ABSTRACT

SCHNEIDER, P. L. Physiological responses to recreational snowshoeing in males. MS in Adult Fitness/Cardiac Rehabilitation, May 1999, 34pp. (J. Porcari).

The purpose of this study was to provide descriptive data on the physiological responses of subjects to snowshoeing at a self-selected pace on flat and variable terrains. Ten male (age = 26.9 $\pm$ 6.76 yr, ht = 178.1 $\pm$ 7.72 cm, wt = 86.9 $\pm$ 7.62 kg) volunteers snowshoed at a self-selected pace in random order for 30 minutes on flat and variable terrain courses. It was found that HR (151 vs 161 bpm) and RPE (13.6 vs 15.2) were significantly ($p < .05$) higher on the variable course compared to the flat course. VO_2 (38.1 vs 41.7 ml/kg/min) also tended to be higher on the variable course, however, the difference was not significant ($p > .05$). The average caloric expenditure on the flat course was 492 total kcals and on the variable terrain course was 523 total kcals. 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.

PHYSIOLOGICAL RESPONSES TO RECREATIONAL SNOWSHOEING IN MALES

A MANUSCRIPT STYLE THESIS PRESENTED

TO

THE GRADUATE FACULTY

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BY

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THEISIS FINAL ORAL DEFENSE FORM

Candidate: Patrick L. Schneider

We recommend acceptance of this thesis in partial fulfillment of this candidate's requirements for the degree:

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The candidate has successfully completed the thesis final oral defense.

Thesis Committee Chairperson Signature	3/31/98 Date
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This thesis is approved by the College of Health, Physical Education, and Recreation.

Associate Dean, College of Health, Physical Education, and Recreation	4-10-98 Date
Dean of Graduate Studies	4-10-98 Date

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INTRODUCTION

The benefits of physical activity are well-established, and emerging studies continue to support an important role for habitual exercise in maintaining overall health and well-being (2). According to the Surgeon General's Report on Physical Activity and Health, physical activity reduces the risk for developing or dying from coronary heart disease, noninsulin-dependent diabetes, hypertension, and colon cancer, reduces symptoms of anxiety and depression, contributes to the development and maintenance of healthier bones, muscles, and joints, and helps control body weight. Physical activity also may help older adults maintain the ability to live independently and help prevent falling and fractures (13).

Although walking, jogging, and biking are common modes of activity when the weather is favorable, environmental conditions in some parts of the country throughout the winter months are not quite as conducive to these types of activities. For the individual who enjoys remaining active outdoors, winter activities are limited to those such as cross-country skiing, ice skating, and snowshoeing. Snowshoeing is currently being viewed as a wintertime version of exercise walking. As a fitness activity, snowshoeing provides health and fitness gains similar to walking, running, and cycling (5). In addition, snowshoeing has the added benefits of being an easy to perform, environmentally friendly, low impact activity that can be enjoyed individually or as a group. In recent years, the popularity of snowshoeing has increased substantially. Nearly one million people are expected to try snowshoeing this winter, a figure that is up from 440,000 in 1994, according to the National Sporting Goods Association (8).

Part of the rise in snowshoe popularity can be attributed to improvements in technology. Over the past several years, snowshoes have gotten smaller, lighter, and less cumbersome while maintenance-free aluminum frames have replaced the high-maintenance wood versions (5). Modern materials and designs have cut down on the weight and provide maximum traction and control. Today's snowshoes and bindings are far easier to use than that of the comparatively larger, wider snowshoes of the past.

Although the popularity of snowshoeing is increasing at a rapid rate, very little research has been done to determine its physiological effects. In addition, studies conducted have failed to include important variables affecting the results of each study. For example, some studies failed to include descriptive characteristics of the snowshoes that were tested (4), while others lacked important information regarding either snow depth or the depth of each depression (4,7); all critical factors in respect to snowshoeing from an energy cost perspective. 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

Subject Selection

Ten apparently healthy male volunteers between the ages of 20 and 50 were recruited to participate in this study. All subjects were required to be at least moderately active, defined as exercising continuously for at least 20-60 minutes three days/week (2). All subjects signed a written informed consent (see Appendix A) approved by the University of Wisconsin-La Crosse Institutional Review Board prior to the beginning of the study.

