collected via finger stick at the end of each stage for lactate determination (3min. 20s.). Peak VO_2, peak HR, peak lactate and time to exhaustion were determined using a separate maximal skate roller-skiing 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.

Double-pole upper-body power was determined using an electronically braked power ergometer. An incremental protocol lasting about three minutes was used and power output was expressed in watts•kg^{-1}.

Skiers also completed an arms-only roller-skiing treadmill protocol to determine upper-body VO_2 peak and double-pole time to exhaustion. A constant grade of 7% was utilized with speed increases of 8 m•min^{-1} per stage.

Two weeks after laboratory testing, participants competed in a timed, NCAA sanctioned, 5-K ski skating race.

The heart rate and VO_2 at lactate threshold, peak lactate, peak heart rate, upper body power and VO_2 values as well as endurance time for both roller-skiing protocols, were recorded and analyzed.

Statistical Analysis

Pearson product-moment correlations were used to determine which predictor variables were highly related to 5-kilometer ski time. Significantly ($p<.05$) related variables and those thought important to the model were subjected to multiple regression analysis using the enter and stepwise methods with significance set at $\alpha=0.05$.

Results

Ski-skating VO_2peak, ski-skating time to exhaustion, double-pole time to exhaustion, upper-body VO_2peak and upper-body power explained 93% of the variance in 5-K ski time (r =0.962, p=0.023). Double-pole time to exhaustion (β=.69, r =-0.74, $p<0.05$) and ski-skating VO_2peak (β=.63, r =-0.73, $p<0.05$) were most related to skiing performance. Stepwise regression suggests that double-pole time and ski-skating VO_2peak together were capable of explaining 91% of the variance in ski time (p=.002). Although roller-ski time to exhaustion was significantly correlated with ski performance (r =-0.68, β=-.06), it did not significantly contribute to the explained variance in 5-K time. Heart rate and VO_2 at lactate threshold during treadmill skate roller-skiing were not significantly related to ski performance (r =-0.08, p=0.86; r =-0.28, p=0.47 respectively). Upper-body peak power was moderately related to double-pole time to exhaustion and upper-body VO_2 peak (r =0.57, p=0.042; r =0.59, p=0.035 respectively).

Table 2. Relationships between laboratory tests and 5K ski time

	R	Standardized β (enter method)	Standardized β (stepwise)
Double Pole Time	-0.74*	.69*	.57*
Roller-ski Time	-0.68*	-.06	
Double Pole Peak VO_2	-0.19	-.47	
Roller-ski Peak VO_2	-0.73*	.63*	.56*
Peak Power	-.031	.24	

*significant at the $p<0.05$ level

Discussion

Although the HR and VO_2 at LT have been positively related to performance in other endurance sports, this was not evident in the current study. This may have occurred because skiers race at intensities that are much higher than LT. In an aerobic sport like cross-country skiing, it is not surprising that roller-skiing VO_2peak was significantly related to performance. However, the strong relationship between double-pole time to exhaustion and 5-K ski time is less obvious. To endure the incremental double-pole protocol, skiers needed to possess superb muscular endurance, upper-body power, and an upper-body aerobic capacity sufficient to reach high work loads. Peak power was not significantly related to ski time but did show a strong positive relationship to upper-body VO_2 peak and to double-pole time to exhaustion. These data suggest that laboratory protocols measuring roller-ski VO_2peak, double-pole time to exhaustion, and possibly upper-body power should be used to: monitor the effects of training, track the performance of athletes, and to predict ski skating performance.

References

1. Mygind, E., L.B. Andersen, and B. Rasmussen. Blood lactate and respiratory variables in elite cross-country skiing at racing speeds. *Scandinavian Journal of Medicine and Science in Sport.* 4:243-251, 1994.

2. Rundell, K.W. Treadmill roller-ski test predicts biathlon roller-ski race results of elite U.S. biathlon women. *Medicine and Science in Sports and Exercise.* 27:1677-1685, 1995.