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Review Article

Altitude Training for Athletes

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Introduction

Altitude training has long been considered an effective and safe [1] tool for developing moderate to long-duration exercise capacity changes in human physiology. Epitomized by the slogan “live high train low,” we have seen many athletes from fighters to marathoners embrace this concept with success. When done correctly, altitude exposure can provide the athlete with many benefits associated with acclimation to the lower levels of oxygen. However, these benefits do not come without risk. When altitude exposure comes too quickly, or the athlete ignores the physiological signs of overexposure, the consequences can be extreme, ranging from minor sickness to death. First off, athletes need to understand the definitions of training at altitude. ACSM defines altitude categories as low (under 3,937 feet), moderate (up to 7874 feet), high (up to 13,123 feet) and very high (over 13,123 feet) [2]. These classifications are important as the physiological changes that take place tend to change incrementally with ascending heights.

As athletes persist through elevation training, many considerations should be made to climatize appropriately to minimize the risk of injury. Those who avoid the considerations of timely exposure run the risk of developing any number of illnesses ranging from the diagnosis of acute mountain sickness to high altitude cerebral or pulmonary edema [2]. Acute Mountain sickness, the most common and mild of the three, can result in a person falling ill to coughing and respiratory distress for 1-2 days where high altitude edemas can result in death if not dealt with immediately [2]. On the other hand, athletes who follow an intelligent acclimation program can benefit highly from the numerous physiological effects. Initially, those who increase their altitude exposure can expect an increase in heart rate and cardiac output of 30-50% [3]. With an increase in elevation comes a decrease in atmospheric oxygen pressure. This causes a decrease in hemoglobin saturation and arterial oxygen pressure leading to a decrease in available oxygen to the working muscles [4]. The heart must, therefore, increase its rate and output to keep up until acclimation takes place. During the initial exposure, an athlete who oversteps their limits in training can be at a higher risk for developing the deleterious health conditions mentioned earlier as they have not yet made the necessary adaptations to their new environment [2]. Despite this, it only takes an average of two weeks at moderate elevation for the athlete’s heart rate and cardiac output to return to normal [3,2]. Once cardiovascular levels are normalization and acclimation has taken place, the athlete will enjoy an estimated 5-15% increase in hemoglobin and a 30-50% increase in red blood cells [3] allowing the athlete to supply more oxygen to the working muscles when less atmospheric oxygen is available.

While some cardiac adaptations are predictable, others are not. Vo2 Max is one such factor. It is interesting to note that Vo2 max changes seem to be individual and not a standard response. Many athletes will see a noted decrease in Vo2 max upon training at elevation, while some will see increases. To further complicate the matter athletes returning to sea level can see the same unpredictable changes in Vo2 max. Even more interesting is how some athletes can detrain during altitude training. Detraining is typically the result of an overall decrease in work capacity while training at elevation [4]. This information should not detract from the idea that altitude training is beneficial but build the argument that such training should only be done under the supervision of trained professional exercise physiologists. There are too many ways for athletes to be hurt or ruined during such training.

While the cardiovascular benefits of altitude acclimation are vast, one cannot forget the respiratory benefits as well. Athletes exposed to altitude will also, in time, develop respiratory muscles capable of handling reduced oxygen loads. It has been noted that in extreme exposures such as heights above 13,000 feet, the muscles responsible for respiration, namely the diaphragm can suffer fatigue, as more oxygen is demanded [4]. This concept reinforced the need for a tiered acclimation program for desiring athletes so they can build up the proper respiratory muscle endurance while the physiological changes take place. The question continues to remain however, how does one achieve proper acclimation? Numerous studies and coaches have demonstrated the concept of graded altitude exposure to stimulating the physiological adaptations for performance enhancement. A technique that has proven effective has been for athletes to alternate exposure altitudes. Training for one to two weeks at a moderate height, followed by one to two weeks at sea level [4], has proven to allow athletes time to adapt and recover simultaneously. Interestingly athletes can enjoy adaptations far beyond those of their current training elevation. The ACSM has published material showing that while training at a specific altitude, one can have lasting effects and avoid altitude sickness at heights incrementally larger. Coaches can multiply the current level of training by 305m or 1000ft to estimate the upper limit benefits; this equation has held to 14,000 ft [2].

Taking physiology, a step further, athletes and coaches can use modern technology to establish current baselines and adaptation responses in their athletes. Pulse oximetry is one such tool. As athletes train and adapt to increasing altitudes, knowledge of oxygen saturation can clue coaches into what is going on physiologically with their athletes. Monitoring saturation levels can help teams decide if athletes are ready to train hard or if further adaptation time is needed [5]. Despite the benefits of training at altitude, the sheer convenience of living high and training low can be a deterrent for many people. Many times, athletes do not live in locations allowing exposure to such vast environments. The inconvenience of individual relativity to high and low landscapes has spawned an entirely new wave of research into various techniques that can create the physiological response one gets from training at elevation without actually having to train there. One such technique has been rebreathing. The concept of rebreathing was used to effectively create arterial hypoxia similar to that of moderate to high altitude exposure. However, this concept was proven to be ineffective at creating lasting effects the way true acclimation does [6,7] also concluded that hyperbaric high-altitude simulated living provided no benefit over actual low living performance at sea level. The meta-analysis by [8] Bonetti and Hopkins (2009) supports the idea that artificial hyperbaric simulation of altitude does not provide the same benefits as actual exposure to increased elevation.

Oxygen restricting masks and breathing devices have also made an impact on the market. Many claim to provide the same benefits as attitude training, yet the facts may suggest otherwise. Some researchers have noted that wearing oxygen deprivation masks during activity can induce moderate hypoxia [9] but cannot stimulate hemoglobin production [9]. This is a blow to the current claims of many manufacturers as hemoglobin production and blood chemistry changes are some of the more beneficial aspects of altitude training. What the research has shown is that oxygen deprivation masks may improve Vo2 max in other ways. These devices may serve as quality respiration trainers aiding in the development of many of the muscles responsible for breathing [9,11]. While not the same as altitude training, these products may have their place in breathing training after all.

The ramifications of training at higher elevations cannot be overlooked. Human physiology has an amazing ability to adapt to its imposed demands. These adaptations can have lasting effects leading to improved performance and output with little risk when proper precautions are taken. However, when proper precautions are not taken, athletes can suffer gravely. Interestingly despite our best efforts, humans have yet to recreate the benefits seen by simply adapting to our natural surroundings.

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