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Risk Stratification for Athletes and Adventurers in High-Altitude Environments: Recommendations for Preparticipation Evaluation

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High-altitude athletes and adventurers face a number of environmental and medical risks. Clinicians often advise participants or guiding agencies before or during these experiences. Preparticipation evaluation (PPE) has the potential to reduce risk of high-altitude illnesses in athletes and adventurers. Specific conditions susceptible to high-altitude exacerbation also important to evaluate include cardiovascular and lung diseases. Recommendations by which to counsel individuals before participation in altitude sports and adventures are few and of limited focus. We reviewed the literature, collected expert opinion, and augmented principles of a traditional sport PPE to accommodate the high-altitude wilderness athlete/adventurer. We present our findings with specific recommendations on risk stratification during a PPE for the high-altitude athlete/adventurer.

Key words: preparticipation evaluation, altitude, chronic disease AND altitude, wilderness sports, wilderness athlete

Introduction

High-altitude trekking and mountaineering are popular internationally. Davies et al[1] suggest 30 000 trekkers annually attempt Mt. Kilimanjaro. Records from sagarmatha National Park, Solukhumbu, Nepal, report 37 000 Everest trekkers annually as of April 2015.[2] Hackett and Roach[3] estimate 30 million Western States visitors, 1200 McKinley climbers, 10 000 Rain climbers, and over 4000 Aconcagua climbers are at risk for altitude illness each year. These authors go on to say “Increasingly, physicians are confronted with questions of prevention and treatment of high-altitude medical problems as well as the effects of altitude on preexisting medical conditions.”[3]

Few physicians are both qualified and available to provide advice or pretrip counsel to such individuals. Guidelines on preparing individuals for altitude adventures largely do not exist beyond expert opinion from a select few articles. Doan and Luks[4] provide an excellent resource for sports and travel at altitude in individuals with asthma. Collective recommendations reflecting other conditions, however, are rare or nonexistent. Here, we offer suggestions for the health provider who is not an expert in high-altitude medicine on how to facilitate a preparticipation evaluation (PPE) directed to the high-altitude athlete or adventurer. The authors of this article do this by presenting a strategy for risk stratification based on guidelines for the prevention and treatment of acute altitude illness and also consider the presence of health conditions of individuals that pose risk for participation in high-altitude adventures in addition to known risks of injury and illness at altitude.

Giving “clearance” may not be the role of the screening provider regardless of their level of training. Wilderness sports are not typically governed by rules and regulations in the same way as traditional or organized sports. Although high-altitude-guided trips in many cases require a physician clearance, this process is not

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standardized nor outlined for the screening provider. With a focused outline on areas specific to altitude adventures, the screening provider can assess risk by evaluating the health status and stability of chronic conditions of the participant. The provider can then risk stratify the high-altitude athlete/adventurer and educate him/her based on those findings.

Building on principles of a traditional PPE,[5] an evaluation for altitude adventures should emphasize altitude-specific issues. In general, this will involve screening for life-threatening/disabling conditions and for conditions that can predispose to injury or illness. Secondary objectives should determine overall health and facilitate a discussion on health-related topics.[5]

Ultimately, the individual's health status will predict the extent of the PPE, and the history is the most important component.[5] Physical examinations may not always occur, as in the case of clinicians reviewing health history forms of clients on guided expeditions or providing counsel to individuals over the phone or Internet. Referral to specialists may be indicated for any issues needing further evaluation. Concerns for heart disease such as hypertrophic cardiomyopathy, long QT syndrome, and Wolff–Parkinson–White will likely indicate a cardiology referral, as would complicated pulmonary or gastrointestinal concerns need specialty evaluation. We recommend being thorough yet reasonable to avoid unnecessary studies or interventions.

Because medical care is not always immediately available on high-altitude adventures, the other members of the group may become the health care providers. Because of this, patients with chronic medical conditions have an obligation to inform their teammates of the severity, extent, and treatment options for their conditions. We encourage self-awareness in the high-altitude athlete/adventurer and open disclosures to a team about the status of health conditions.

Methods

Using the databases of MEDLINE, Cochrane, and Embase, we cross-referenced the key term "preparticipation evaluation" with variations of "altitude," "chronic disease AND altitude," "wilderness sports," and "wilderness athlete" to identify articles published in English from peer-reviewed journals. We also referenced book sections to facilitate discussions on altitude physiology.

Basic Principles of Altitude Physiology

Understanding adaptation to high altitude is essential to provide guidelines that optimize both the health and success of the high-altitude athlete/adventurer training or performing at high altitude. High altitude is defined as 1500 to 3500 m (∼4950-11 500 ft), very high altitude as 3500 to 5500 m (∼11 500-18 050 ft), and extreme altitude as >5500 m (∼18 050 ft), over which long-term acclimatization is considered impossible.[3]

The body can acclimatize to achieve near sea level values of exercise performance while training at modest altitudes (approximately 2500 m/8200 ft). But, even prolonged duration and training at moderate to very high altitudes does not bring exercise ability back to sea level performance.[6] Variability to acclimatization, likely based on genetics, results in a broad bell-shaped curve of human physiologic responses to altitude. Some individuals never fully adapt to altitude and can incur acute, subacute, and/ or chronic altitude illness. The first public awareness of the effect of high altitude on athletic competition occurred in the 1968 Olympics in Mexico City (2200 m/7200 ft) where the best athletes in the world from lower altitudes experienced poorer performances in aerobic events than had been expected.[7]

Aerobic capacity decreases on ascent to high altitude because of the decrease in partial pressure of oxygen and thus availability of oxygen in the inspired air.[6,8–10] The fraction of oxygen in the earth's atmosphere remains constant at 0.2093, whereas the density of the air as measured by the barometric pressure (Pb, mm Hg) decreases.[11] To obtain the same amount of oxygen requires moving increasingly greater volumes of air in the lungs, so ventilation increases on ascent to high altitude.[12,13] It occurs immediately and results in a higher alveolar PO_2 and lower alveolar PCO_2, thus supplying a higher level of oxygen for gas exchange than would otherwise be expected if ventilation did not increase. The subsequent progressive increase in alveolar ventilation over days and weeks increases alveolar and arterial PO_2.

Further acclimatization occurs from 2 adaptations: (1) the compensatory excretion of bicarbonate from the kidneys leading to a metabolic acidosis (partial compensation of the respiratory alkalosis) and (2) increasing sensitization of the carotid body. Responses vary widely, which has implications for adaptation, performance, and susceptibility to altitude illnesses (HAI), whereas at low altitude, the manifestations of these characteristics go unnoticed.

Dyspnea is experienced on the first ascent, even at modest altitudes. This dyspnea decreases somewhat on acclimatization to a specific altitude while ventilatory drive and resting and exercise ventilation are increasing.

Gas exchange across the alveoli occurs normally, but the lower alveolar PO_2 imposes a diffusion limitation of oxygen from the air to the blood resulting in further hypoxemia.[14,15] As high altitude increases, the diffusion limitation for oxygen increases such that there is not sufficient time for full equilibration of alveolar PO_2 with capillary PO_2. This process is accentuated by exercise when the transit time of