

## An Investigation of Metabolic and Cardiovascular Responses of Walking With and Without a Shoe-Lift on the Contralateral Foot of an Immobilized Extended Knee.

Tommy Boone., Director, Exercise Physiology Laboratories, Department of Exercise Physiology, The College of St. Scholastica, Duluth, MN 55811

**Purpose:** The use of a shoe-lift added to the contralateral foot of an immobilized extended knee is purported to improve walking efficiency (1). The intent of this study was to determine the metabolic cost and cardiovascular responses of the use of a shoe-lift in subjects who unilaterally could not flex their knees. **Methods:** Eight male subjects (mean age, height, and weight are  $23 \pm 4$  yr,  $162 \pm 8$  cm, and  $84 \pm 6$  kg, respectively) participated in two exercise sessions, the order of which was randomized for each subject. In one walking session, the subjects walked wearing an external knee immobilizer applied unilaterally to keep the right knee in full extension throughout the gait cycle. In another walking session, subjects wore a one-inch shoe-lift added to the contralateral foot of an immobilized extended knee. Subjects walked on a treadmill at 3.5 mph at 0% grade for 10 minutes during both walking sessions. During each session, subjects were connected to a Medical Graphics metabolic analyzer that measured steady-state oxygen consumption ( $\text{VO}_2$ ) and related respiratory measures during minutes 5 through 9. Heart rate (HR) was monitored during the last 10 seconds of each minute, then averaged across minutes 5 through 9. Cardiac output (Q) was determined during minute 10 of both walking sessions using the  $\text{CO}_2$  rebreathing technique (2). **Statistics:** Metabolic and cardiovascular data were compared by separate one-way repeated measures ANOVA ( $p < 0.05$ ). **Results:** The shoe-lift had no significant ( $p > 0.05$ ) effect on  $\text{O}_2$  rate ( $\text{VO}_2$ , L/min) or  $\text{O}_2$  cost (mL/kg/m). There were no significant differences in carbon dioxide production ( $\text{VCO}_2$ ), respiratory exchange ratio (RER), expired ventilation ( $\text{Ve}$ ), and frequency of breaths (Fb). Similarly, there were no significant differences in the subjects' cardiovascular responses: HR, stroke volume (SV), Q, arteriovenous oxygen difference ( $\text{a-vO}_2$  diff), and systemic vascular resistance (SVR). The mean values  $\pm$  SD for  $\text{O}_2$  rate,  $\text{O}_2$  cost, HR, SV, Q,  $\text{a-vO}_2$  diff, and SVR are presented in Table 1.

Variable	With Shoe-Lift	Without Shoe-Lift	F-ratio & Prob
<b><math>\text{O}_2</math> Rate</b> (L/min)	$1.24 \pm .12$	$1.19 \pm .17$	1.54 & .25
<b><math>\text{O}_2</math> Cost</b> (mL/kg/m)	$.159 \pm .018$	$.151 \pm .012$	2.81 & .14
<b>HR</b> (bpm)	$94 \pm 9$	$98 \pm 12$	1.67 & .24
<b>SV</b> (ml/b)	$136 \pm 8$	$138 \pm 9$	0.89 & .42
<b>Q</b> (L/min)	$11.86 \pm .8$	$12.34 \pm .9$	5.85 & .09
<b><math>\text{a-vO}_2</math> diff</b> (mL/100 mL)	$10.3 \pm 2$	$9.65 \pm .4$	0.25 & .65
<b>SVR</b> (mmHg/L/min)	$8.7 \pm .8$	$8.5 \pm 1$	0.10 & .77

**Discussion:** The results indicate that the shoe-lift added to the contralateral foot of the immobilized extended knee had no effect on  $\text{O}_2$  cost during walking and the .05 L/min difference in  $\text{O}_2$  rate is too small to be clinically significant. Walking efficiency was not improved. Likewise, the non-significant change in  $\text{VO}_2$  [where  $\text{O}_2$  rate is the product of  $\text{O}_2$  transport ( $Q = \text{HR} \times \text{SV}$ ) and  $\text{O}_2$  utilization ( $\text{a-vO}_2$  diff)] is a function of the non-significant changes in the subjects' central (Q) and peripheral ( $\text{a-vO}_2$  diff) adjustments during the walking sessions. The likelihood of benefiting from a shoe-lift is extremely low. This finding appears to disagree with the report by Abdulhadi et al. (1). We conclude that the use of a shoe-lift in subjects who unilaterally cannot flex their knees does not result in improvement in walking efficiency. Further studies are needed to determine whether other subjects or patients with a unilaterally immobilized knee would benefit from a contralateral shoe-lift. **References:** 1. Abdulhadi H. et al. *Arch Phys Med Rehabil.* 77: 670-672, 1996. 2. Heigenhauser G. et al. *Chest.* 10: 255-264, 1989.