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T. A. Rogers, A. C. Buck and J. C. Klopping

October 1965

ARCTIC AEROMEDICAL LABORATORY

AEROSPACE MEDICAL DIVISION
AIR FORCE SYSTEMS COMMAND
FORT WAINWRIGHT, ALASKA

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FOREWORD

This report is prepared under contract AF 41(609)-1918 (Project 8238, Task 823803) with the Pacific Biomedical Research Center, University of Hawaii, Honolulu, Hawaii. The report covers research carried on from 15 February 1964 to 15 March 1964. One of the authors, John C. Klopping, is with the Department of Radiology, Stanford University School of Medicine. Air Force program monitor is Dr. David Vaughan, ALRB, Arctic Aeromedical Laboratory.

This technical report has been reviewed and is approved.

HORACE F. DRURY
Director of Research

ABSTRACT

The Wolff Integrating Motor Pneumotachograph was utilized to determine oxygen consumption of men traveling on foot, on snowshoes or on skis. As expected, the energy cost of walking in unbroken snow was greater than that of any other activity studied. The advantage of wearing snowshoes in deep snow varied greatly, evidently according to the skill of the wearer. The authors concluded that when the subject is wearing skis, the most effecient speed for covering a long distance is best determined by the subject himself, since caloric cost is approximately independent of speed within a reasonable range of speeds.

I

INTRODUCTION

The Wolff Integrating Motor Pneumotachograph (1, 2) was utilized to determine the oxygen consumption of men traveling on skis or snowshoes, or without either.

II

METHODS

Seven subjects wore IMPs for periods of about one hour while standing outdoors quietly, adequately clothed and not shivering. The rates of oxygen consumption determined were taken as the "resting rates", and were subtracted from the oxygen consumption rates later determined on the same subjects while active, to arrive at the extra energy cost of the activity. The subjects traversed a 2-1/2 mile course laid out on the snow-covered, frozen Chena River near Fort Wainwright. They followed the course on foot along a trail beaten by dog teams, on skis along the same trail, on foot in unbroken snow alongside, and on snowshoes in unbroken snow.

III

RESULTS AND DISCUSSION

As would be expected, the energy cost of walking in unbroken snow is greater than that of any other activity studied. The snow was 13 cm deep, and the subjects' footprints were ordinarily 9 cm deep. The subjects' extra oxygen consumption while walking at about 2.3 mph in the deep snow was greater than that while walking at the same speed on the trail by a mean factor of 2.4. For a 70 kg man, the total oxygen consumption while walking in the deep snow at 2.3 mph was 2.45 l/min, which is more than 60% of the normal maximal oxygen uptake and represents a caloric expenditure of 715 kcal/hr.

The advantage of wearing snowshoes in the deep snow varied greatly, evidently according to the skill of the wearer. One subject actually used more energy walking with snowshoes than without; two other subjects utilized 70% as much energy, and the remainder used about 50%.

The extra energy cost of skiing on the level trail increased approximately linearly at speeds between 3 and 6 mph; this is plotted in Figure 1.

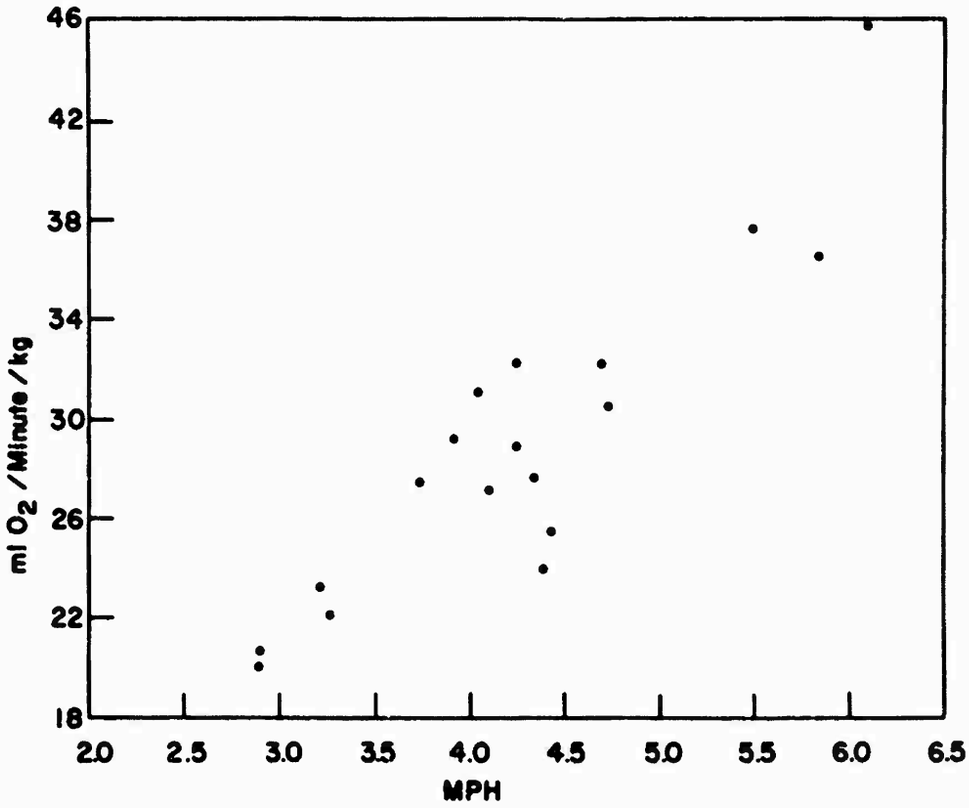

FIGURE 1

Oxygen consumption while skiing (above that of resting)

The caloric expenditure rate of a highly skilled skier (65 kg) at 6.1 mph sustained over a 2.5 mile course was 877 kcal/hr. Four hours of activity at this level would be equivalent to a full 24 hour energy output of the same man at a moderate level of activity.

The apparent linearity of Figure 1 is quite interesting. A line may be fitted to the data points which passes through the origin, and this is physiologically satisfactory. A corollary of the graph's apparent linearity is that between 3 and 6 mph, the caloric cost of traveling a mile is independent of the speed. The conclusion would be then, that the most efficient speed for covering a long distance on skis is best determined by the subject himself. Since the caloric cost is approximately independent of speed in this reasonable range of speeds, the subject can choose the level of activity which causes him the least circulatory and respiratory distress.

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