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ENERGETICS AND METABOLIC ECONOMY OF CROSS COUNTRY SKIING

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INTRODUCTION

Cross-country skiers performing the two-skate technique move their skis in a skating motion while simultaneously poling on every second footfall. Most skiers prefer to pole on either the left or right ski while synchronising their breathing to the movement of their poles. A 1:1 locomotion-respiration coupling has been observed when quadruped animals gallop: when the forelimbs flex, the animal exhales, and when the forelimbs extend, the animal inhales [1]. A coupling of breathing and poling action is also observed in cross-country skiers, however the effect of this coupling on metabolic efficiency is unknown [2]. The purpose of this study was to evaluate the effect of reverse breathing and reverse poling on efficiency. We hypothesized that skiers would be less metabolically efficient when poling on their non-preferred side and when breathing in a reversed pattern.

METHODS

Nine skiers (8 males, 1 female) roller skied at a constant sub-threshold speed for four conditions each lasting four minutes. Metabolic efficiency was determined using rate of oxygen uptake ($\dot{V}O_2$), where a higher $\dot{V}O_2$ indicates higher energy consumption and thus lower efficiency. Force data were collected via strain gauges in the poles and roller skis (128Hz). Conditions one and four, which acted as the controls, consisted of the athlete breathing normally and poling on their preferred side. In the second condition, the athletes poled on their non-preferred side while maintaining normal breathing patterns. For the third condition, the athletes returned to poling on their preferred side while they reversed their breathing. Within subject comparisons between trials were conducted via repeated measure ANOVAs.

RESULTS

$\dot{V}O_2$ increased significantly when skiers switched from the first control to the reverse poling (p=0.075) and reverse breathing conditions (p=0.073) (Figure 1). $\dot{V}O_2$ decreased significantly when the skiers returned from reversed breathing to the second control (p=0.079) (Figure 1).

There were no differences in impulse, mean cycle time, mean contact time, or mean limb recovery time for conditions two or three compared to the controls.

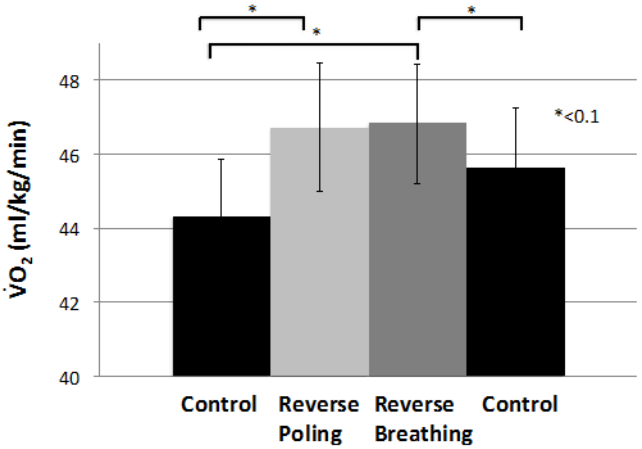

Figure 1. Rate of oxygen consumption for all conditions. Values expressed as means ± 1SE (n=9).

DISCUSSION AND CONCLUSIONS

The increase in $\dot{V}O_2$ for reverse poling and reverse breathing indicates that these two conditions are less metabolically efficient than the control conditions. Previous work on respiration-locomotion coupling revealed changes in abdominal pressure resulting from movement [3]. This mechanical alteration of intra-abdominal pressure drives breathing, which allows active respiratory muscles to perform less metabolic work [1]. Reversal of this phenomenon may explain the drop in efficiency observed with reverse breathing.

Force data from the reverse poling technique revealed no changes in gait mechanics. It is possible that despite symmetrical forces, there may have been subtle differences not identified in this study. Future research should examine gait changes for the reverse poling technique.

REFERENCES

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