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Metabolic Responses to Exercise

PHYSIOLOGICAL RESPONSES TO RECREATIONAL SNOWSHOEING

PATRICK L. SCHNEIDER, JOHN P. PORCARI, JEFF D.A. ERICKSON, CARL FOSTER, GLENN BRICE,  
 ALAN FREEMAN

University of Wisconsin-La Crosse, La Crosse, WI

ABSTRACT

PATRICK L. SCHNEIDER, JOHN P. PORCARI, JEFF D.A. ERICKSON, CARL FOSTER, GLENN BRICE, ALAN Freeman **Physiological Responses To Recreational Snowshoeing**. JEPonline. 2001;4(3):45-52. In recent years, the popularity of snowshoeing has increased due to innovations in snowshoe design; they are smaller, lighter, have maintenance-free aluminum frames, and a more versatile binding system. The purpose of this study was to provide descriptive data relative to exercise intensity when subjects snowshoed at a self-selected pace on both flat and variable terrain. Twenty volunteers (10M and 10F) aged 21-42 years participated in the study. Subjects snowshoed at a self-selected pace for 30 minutes on flat and variable terrain courses, in random order. Individual subjects were tested within a 2-3 day span so that conditions would be similar due to the possible effect that snow conditions and temperature may have had on the results.  $VO_2$  (ml/kg/min), HR (b/min), RPE, and caloric expenditure (Kcals/30 min) were measured during each trial.  $VO_2$  and Kcals were determined using the Aerosport KB1-C portable oxygen analyzer, HR was measured with a Polar HR watch, and RPE was assessed using the Borg (6-20) scale.

<i>Variable</i>	<i>VO<sub>2</sub></i>	<i>HR</i>	<i>RPE</i>	<i>Kcals</i>
<i>Flat</i>				
<i>Males</i>	38.1±5.91	151±7.7	13.6±.51	492± 81.2
<i>Females</i>	37.9±4.45	144±10.8	13.8±1.22	372±75.6
<i>Variable</i>				
<i>Males</i>	41.7±4.89	161±10.7	15.2±1.22	523±54.8
<i>Females</i>	39.5±8.60	161± 9.2	15.0±1.33	387±62.5

It was found that snowshoeing on the flat and variable courses elicited HR values equivalent to 75 and 84% of age-predicted maximal HR, respectively. The average RPE values of 13.7 and 15.1 indicate that the subjects were working "somewhat hard" to "hard" on the two courses, and the caloric expenditure values compare favorably to other common exercise modes. The results of this study indicate that snowshoeing at a self-selected pace

continuously for 30 minutes provides sufficient intensity to increase cardiovascular endurance and positively alter body composition based on current ACSM guidelines.

Key Words: Winter fitness, Recreation, Outdoor activities

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## **INTRODUCTION**

Regular participation in aerobic exercise has been shown to have a positive effect on cardiovascular fitness and health (1). According to the Surgeon General's report (2), the popularity of exercise has increased tremendously in the last decade and approximately 40% of the adults in the United States exercise on a regular basis. While walking and jogging are perhaps the most widely employed modes of aerobic activity, some people do not feel comfortable participating in these forms of exercise during the winter months. Instead, they turn to activities like cross-country skiing and snowshoeing.

In the past decade, participation in snowshoeing has grown dramatically. In 1997, American Sports Data reported that regular snowshoers totaled 1.2 million; a figure which was up over 300% from 1994 (3). Part of the rise in snowshoe popularity can be attributed to technology. Over the past several years, snowshoes have gotten smaller, lighter, and less cumbersome. Maintenance free aluminum frames have replaced the heavier, higher-maintenance wood versions and synthetic materials like ArcTec and Nyltex have replaced the rawhide webbing. In addition, easy to use, pivoting binding systems have made snowshoes more user friendly. Many of the binding systems also feature a steel crampon which enhances stability on variable terrain.

Although the popularity of snowshoeing has increased at a rapid rate, very little research has been conducted to determine its potential physiological benefits. In addition, those studies which have been conducted failed to include or measure important variables which could affect the physiological responses. For example, some studies did not include descriptive characteristics of the snowshoes themselves (4), while others lacked important information about the depth of the snow or the depth of each depression (i.e., floatation) (4,5); each a critical factor which can significantly affect the energy cost of snowshoeing. In order to expand the research done in this area, the purpose of this study was to provide descriptive data relative to exercise intensity when subjects snowshoed at a self-selected pace on flat and variable terrains.