Snowshoeing Orientation

Prior to testing, each subject was given specific instructions regarding proper snowshoeing technique and was allowed an opportunity to practice in an area located near the start of the course. Upon demonstrating sufficient skills on snowshoes, each subject was read specific instructions concerning their participation in the study prior to the actual start of the test (see Appendix B). Subjects tested used the Yukon model snowshoes manufactured by Tubbs Co. (Stowe, VT), which measure 10" x 36" and weigh 5 lbs per pair.

Data Collection and Procedures

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 average grade of the variable terrain course was 18%. The average grade was 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. 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 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 while wind velocity was measured using a hand held anemometer (Sims, Model BT). Throughout the testing, subjects wore a KB1-C (Aerosport) ambulatory metabolic system, which measured oxygen consumption and caloric expenditure. Oxygen consumption (VO_2) and caloric expenditure (kcals) were recorded every minute. Pneumotach flow calibration of the KB1-C was accomplished using calibrated gases and a standard flow 3.00 L calibration syringe ensuring accurate data collection. Heart rate was also recorded every minute using the Polar XL heart rate monitor.

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. At the conclusion of each session, subjects were asked to rate their effort for each 30 minute session using the Borg 6-20 scale (3) (see Appendix C).

Statistical Analysis

Basic descriptive statistics were used to characterize the subject population and to summarize the physiological responses to the two snowshoeing conditions. Paired t-tests were used to compare the physiological responses to snowshoeing on the flat and variable courses. Significance was measured at $p < .05$ for all statistical analyses.

RESULTS

The descriptive characteristics of the 10 subjects who participated in the study are presented in Table 1.

Table 1. Descriptive physical characteristics of the subjects.

Variable	$X \pm SD$	Range
Age (yrs)	26.9 ± 6.76	21-42
Height (cm)	178.1 ± 7.72	165.1-190.0
Weight (kg)	86.9 ± 7.62	75.8-99.8

Each subject completed both courses within a 2-3 day span to minimize differences in the environmental conditions. The average temperature throughout the testing was -3° (C) and ranged from –12.2° to 1° (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.

The results of the physiological responses to snowshoeing on the flat and variable terrain courses are presented in Table 2. Subjects snowshoed at an average speed of 3.3 mph on the flat course and 2.9 mph on the variable terrain. There was a significant difference ($p < .05$) in the speed at which subjects snowshoed on the two courses. Overall, subjects snowshoeing on the variable terrain elicited significantly higher ($p < .05$) heart rates (HR) and ratings of perceived exertion (RPE) compared to the flat course. VO_2 values and kilocalories (kcals) tended to be higher on the variable course, however, this difference was not significant ($p > .05$).

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

Category	Flat Mean ± SD	Variable Mean ± SD
VO_2 (ml/kg/min)	38.1 ± 5.91	41.7 ± 4.89
HR (bpm)	151 ± 7.7	161 ± 10.7 *
Kcals (30 min)	492± 81.2	523± 54.8
RER	.93 ± .04	.92 ± .11
RPE	13.6 ± .51	15.2 ± 1.22 *

* indicates a significant difference in comparison with the flat course ($p < .05$)

Figures 1 and 2 present representative HR and VO_2 data for a single subject snowshoeing for 30 minutes on the flat and variable courses.

