WILDERNESS & ENVIRONMENTAL MEDICINE, **23,** 15–23 (2012)

ORIGINAL RESEARCH

Peripheral Arterial Desaturation Is Further Exacerbated by Exercise in Adolescents With Acute Mountain Sickness

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Objective.—Rapid ascent to altitude can result in the development of high altitude illnesses such as acute mountain sickness (AMS). This study aimed to investigate AMS symptoms in adolescents and study basic cardiopulmonary measurements at altitude.

Methods.—Thirty-eight adolescents aged 16 to 19 years flew to 3500 m from 215 m and continued over a 23-day period to ascend to a maximum altitude of 5200 m. Each member of the expedition completed a Lake Louise Self-Assessment Questionnaire (LLSAQ) on a daily basis, and AMS was defined as a score of ≥3, with an associated headache. Physiology measurements included a step test, and both before and after exercise pulse oximetry, blood pressure, and pulse rate.

Results.—Oxygen saturation inversely correlated with altitude ($P = .001$). Mean pulse rate increased from 70 beats/min (±6.5) at 215 m to 83 beats/min (±2.2) at 3500 m ($P = .01$), and a rise in blood pressure with ascent was highlighted ($P = .004$). The majority of subjects (84%) had an LLSAQ of 3 or more on at least 1 occasion, and they tended to record higher pulse rates ($P = .005$) and lower oxygen saturations ($P = .001$). Exercise-induced drops in oxygen saturation and raised pulse rates were more prolonged in subjects with severe AMS compared with subjects not having AMS ($P = .046$ and $P = .005$, respectively).

Conclusions.—The LLSAQ scoring system appeared to be a simple and effective technique to aid the diagnosis of adolescents who have AMS, and it may help improve the safety of large groups traveling to altitude. The AMS subjects tended to have low oxygen saturations and high pulse rates, highlighting potential areas for further research.

Key words: acute mountain sickness, altitude, adolescents

Introduction

As foreign travel to remote locations becomes more popular, an increasing number of people, including adolescents, are ascending to high altitude environments. Altitude exposure can lead to a number of altitude-related illnesses, some of which are self-limiting whereas others are more serious. Numbers of persons affected are rising as travel to high altitude is increasing. The rate of ascent can affect the incidence of such conditions, and a wider recognition of the risks is to be encouraged.

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On ascent to altitude, the atmospheric pressure falls. Although the fraction of oxygen in inhaled air (Fio_2) remains constant at 21%, the oxygen partial pressure drops from approximately 160 mm Hg at sea level to 103 mm Hg at 3500 m: a reduction in available oxygen of 35%.[1] Altitude illness can vary from simple headache that resolves spontaneously to high altitude pulmonary edema and high altitude cerebral edema, which require prompt treatment. Acute mountain sickness (AMS) is usually a self-limiting condition that develops shortly after ascent to high altitude and usually resolves after a few days of acclimatization.[2] It can occur above approximately 2500 m and has the symptoms of headache, nausea, vomiting, fatigue, and sleep disturbances. Symp-

toms are more likely to occur or become more severe at higher altitude and when ascent is rapid.[3] Although acclimatization occurs if ascent to altitude is more gradual, some persons are inherently more susceptible to AMS.

Published studies of AMS show a wide range of incidences, among both adults and adolescents. A suggestion that adolescents are at greater risk of AMS than adults is supported by the results of some studies that found higher incidence rates among adolescent populations.[4,5] A 27.0% incidence rate of AMS among adults at 4400 m was identified in 1 study, with the rate among adolescents in the group reported as 50.0%.[4] Another study of adults and adolescents showed similar incidences: 25.0% and 45.0%, respectively, on ascent to altitudes of 2000 m to 3000 m.[6] Even higher rates of AMS among adolescents have been shown by other studies, one of which identified a prevalence of 91.7% in a group of 15- to 18-year-olds traveling to 5500 m.[5] The evidence is not conclusive, however, and many studies do not show this higher incidence among younger people.[7,8] As recent studies show, the daily incidence even within a single study can vary markedly. Adolescents traveling to altitudes as high as 4100 m showed incidences of AMS ranging between 3.8% and 42.3%.[9] The varying incidences reported in the literature highlight the challenge of understanding the mechanisms involved. The altitude reached, ascent rates, physical activity while at altitude, and factors such as fitness, comorbidities, and general health may all play a part.

The Lake Louise Self-Assessment Questionnaire (LLSAQ) was originally a research tool,[10,11] but has been found to be potentially beneficial to trekking groups as a means of identifying persons displaying symptoms of AMS and of adapting the itinerary accordingly. The LLSAQ scores symptoms of headache, nausea, vomiting, fatigue, and sleep disturbances according to severity, and total scores for an individual subject are collated. The system has been used in many studies of adults at altitude, but fewer studies have investigated adolescents.[5,9]

The aim of this study was to record the symptoms of AMS in an adolescent population ascending to altitude. We further sought to investigate whether AMS, as diagnosed using the LLSAQ, was associated with particular trends in oxygen saturation, pulse rate, and blood pressure both before and after exercise.

Methods

The study was performed on a British Schools Exploring Society (BSES) group of young people traveling to altitude for the first time. All participants were healthy, taking no prophylactic drug treatments for AMS, and gave written informed consent to take part in the study. Written approval for the study was obtained from the Coventry and Warwickshire Research and Ethics Committee.

The participants traveled from the United Kingdom to New Delhi (at 215 m), where initial "sea level" measurements were taken as a control, and subsequently flew to Leh, Ladakh (at 3450 m). Measurements were taken daily while the subjects were acclimatizing for 4 days in Leh and during subsequent ascent along the Thansglasgo and surrounding valleys. Thirty-eight adolescents took part and underwent an identical ascent profile for the initial 7 days of the expedition. One person left the expedition on day 7 owing to development of suspected pulmonary edema. The expedition then split into 2 groups. One group (9 females, 10 males) proceeded up a valley to a maximum height of approximately 5800 m and completed recordings to 5200 m over an additional

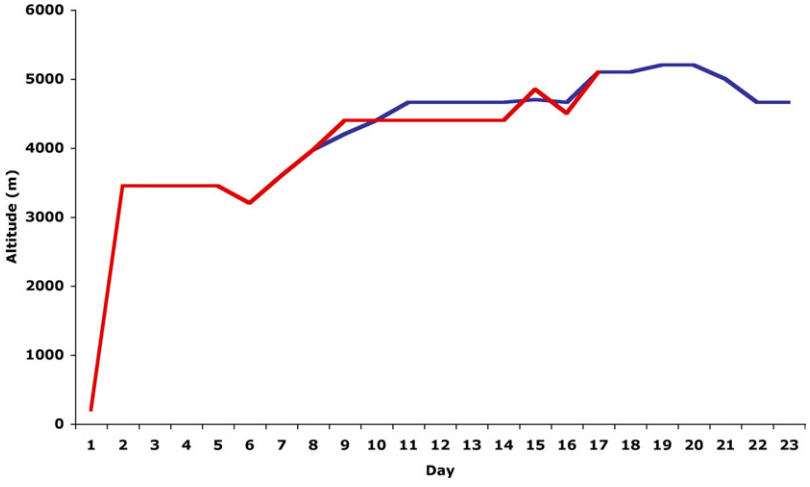

Figure 1. Expedition altitude ascent profiles. Group 1 (blue line) recorded data for 23 days, and group 2 (red line) recorded data for 17 days.

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