## **METHODS**

Ten men and ten women between the ages of 21 and 42 years were recruited to participate in this study. All subjects were apparently healthy and were required to be at least moderately active "defined as exercising for at least 20-60 minutes per day, three days per week" at the time of the study. All subjects signed a written informed consent document prior to participating in the study.

Prior to testing, each subject was given specific instructions regarding proper snowshoeing technique and was allowed an opportunity to practice for 5 minutes in an area located near the start of the course. Upon demonstrating sufficient skills on snowshoes, each subject was then tested. No specific limitations were placed on subject apparel, however, subjects were encouraged to dress appropriately for the anticipated temperature given that they would be exercising outside for 30 minutes. Snowshoe size was determined based on the anticipated average weight of the males and females involved in the study. Male subjects were tested using the Yukon model snowshoes manufactured by the Tubbs Company, which measure 10" x 36" and weigh 5 lbs per pair, while female subjects used the Tubbs Katahdin model, which measure 8" x 25" and weigh 3.1 lbs per pair. Each subject was tested on two separate courses. One course consisted of relatively flat terrain while the other

course was reasonably hilly. The flat course had a 0% grade while the other course had a variable terrain with an average grade of approximately 18%. Grade estimations were determined using topographical surveying techniques.

Each course was marked in 100 yard increments with both courses spanning a total of 500 yards. Subjects were instructed to travel at a self-selected pace for 30 continuous minutes and to walk next to their previous track to ensure they were consistently walking on fresh snow. Each course was completed on separate days, in random order. Every attempt was made to test individual subjects within a 2-3 day span so that environmental conditions would be similar due to the possible effect that snow conditions and temperature may have had on the results. Prior to each test, air temperature was determined using a hand-held mercury thermometer and wind velocity was measured using a hand-held anemometer.

Throughout the testing, subjects wore an Aerosport KB1-C ambulatory metabolic system, which measured oxygen consumption and caloric expenditure. Oxygen consumption ( $\text{VO}_2$ ) and caloric expenditure (kcal) were recorded every minute. Heart rate was also recorded every minute using a Polar XL heart rate monitor. At the conclusion of each 30 min session, subjects were asked to rate their perceived effort using the Borg 6-20 scale (6).

Snow depth, which was determined by measuring the snowpack base along with any additional accumulation, was determined on the day of the testing. To assess flotation, the depth of depression was measured by placing a straight edge horizontally across the snowshoe impression. Three vertical measurements were taken from each of the medial, lateral, and posterior portions of the impression. These values were averaged to determine the overall depression.

Basic descriptive statistics were used to characterize the subject population and to summarize the physiological responses to the two different courses. Paired t-tests were used to compare the responses between the two courses. The alpha level was set at  $p < 0.05$  to represent statistical significance.

## RESULTS

The descriptive characteristics of the 20 subjects who participated in the study are presented in Table 1. The average temperature throughout the testing was  $-3^\circ$  (C) and ranged from  $-12.2^\circ$  to  $1^\circ$  (C). The average wind velocity was 7.8 mph and ranged from 6 to 11 mph, while the average snow depth consisted of a 14 cm snow base under 13.5 cm of new accumulation. Throughout the testing, the medial, lateral, and posterior depressions of the snowshoes averaged 10.4, 10.8, and 8.4 cm, respectively for the males and 10.9, 11.5, and 8.3 cm, respectively for the females.

The results of the physiological responses to snowshoeing on the flat and variable terrain courses are presented in Table 2. The male and female subjects snowshoed at a significantly faster pace on the flat course versus the variable course (males, 3.3 vs. 2.9 mph; females, 3.2 vs. 2.9 mph); respectively. Overall, subjects snowshoeing on the variable terrain elicited significantly higher heart rates (HR) and ratings of perceived exertion (RPE) compared to the flat course. Oxygen consumption values and caloric expenditure tended to be higher on the variable course, however, this difference was not significant. Males burned significantly more calories than females on both courses and had significantly higher heart rates on the flat course.

Figures 1 and 2 present representative HR and  $\text{VO}_2$  data for a single male subject snowshoeing for 30 minutes

on the flat and variable courses.