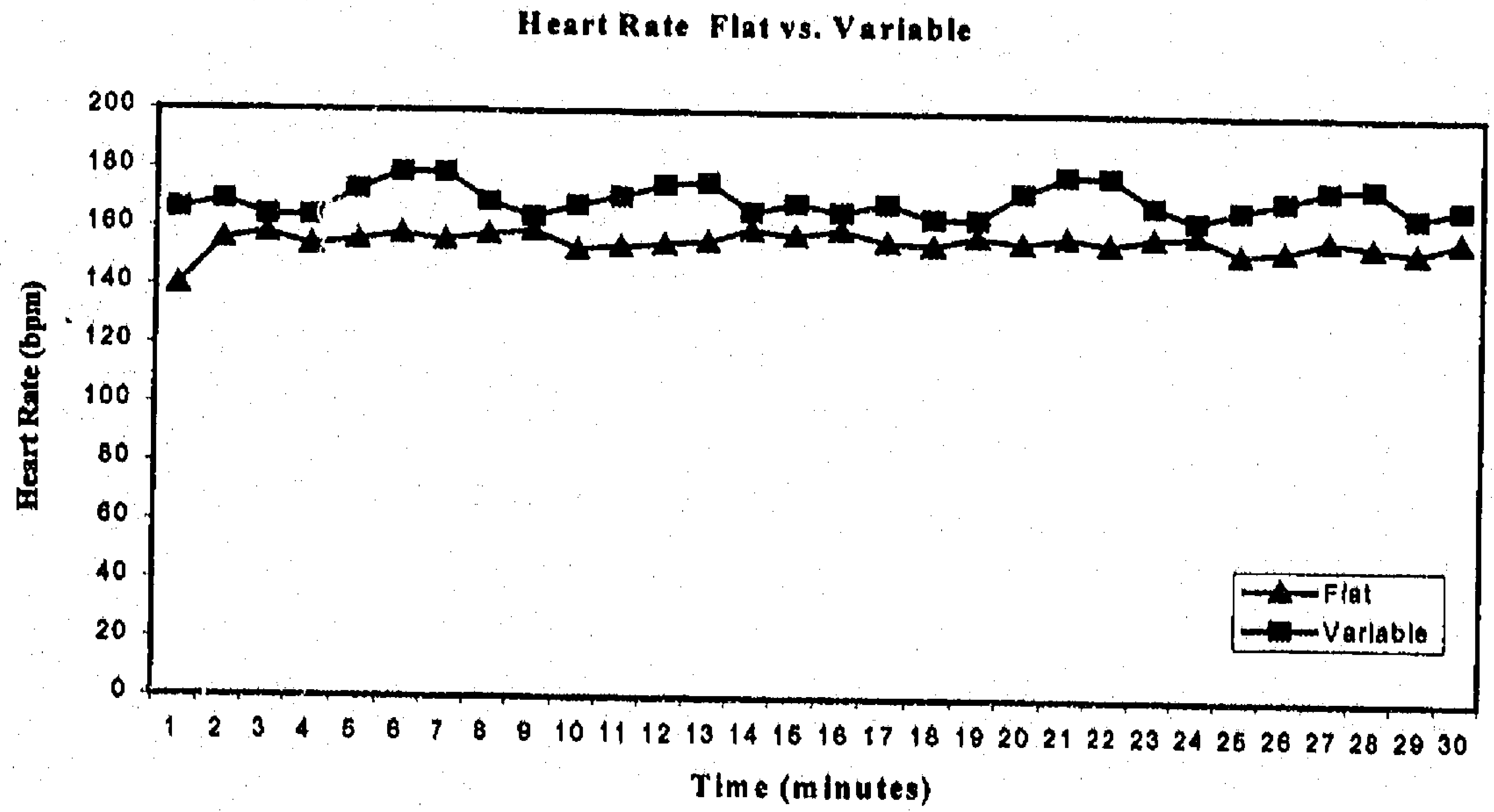

Figure 1: The heart rate response of a single subject snowshoeing for 30 minutes on both the flat and variable terrain courses.

