WILDERNESS & ENVIRONMENTAL MEDICINE, **22,** 250–256 (2011)

BRIEF REPORT

# Effects of Oxygen Supplementation on Acute Mountain Sickness Symptoms and Functional Capacity During a 2-Kilometer Walk Test on Chajnantor Plateau (5050 Meters, Northern Chile)

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**Objective.—**The aim of this study was to test the hypothesis that administration of low-flow oxygen will improve physical performance in subjects unacclimatized to altitude. We evaluated the effects of oxygen supplementation on functional capacity and acute mountain sickness (AMS) symptoms in young, healthy male and female subjects who performed a 2-km fast walk test following rapid ascent to the Chajnantor plateau (5050 m above sea level) in Northern Chile.

**Methods.—**The participants were randomly distributed into 2 groups according to oxygen supplementation levels: 1 or 3 L $O_2 \cdot min^{-1}$. Within each group, males and females were evaluated separately. A preliminary walk test was carried out at sea level on a 100-m long, flat track with 10 U-turns. For the first walk at altitude, subjects carried the supplementary oxygen system but did not breathe the oxygen. Subjects received oxygen through a facemask the following day during the second test. The nights prior to altitude tests were spent at 2400 m in San Pedro de Atacama.

**Results.—**Supplementary oxygen administration during a 2-km walk test significantly improved walking times at 5050 m. We also observed a significant improvement in AMS symptoms. As expected, however, performance was poorer at altitude compared to test values at sea level, despite supplementary oxygen administration.

**Conclusions.—**Our findings demonstrate the beneficial effects of supplementary oxygen administration on physical capacity, reducing the incidence of AMS and, thus, improving health and safety conditions for high altitude workers following rapid ascent, when adequate acclimatization is not possible.

*Key words*: altitude work, acute mountain sickness, supplementary oxygen, 2-km walk test, Chajnantor plateau

## Introduction

Several groups of workers, including researchers at astronomical observatories and miners or railway workers in the Andes and Central Asia, are routinely required to undergo a fast ascent from lowland levels to moderate and even high altitudes. Although some individuals show a good response to sudden altitude exposure, others do not, and they experience different degrees of acute mountain sickness (AMS). The symptoms characterizing AMS can be assessed using the Lake Louise AMS score.[1] Depending on intensity, AMS symptoms can produce a marked reduction in the capacity to carry out daily activities such as walking or completing work tasks.[2] Many workers live at low altitude or sea level, and may carry out a wide range of activities before hypoxia occurs, depending on their work schedule.

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The Atacama Large Millimeter/Submillimeter Arrays (ALMA) project was launched by an international consortium in 2003. The observatory is situated on the Chajnantor plateau (5050 m) in the Antofagasta region, and has a permanent base camp at 2900 m that provides residential and leisure facilities for all personnel, including ALMA project employees and employees from contracting companies. The site hosts a variety of engineers, scientists, journalists, and other visitors, resulting in a heterogeneous population characterized by wide variations in age, health status, and physical condition. Both personnel and visitors are required to withstand very harsh environmental conditions, including high altitude, temperatures below 0°C, wind speeds that are normally between 40 to 50 km per hour, and elevated thermal radiation.[3] These harsh environmental conditions constitute a significant cause of delays in the work schedule as compared to similar tasks at lower altitudes. In addition, companies encounter great difficulties in retaining specialized personnel, who leave because of altitude intolerance. Furthermore, the incidence of vehicle accidents (especially vehicles overturning during descent) may be exacerbated by hypoxia, which can diminish sensorial perception, mental concentration, and speed of reaction, all implying a reduced ability to function.

It is well known that working conditions for commuters to high altitude can be improved significantly by oxygen enrichment of room air,[4] especially at altitudes such as those on the Chajnantor plateau (5050 m).[5] However, most of the current tasks at the Chajnantor site are performed outdoors. Thus, it could be interesting to identify the minimum flow of supplementary oxygen required to prevent AMS. The main goal of this study was to test the hypothesis that administration of low-flow oxygen will improve physical performance in subjects who have not been acclimatized to altitude. To this end, we collected data from a 2-km walk test conducted at high altitude (5050 m) with 2 levels of supplementary oxygen administration in healthy young male and female subjects. A walk test was chosen since walking is one of the most basic human activities and is absolutely necessary in order to carry out many habitual everyday tasks. Our results provide suggestions for optimization of functional capacity and reduction of AMS symptoms in individuals carrying out submaximal exercise tasks at altitude.

## Materials and Methods

### SUBJECTS

Eleven young women and 16 young men were initially selected from kinesiology students at the University of Antofagasta. All subjects were voluntary participants in the study and were sea-level residents with no prior exposure to altitude within the previous 6 months. None of the subjects had a medical history of pathology or had experienced a previous episode of altitude sickness. One man and 3 women were later excluded from the study following their inability to finish at least one of the walking tests at 5050 m. Table 1 shows the anthropometric characteristics of the experimental subjects used to obtain the data. The participants gave their informed consent to participate in the study following attendance at an information session provided at the beginning of the study, in accordance with the recommendations of the Declaration of Helsinki.

**Table 1.** Anthropometric data of the study participants (mean ± standard deviation)

| | *Males* | *Females* |
|---|---|---|
| n | 15 | 8 |
| Age (years) | 21.9 ± 2.0 | 20.4 ± 0.5 |
| Weight (kg) | 73.5 ± 15.2 | 58.6 ± 5.8 |
| Height (cm) | 172.9 ± 5.0 | 161.1 ± 6.3 |
| BSA ($m^2$) | 1.9 ± 0.20 | 1.6 ± 0.10 |
| BMI ($kg/m^2$) | 24.5 ± 4.3 | 22.6 ± 1.9 |

BSA, body surface area; BMI, body mass index.

### PROCEDURE

The study participants performed a 2-km walk test in accordance with Oja et al.[6] The test was carried out on a 100-m long, flat track delineated by a row of cones marking 10 U-turns. Each subject performed 3 walk tests. Before beginning, and while still located at the starting point, they were given the following simple instructions: "Walk at a regular pace, as fast as you can, but without running." Following these instructions, exercise intensity was sufficient to reach around 80% of their heart rate reserve. The estimated percentage of heart rate reserve (%HRR) was calculated according to the formula proposed by Strath et al[7] and this value was used to evaluate the extent of individual accomplishment in the 2-km walk test.

The first 2-km walk test (*Walk 1*) was performed at sea level on the grounds of the University of Antofagasta, and participants subsequently performed 2 more tests at Chajnantor (5050 m) according to the following experimental protocol: Subjects were randomly assigned to 2 groups with different levels of oxygen administration. One group of individuals received supplementary oxygen at a rate of 1 L $O_2 \cdot min^{-1}$, and the other group received 3 L $O_2 \cdot min^{-1}$. Eight men and 4 women were administered 1 L $O_2 \cdot min^{-1}$, forming the groups M1L and W1L, and 7 men and 4 women were administered 3 L $O_2 \cdot min^{-1}$, forming the groups M3L and W3L, respectively. Supplementary oxygen was administered via a Campbell face mask connected