**Table 1. Descriptive physical characteristics of the subjects.**

<i>Variable</i>	<i>Mean±SD</i>	<i>Range</i>
<i>Age (yrs)</i>		
<i>Males</i>	26.9±6.76	21-42
<i>Females</i>	27.3±7.08	21-39
<i>Height (cm)</i>		
<i>Males</i>	178.1±7.72	165.1-190.0
<i>Females</i>	167.1±5.28	158.5-173.0
<i>Weight (kg)</i>		
<i>Males</i>	86.9±7.62	75.8-99.8
<i>Females</i>	65.8±6.63	57.3-77.6

**Table 2. Physiological measurements of the subjects while snowshoeing on the flat and variable terrain courses.**

<i>Category</i>	<i>Flat</i>	<i>Variable</i>
	<i>Mean±SD</i>	<i>Mean±SD</i>
<i>VO<sub>2</sub> (ml/kg/min)</i>		
<i>Males</i>	38.1±5.91	41.7±4.89
<i>Females</i>	37.9±4.45	39.5±8.60
<i>HR (b/min)</i>		
<i>Male</i>	151±7.7	161±10.7 *
<i>Females</i>	144±10.8 #	161±9.2 *
<i>Kcals (30 min)</i>		
<i>Males</i>	492±81.2	523±54.8
<i>Females</i>	372±75.6 #	387±62.5 #
<i>RPE</i>		
<i>Males</i>	13.6±0.51	15.2±1.22 *
<i>Females</i>	13.8±1.22	15.0±1.33 *

\* indicates a significant difference in comparison with the flat course ( $p < 0.05$ )

# indicates a significant difference in comparison with the males ( $p < 0.05$ )

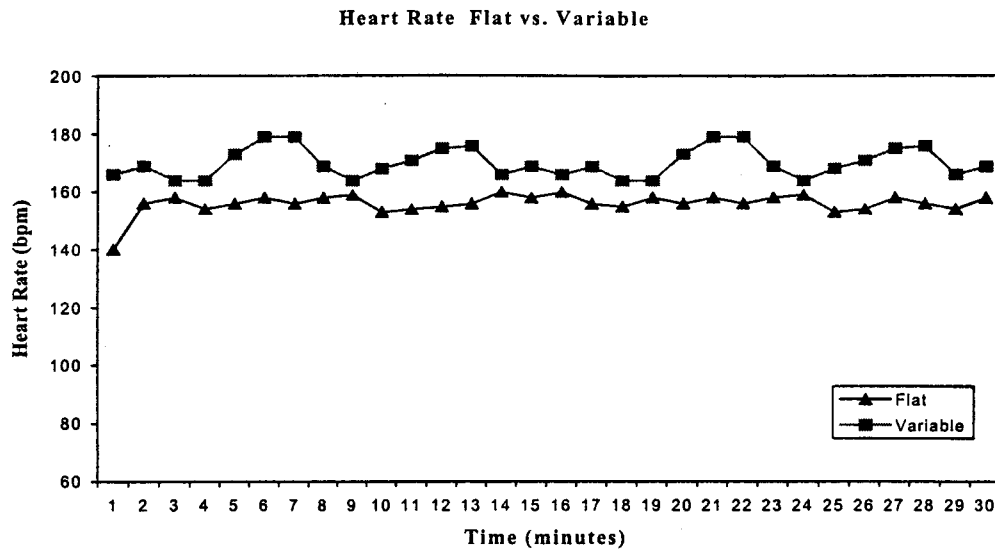


Figure 1. The heart rate response of a male subject snowshoeing for 30 minutes on both the flat and variable terrain courses.