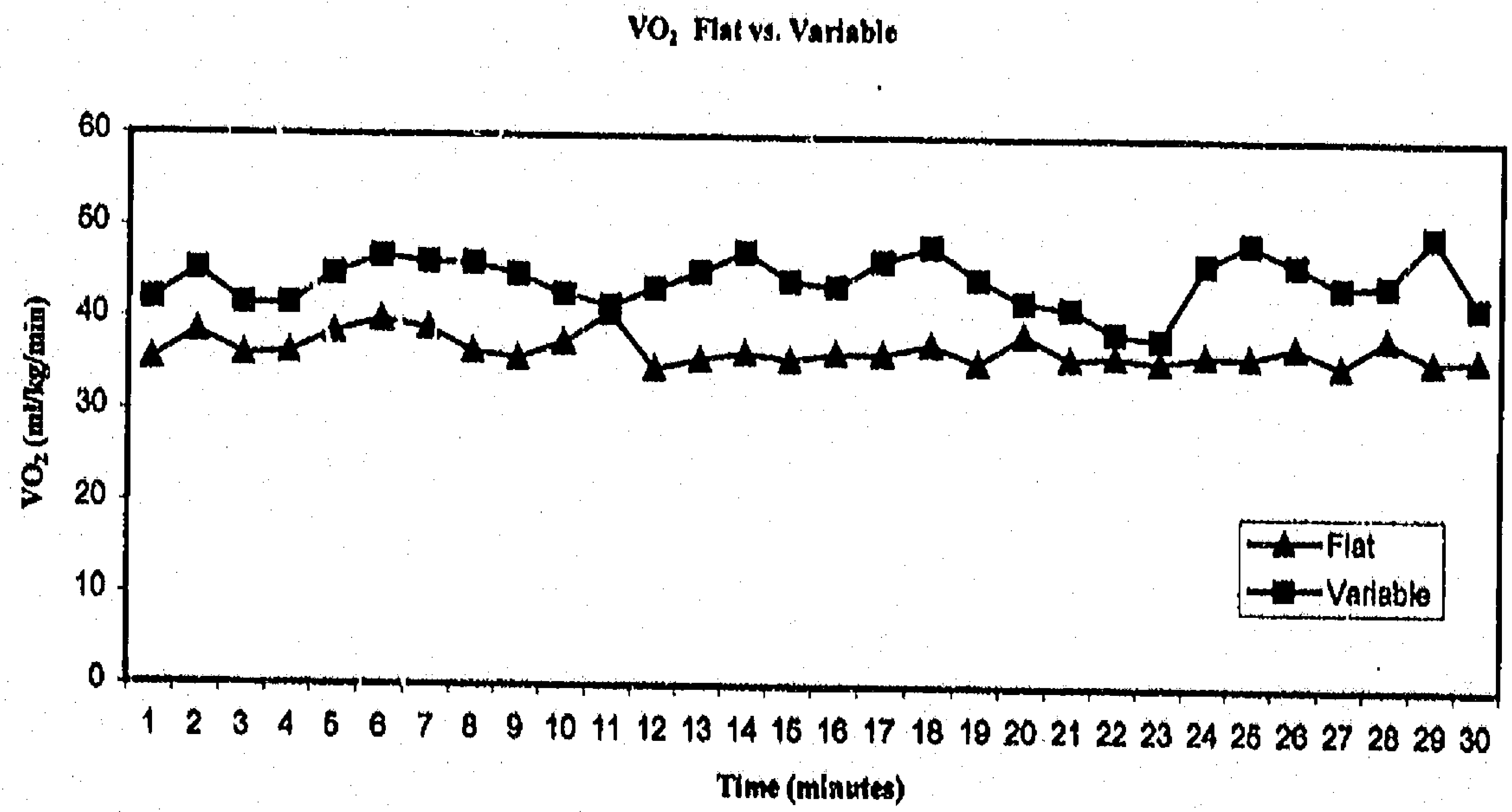

Figure 2: The VO_2 response of a single subject snowshoeing for 30 minutes on both the flat and variable terrain courses.

DISCUSSION

The purpose of this study was to determine the physiological effects of snowshoeing on both flat and variable terrain in males. It was found that the mean VO_2 for both the flat and variable courses was 38.1 ml/kg/min (3.31 L/min) and 41.7 ml/kg/min (3.56 L/min), respectively, which is the equivalent of 10.9 and 11.9 METs. The average heart rates obtained were 151 bpm for the flat course and 161 bpm for the variable terrain course. Caloric expenditure for 30 minute duration on the flat course was 492 total calories (16.4 kcals/min), while on the variable terrain course subjects averaged 523 total calories (17.4 kcals/min).

Due to the fact that there are differences in walking speed between studies, and most studies do not report grade, depression depth, snow depth, or snowshoe characteristics, it is difficult to make direct comparisons between the results of the current study and related literature. According to Buskirk et al. (4), the average caloric expenditure during snowshoeing was 6.21 kcal/min, whereas the results of this study indicate a caloric expenditure equivalent to 16.4 kcal/min on the flat course and 17.4 kcal/min on the variable terrain course. In addition, Buskirk et al. recorded an average oxygen consumption of 17.5 ml/kg/min, while the current study elicited average VO_2 values of 38.1 ml/kg/min and 41.7 ml/kg/min on the flat and variable terrain courses respectively. The substantial difference between caloric expenditure and oxygen consumption between the two studies may be attributed to a variety of factors. First, subjects in this study walked at an average speed of 3.3 mph on the flat course and 2.9 mph on the variable terrain course as opposed to 2.2 mph as reported by Buskirk et al.

Second, a variety of factors that can dramatically affect energy expenditure such as depth of snow, depression depth, and snowshoe characteristics were not recorded in the Buskirk et al. study.

Many of the physiological variables that were recorded in this study were also assessed by Knapik et al. (7). Knapik et al., however, collected data from just four subjects and used four different types of snowshoes. Of the four snowshoes tested, the Assault model, manufactured by Pride, was the most similar to the Yukon model used in the current study. Both the Pride and Yukon models consist of an aluminum frame to which a solid plastic membrane is attached. The boot binding systems are attached to the aluminum frame by a plastic-covered piece of steel that allow the binding to pivot as the subjects walked. On the underside of each snowshoe are two crampons designed to maximize traction. In addition, while the Pride Assault shoes measured 9" x 29" and the Tubbs Yukon model measured 10" x 36", both shoes weighed approximately 5 lbs per pair. In comparing the physiological variables, both studies determined VO_2 and heart rate while subjects snowshoed on two different courses. According to Knapik et al., the oxygen consumption of the subjects was 17.4 ml/kg/min and 22.0 ml/kg/min on the downhill and uphill courses, respectively, while subjects snowshoed at a 2.4 mph pace. The current study found VO_2 to be 38.1 ml/kg/min and 41.7 ml/kg/min on the flat and variable terrain courses respectively. In addition, while Knapik et al. reported heart rate values of 123 bpm and 143 bpm on the downhill and uphill courses, the current study elicited heart rates of 151 bpm and 161 bpm on the flat and variable terrain courses.

In regard to depression depth, Knapik et al. reported medial, lateral, and posterior depressions as 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, respectively. These significant differences in depression depth may explain the sizable difference in oxygen consumption and heart rate values. In addition, in the current study, subjects walked at an average pace of 3.3 mph on the flat course and 2.9 mph on the variable terrain course compared with the average pace of 2.4 mph as reported by Knapik et al. This significant difference in walking speed may also explain the difference in oxygen consumption and heart rate values.

The findings of this study are significant in that they demonstrate the physiological benefits of snowshoeing at a somewhat strenuous level for just 30 minutes. The current study determined that the average subject worked at approximately 10.9 METs on the flat course and 11.9 METs on the variable terrain course which corresponds to similar MET requirements of various 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) (1). In addition, the ACSM recommends that the intensity of exercise be prescribed as 60 to 90% of maximum heart rate to obtain the fitness benefits of exercise (2). In this study, heart rate values averaged 151 bpm on the flat course and 161 bpm on the variable terrain course which correspond to 78 and 83% of the average subject's maximum heart rate. Additionally, according to the Surgeon General's Report on Physical Activity and Health, health benefits occur at a "moderate" level of activity – a level sufficient to expend about 150 calories of energy per day, or 1000 calories per week (9). Therefore, the results of this study indicate that snowshoeing just 30 minutes a day is well in excess of that threshold.

In summary, it appears that snowshoeing provides a sufficient enough intensity to increase cardiorespiratory endurance and positively alter body composition. It must be understood, however, the 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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APPENDIX A

INFORMED CONSENT

INFORMED CONSENT FOR THE PHYSIOLOGICAL EFFECTS OF RECREATIONAL SNOWSHOEING

I, ____________________, volunteer to participate in a study investigating the physiological effects of recreational snowshoeing. I understand that my participation in this research study will require a minimum of 2 days consisting of practice sessions, and walking on two courses, varying in terrain, for 30 minutes each session. All sessions will be scheduled at my convenience and conducted by Patrick Schneider under the direction of Dr. John Porcari. I realize that during the testing I will be carrying a portable oxygen analyzer used to calculate expired air that has been explained and demonstrated to me. My heart rate will be recorded throughout the tests with a heart rate monitor strapped to my chest.

I consent to the publication of the results of this study so long as the information is anonymous and disguised so that no identification of individual subjects can be made. I further understand that although a record will be kept of my participation in the study, all experimental data collected from my participation will be identified by number only.