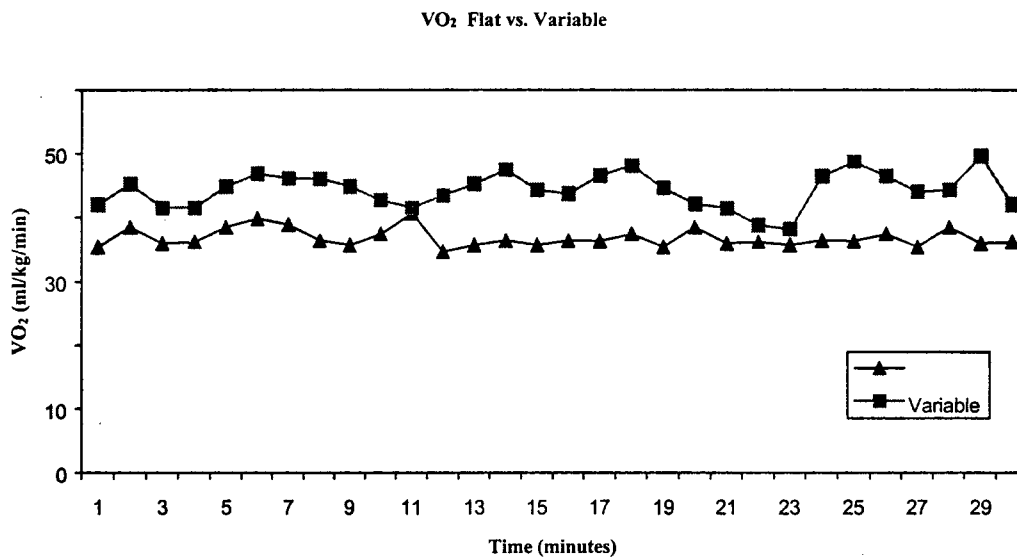


Figure 2. The VO<sub>2</sub> response of a male subject snowshoeing for 30 minutes on both the flat and variable terrain courses.

**DISCUSSION**

Although the literature is rather limited in respect to snowshoeing in particular, several studies have been conducted to assess the physiological responses to exercise in a cold environment. A study conducted by Leon et al. (7) indicated that when normal men inhale air chilled to levels frequently encountered in the winter months (-16° C or 3° F), cardiovascular performance is affected. The primary change observed is an increase in cardiac index in the absence of change in heart rate. Thus, stroke volume is increased. In addition, systemic vascular resistance remains reasonably stable, and, as a result, modest increases in blood pressure and mean

systolic blood pressure occur. Since left ventricular ejection time does not change, the principal response to cold air breathing may be viewed as an increase in the mean rate of left ventricular ejection. In a related study, Epstein et al. (2) examined the hemodynamic effects of cold environmental temperatures in subjects with and without CAD. Central venous and arterial pressures, and cardiac output were obtained at rest and at moderate exercise levels at temperatures of 25° C and 15° C. Results indicated that in both groups, mean systemic arterial pressure, total peripheral resistance, and left ventricular minute work were higher at 15° C than at 25° C. Cardiac output, heart rate and stroke volumes were the same at both temperatures. Therefore, as a result of this study, it is evident that the heart is required to work harder during exercise in cold temperatures than in warm or neutral temperatures indicating the need for reduced exercise workloads.

The main purpose of this study was to determine the physiological responses to recreational snowshoeing on flat and variable terrain. We found that male subjects worked at approximately 10.9 and 11.9 METs, while female subjects averaged 10.8 and 11.3 METs on the flat and variable terrain courses, respectively. These MET equivalents would indicate that snowshoeing compares favorably to other common aerobic activities, such as running at 6 mph (10 METs), swimming at 75 yards/min (11 METs), cross-country skiing at 5-8 mph (9 METs), and bicycling at 14-16 mph (10 METs) (9). In addition, the ACSM recommends that exercise intensity be prescribed at 60 to 90% of maximum heart rate in order to obtain cardiorespiratory benefits (1). In this study, heart rate values for males on the flat and variable terrain courses corresponded to 78 and 83% of predicted maximal heart rate while females averaged 75 and 84% of predicted maximal heart rate on the same courses. Thus, our subjects were well within a cardiorespiratory training zone on both courses.

A major question that people want answered when they exercise is how many calories they are burning. The men expended approximately 500 Kcals during the 30 min sessions while females burned approximately 375 Kcals. There was very little difference in caloric expenditure between the two courses. The downhill portion of the variable course tended to balance out the higher caloric expenditure required for the uphill sections. It should be noted that men had higher caloric expenditure values than females due to their greater body weight.

Direct comparisons between the current study and other studies reported in the literature are somewhat difficult because of differences in snowshoeing speed, terrain, snowshoe characteristics, and failure to report snow conditions, however, some general comparisons can be made based on the information reported in each study. For instance, many of the physiological variables that were recorded in the current study were also assessed by Knapik et al. (5). Both studies determined  $\text{VO}_2$  and heart rate while subjects snowshoed on two different courses. According to Knapik et al., the oxygen consumption of their subjects was 17.4 ml/kg/min and 22.0 ml/kg/min on downhill and uphill courses, respectively, compared to combined values of 38.7 ml/kg/min and 39.9 ml/kg/min on the flat and variable courses in the current study. In addition, Knapik et al. reported heart rate values of 123 and 143 b/min on the downhill and uphill courses, compared to average heart rates of 144 to 161 b/min on similar courses in the current study. In regard to depression depth, Knapik et al. reported medial, lateral, and posterior depressions of 5.4, 5.0, and 5.5 cm, while the current study recorded the same depressions as 10.4, 10.8, and 8.4 cm for the males and 10.9, 11.5, and 8.3 cm for the females, respectively. Another major difference between the studies was the speed of snowshoeing. Subjects in the study by Knapik et al. averaged 2.4 mph compared to about 3.0 mph in the current study. The differences in speed coupled with the fact that their subjects sank to a lesser degree probably explain the sizeable differences in heart rate and oxygen consumption values between studies.