As with any exercise, there exists the possibility of adverse changes occurring (i.e. dizziness, shortness of breath, muscle fatigue, etc.) during the test. In addition, I may feel tired at the end of the exercise session. As a result of exercising outdoors during the winter months, there may also be a risk of hypothermia and/or frostbite. If any abnormal observations are noted, the test will be terminated immediately.

I consider myself to be in good health and to my knowledge, I am not infected with a contagious disease or have any limiting physical condition or disability, especially with regard to my heart that would preclude my participation in the exercise tests as described above. I have read the foregoing and I understand what is expected of me.

Any questions which may have occurred to me have been answered to my complete satisfaction. I, therefore, voluntarily consent to be tested. Furthermore, I know I may withdraw from these tests at any time.

I hereby acknowledge that no representations, warranties, guarantees or assurances of any kind pertaining to these procedures have been made to me by the University of Wisconsin-LaCrosse, the officers, administration, employees or anyone acting on behalf of them. Concerns about any aspects of this study may be referred to the principal researcher (Patrick Schneider (608) 269-1850) and thesis advisor (Dr. John Porcari (608) 785-8684, University of Wisconsin-LaCrosse, Exercise and Sports Science Department, Room 216).

Signed: ______________________ Date: __________

Researcher: ______________________ Date: __________

Witness: ______________________ Date: __________

APPENDIX B

TEST INSTRUCTIONS

TEST INSTRUCTIONS

The test to be performed will last for a duration of 30 minutes. Orange, surveyor flags are marked in 100-yard increments with two crossing flags at the 500-yard marker. When you reach the crossing flags, turn around and walk back parallel to, but not on top of your previous track. Walk in fresh snow throughout the entire duration of the course. Upon completion, we will ask you to rate your perceived exertion for the test. Perceived exertion is the overall effort or distress of your body during exercise. The RPE chart ranges from 6 to 20; with 6 indicating no perceived exertion at all and 20 being a maximal effort. Snowshoe at a self-selected pace, which should be a pace that you can maintain at a level of 13 to 15 on this scale. Do you have any questions?

APPENDIX C

RATINGS OF PERCEIVED EXERTION SCALE

Ratings of Perceived Exertion Scale *

6	
7	Very, very light
8	
9	Very light
10	
11	Fairly light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Very, very hard
20	

* Borg, G. Perceived exertion: a note on "history" and methods. *Med. Sci. Sports* 5:90-93, 1973.

APPENDIX D

DATA COLLECTION SHEET

Data Collection Sheet

Date: ____/____/____

Subject I.D. ______ Course: _______ Age: _______

Height (in): ________ Weight (kg): __________

Distance (yds): _________

RPE: ______

Depression Depths (cm): Medial: _____, _____, _____
Lateral: _____, _____, _____
Posterior: _____, _____, _____

Temperature (C°): ______

APPENDIX E

PICTURE OF SNOWSHOES

APPENDIX F

SUBJECT SNOWSHOEING

APPENDIX G

MEASUREMENT OF DEPRESSION DEPTH

APPENDIX H

REVIEW OF RELATED LITERATURE

REVIEW OF RELATED LITERATURE

Introduction

Regular physical activity assists in maintaining an individual's overall health and well-being and provides a variety of physiological and psychological benefits. Several studies have indicated that regular activity reduces many of the risk factors involved in premature mortality and morbidity. Although a variety of activities can be maintained throughout the summer months, the list of outdoor activities popular throughout the winter months in certain parts of the country is relatively limited. Common outdoor winter activities include snowshoeing, snowboarding, and downhill and cross-country skiing. Over the past several years the popularity of snowshoeing has increased at a rapid rate and is continuing to climb (5). Snowshoeing is currently being viewed as a wintertime version of exercise walking (2).

History of Snowshoeing

Snowshoes have been utilized for as long as 6,000 years and they were one of the earliest forms of transportation. Starting with the basic bearpaw shape, the indigenous people of North America developed numerous frame patterns suited to all possible snow and terrain conditions (2). Since snowshoes were used more for utility and survival, they were originally designed to maximize weight carrying capacity and tended to be substantially larger than the snowshoes of today. Throughout history, snowshoes have proven to be very helpful to individuals such as trappers, hunters, explorers, and surveyors.

It was not until 1862 that the first commercial, large-scale production of snowshoes began. In a short amount of time, other manufacturers joined in and after only a few decades the majority of snowshoes were factory built (2). Although the traditional styles used throughout much of this century were the result of centuries of evolution, the past 10 years of snowshoe evolution has in fact appeared to be more of a revolution.

Technological Developments

A snowshoe, by definition, is simply the platform that keeps you from sinking into the snow (9). The basic concept of snowshoeing involves staying aloft by increasing the surface area of your feet, thereby reducing how much you sink in the snow (2). Snowshoes are basically extensions of the foot. Moreover, as people think of snowshoeing they often conjure up an image of an individual trudging through the snow with tennis rackets strapped to their feet. However, thanks to technological developments, snowshoes are now lighter and require much less maintenance than those of the past. Although the frame of snowshoes can be wood, metal, or plastic, the newer models are often aluminum (9). In the traditional shoe, the decking, or portion stood on, was made of leather lacing or webbing. In the newer shoes it is often a solid, puncture-resistant synthetic material. This newer material is advantageous in that the surface collects less snow and ice while requiring less maintenance than the older version (9). Therefore, like other exercise shoes, snowshoes have also improved substantially over the years.

Studies on Walking in Snow

Despite the fact that snowshoeing is gaining popularity, limited research has been conducted regarding this particular form of activity. Therefore, this review of literature examines the research related to snowshoeing as well as other similar activities.

In 1959, a study conducted by Heinonen, Karvonen, and Ruosteenoja (3) determined the energy expenditure of walking in snow at various depths. In this study, seven male subjects walked at their natural walking pace on level, snow-covered fields. The depression made in the snow by the feet was then measured from the surface to the point corresponding to the ball of the foot. The mean depression, calculated from 30 to 50 measurements, ranged from 0 to 43 cm. It was found that cal/kg of body weight per horizontal meter walked, denoting energy cost, ranged from .6 on firm ground with no depression to 9.5 cal/kg/m in deep snow with a 39 cm depression. The researchers determined that as the depth of the foot depression increased, length of stride and mean speed decreased while energy expenditure increased linearly.

In a similar study, Pandolf, Haisman, and Goldman (6) determined the metabolic cost and terrain coefficients for walking on snow. The purpose of this study was to provide information about the energy expenditure for fixed pace snow walking at various depths as well as the depression depth and walking velocity at which snow walking could no longer be maintained. In this study, ten male subjects each walked at two speeds (1.5 and 2.5 mph) on a level treadmill, and on a wide variety of snow depths. Following each snow walk, the mean depression made in the snow was calculated from at least 10 measurements. At a walking speed of 4 km/hr (2.4 mph) the average depression measured 35 cm, while the depression when walking at 2.4 km/hr (1.4 mph) averaged 38 cm. Energy expenditure, which was measured when the subjects terminated snow walks due to exhaustion averaged 51.4 ml/kg/min and ranged from 39.72 ml/kg/min to 61.12 ml/kg/min. The findings of this study indicate a strong linear relationship between energy expenditure and depth of depression with a correlation coefficient of .87, indicating that as energy expenditure increased as depth of depression increased. As indicated by Heinonen et al., it is evident that walking in snow even at slow walking velocities, is an extremely strenuous form of locomotion.

In 1976, Smolander, Louhevaara, and Hakola (8) assessed the physiological strain of differing boot weights while walking in snow. To determine cardiorespiratory strain of different boot weights, seven male and three female subjects walked on a treadmill and a snow covered field while wearing three types of boots: winter jogging boots, rubber boots, and rubber safety boots. The depth of the footprint impression in the snow from the surface to the point corresponding to the ball of the foot averaged 26.1, 25.6, and 26.1 cm in the winter jogging boots, rubber boots, and rubber safety boots, respectively. Self-determined walking speed of the subjects ranged from 1.69 km/hr (1.0 mph) to 3.85 km/hr (2.3 mph). While walking in snow, oxygen consumption averaged 2.24 L/min in the winter jogging boots, 2.34 L/min in the rubber boots , and 2.34 L/min in the rubber safety boots while heart rates averaged 151, 150, and 151 bpm, respectively. The ratings of overall perceived exertion in the snow varied from very, very light (.5) to heavy (5) while averaging 2.3, 2.2, and 2.8 in the winter jogging boots, rubber boots and rubber safety boots. The results indicate that walking in snow substantially increased pulmonary ventilation, oxygen consumption (VO_2), carbon dioxide production, respiratory gas exchange ratio, and heart rate compared with walking tests on the treadmill. During the walking tests on the treadmill and snow, oxygen consumption was slightly, but systematically higher with the heavier rubber boots and rubber safety boots than with the lighter winter jogging boots. This study also indicates walking in snow is strenuous work as indicated by a 50 bpm increase in heart rate and a mean VO_2 of three times as much in the snow walks compared with walking on a treadmill at equivalent speeds.