A study by DeVoe et al. (10) reported on seven females, aged 20-29, who snowshoed for 30 minutes on uphill and downhill courses at a set speed of 2.5 mph. On the uphill course, heart rates averaged 80% of HRmax and subjects burned 7.8 Kcal/min (compared to 84% of predicted HRmax and 12.9 Kcal/min in the current study).

On the downhill course, heart rates averaged 68% of HRmax and subjects burned an average of 5.5 kcal/min (compared to 75% of predicted HRmax and 12.4 kcal/min in the current study). Again, the big difference between our study and theirs was the speed of snowshoeing. Our women averaged approximately 3.0 mph compared to 2.5 mph for the subjects in their study. Another factor which complicates a direct comparison between studies is the fact that their investigation was conducted in Colorado at an altitude of 8000 feet above sea level. This would help to explain the higher heart rates relative to oxygen consumption in their study.

The only other study that has investigated the energy cost of snowshoeing was conducted by Buskirk et al. (4). They also found the average caloric expenditure during snowshoeing to be much lower than in the present study, averaging 6.2 Kcal/min. Once again, however, it must be noted that the speed of snowshoeing in their study was 2.2 mi/hr. Buskirk et al. did not report snow depth or depression.

## CONCLUSIONS

Advances in technology have made snowshoeing an attractive wintertime fitness alternative. Our research found that snowshoeing provides a moderate to strenuous intensity workout which is well within the guidelines recommended by ACSM to improve cardiorespiratory endurance and positively alter body composition. It must be understood, however, that the specific results of this study apply only to snowshoeing under similar conditions. As environmental conditions change, so can the physiological responses to snowshoeing and thus the potential benefits.

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**Address for Correspondence:** Patrick L. Schneider, Franciscan Skemp Healthcare, 700 West Ave. S., La Crosse, WI 54601 ; Phone: (608)785-0940 ext. 2589 ; FAX: (608) 771-9779 ;  
e-mail: [schneider.patrick@mayo.edu](mailto:schneider.patrick@mayo.edu)

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## REFERENCES

1. American College of Sports Medicine. *Guidelines for Exercise Testing and Prescription*, 5<sup>th</sup> Ed. Philadelphia, PA: Williams and Wilkins, 1995.
2. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, and National Center for Chronic Disease Prevention and Health Promotion. *Physical Activity and Health: A Report of the Surgeon General*. Atlanta, GA: Public Health Service, 1996.
3. Tubbs Snowshoe Company, *About Tubbs*, <http://www.tubbssnowshoes.com/>, 1997, Accessed November 16, 1999.
4. Buskirk, E. R. et al. Caloric intake and energy expenditure in a sub-arctic environment (Technical Report No. EP-33). Natick, MA: *Quartermaster Research and Development Center, U.S. Army*. 1956.
5. Knapik, J. J., C. A. Hickey, S. V. Ortega, J. R. Nagel, and R. D. Pontbraind. Energy cost of walking in four types of snowshoes. (Technical Report No. ARL-TR-1175). Aberdeen Proving Ground, MD: *Army Research Laboratory*. 1996.

6. Borg, G. Perceived exertion as an indicator of somatic stress. *Med Sci Sports Exerc* 1970;14:377-87.
7. Leon, D., M. Amidi, and J. J. Leonard. Left heart work and temperature responses to cold exposure in man. *Am J Cardiol* 1970;26:38-45.
8. Epstein, S. E., M. Stampfer, D. Beisner, R. E. Goldstein, and E. Braunwald. Effects of reduction in environmental temperature on the circulatory response to man. *N Engl J Med* 1969;280:7-12.
9. Ainsworth, B. E. et al. Compendium of physical activities: classification of energy cost of human physical activities. *Med Sci Sports Exerc* 1993;25:71-80.
10. DeVoe, D. E., D. M. Husmann, and R. W. Gotshall. Energy expenditure during recreational snowshoeing. *Med Sci Sports and Exerc* 1998;30(5):S59.