A study conducted by Ramaswamy et al. (7) sought to determine the effect of looseness of snow on energy expenditure. The caloric requirements of walking on loose, deep snow were determined using 12 young soldiers. Each subject walked on level, snow covered ground at normal speeds. Impressions of the feet in the snow were measured and averaged for 20 steps and ranged from approximately 1.5 to 63 cm. It was found that the work of walking at a natural speed in moderately deep snow (30 cm) required 600 kcal of energy per hour. In agreement with the findings of Heinonen et al. and Pandolf et al., Ramaswamy et al. found that oxygen consumption values, which were corrected to represent the oxygen requirements of a standard 60 kg man, increased linearly as depth of snow increased. However, Ramaswamy et al. also noted that when snow depth exceeded 37 cm, the oxygen requirement seemed to rise asymptotically despite the fact that the increasing depth of snow resulted in slower walking speeds. Ramaswamy et al. concluded that it can be well understood that walking on very deep snow with its high energy requirements cannot be maintained for a long period of time.

Snowshoeing Studies

A very limited number of studies have sought to determine energy expenditure while snowshoeing. In a 1956 study to determine caloric intake and energy expenditure in a sub-arctic environment, Buskirk et al. (1) determined the energy cost of eight subjects while snowshoeing. Each subject walked at an average speed of 3.7 km/hr (2.2 mph). The results indicated an average caloric expenditure of 6.21 kcal/min and an oxygen requirement averaging 17.5 ml/kg/min. However, in this particular study, neither the depth of snow nor snowshoe characteristics was reported.

In 1996, Knapik, Hickey, Ortega, Nagel, and Pontbraind (4) assessed the energy cost of walking in four types of snowshoes. The four snowshoes tested were the Pride Assault, Montana, British Assault, and the U.S. Army Standard, ranging in weight from 2 to 3 kilograms. Energy cost was examined while four Marines walked at 4 km/hr (2.4 mph) on an open field with each of the four snowshoes. The subjects had previously trained one day with each snowshoe before the energy cost study. The grade of the field was about 2.4% and each subject walked once downhill and once uphill with each snowshoe. Each walking segment was 336 meters long and took approximately five minutes to complete. To gauge flotation, the depth of the snowshoe impression was measured. To determine overall depression, the lateral, medial, and posterior measurements were summed and averaged. The overall depth of depression on each course averaged 5 cm while subjects snowshoed in 8 cm of new snow on top of an undetermined snow base. While subjects walked downhill, oxygen consumption ranged from 16.8 to 20.2 ml/kg/min, and heart rates ranged from 123 to 136 bpm. On the uphill portion of the course, oxygen consumption ranged from 21.0 to 24.5 ml/kg/min, while heart rates ranged from 143 to 155 bpm. In averaging the two courses together, the oxygen requirement of walking at 4.1 km/hr (2.4 mph) both uphill and downhill averaged 20.3 ml/kg/min while the average heart rate was 138 bpm. According to the researchers, the results of this study suggest that favorable characteristics of snowshoes from an energy cost perspective include a hinge and binding system that allows the snowshoe to be dragged across the snow, an upturned front that pushes snow and allows a more horizontal displacement of the snowshoe, and lightweight snowshoe materials combined with a greater surface area.

Summary

Although the popularity of snowshoeing is increasing rapidly (5), the research conducted on the benefits of snowshoeing is very limited. In addition, the few studies that have been performed have been improperly conducted. While most studies failed to include several important variables regarding energy expenditure (1,4), others used an inadequate sample size (4). To compliment the rise in snowshoe popularity it is necessary to develop accurate information regarding snowshoeing from an energy cost perspective.

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