REPORT

High altitude training – developing an international centre for Sri Lanka: evaluating for the best outcome

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Abstract

This article is based on the detailed inception report on technical evaluation, which was presented on request to the Ministry of Sports, Sri Lanka in June 2017, proposing the establishment of a Sports Medicine Human Performance and Research Centre at the planned High Altitude Training Centre (HATC), Nuwara Eliya, Sri Lanka. The report was compiled by the Sports Medicine and Research Evaluation Team at the Faculty of Medicine, University of Colombo and the Project Consultancy Unit, University of Moratuwa in collaboration with international content experts. The objective of this report was to inform the Sports Medicine requirements that should be considered during development of the high altitude training centre in Sri Lanka. This article discusses the scientific basis of altitude training, the global context listing several international centres for altitude training and the Sri Lankan context with the assessment of the environmental suitability and recommendations based on available evidence.

Introduction

High altitudes are defined as geographical locations 3000-5500 m above sea level. Different research studies, various professional bodies and institutions worldwide have specific definitions for 'high altitude'. The consensus statement of FIFA Sports Medical Committee 2008, defines elevations between 0-500 m as 'Near sea level', above 500 m - 2000 m as 'Low altitude', 2000 m - 3000 m as 'Moderate altitude' and above 5500 m as 'Extreme altitude' [1, 2].

Training at low-to-moderate altitudes (500-3000 m) has long been used with endurance athletes to enhance subsequent sea level endurance performance or to acclimatise to competition at altitude. This mainly occurs through the elevations in blood parameters and / or other means of improving oxygen transport and utilisation [3, 4]. This phenomenon of metabolic adaptation provided athletes an alternative mechanism to increase endurance, and thereby, their level of performance in sports. This interest in Altitude Training (AT) has grown since the 1968 Olympics in Mexico City (2400 m), when the impact of hypoxia on sport performance became clear [5]. This has revolutionized the training of athletes for competitions since most of elite athletes engaged in individual endurance sports are now using AT [6] and athletes from different 'team sports' worldwide engage in AT more than ever before.

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The science behind human body responses to altitudes

Human physiological adjustments as a result of exposure to altitude environments have been studied from the 17th century by various scientists.

The science behind the response of the body to altitudes at rest is well understood. The environmental hypoxia (low oxygen levels in the inspired air) that is observed in altitudes results in a series of physiological adaptations in the body that increases oxygen carriage by blood and utilisation by the muscles [7]. The long term physiological benefits or the adaptations to altitudes is mainly by the increase production of red blood cells in the body through stimulation of erythropoietin hormone, which increase due to low oxygen levels in blood (hypoxaemia). This in turn increases the oxygen carrying capacity of blood and endurance-like performance.

Research on body's response to altitude while exercising, has developed over the recent past. The hypoxic stress may not be the only factor involved in the enhancement of performance during training since other central (e.g., ventilation, haemodynamics or neural adaptations) and / or peripheral (e.g., muscle-buffering capacity or economy) factors may also play an important role.

A negative aspect to the physiological effects of acclimatization has also been studied extensively. Research studies have identified decrease in the blood flow to skeletal muscles, larger risk of dehydration, depression of immunity from living in high altitudes, possible effects of decrease in the absolute training intensity, decreased plasma production and increased destruction of red blood cells (haemolysis) after returning to low altitudes [8]. This highlights that best practice once training at altitude would need to be informed by research in order to maximize training responses and minimize potential side-effects of chronic hypoxic exposure.

Types of altitude training

Training that can be completed at altitudes has evolved considerably and can be categorized into three distinct types [4, 9].

1) Live-high train-high (LHTH)
2) Live-high train-low (LHTL)
3) Live-low train-high (LLTH)

These training modalities can be achieved with natural altitude, simulated altitude or a combination of both. The LHTH method involves both living and training at low-to-moderate altitudes to induce positive hematological adaptations. A potential limitation of this technique includes decrease in the aerobic capacity of the person with altitude (1% drop for every 100 m altitude ascent above 1500 m) [10]. This limits training intensities where athletes can't train at similar high intensities than they would normally do near sea level. The LHTL involves living at high altitude while training at lower elevations. This can be achieved either through travelling between different altitude locations or through the use of artificial means of reducing oxygen delivery to the body, such as use of masks (hypoxicators and portable devices) or living in a low oxygen environments (e.g. nitrogen house, hypoxic chamber). With the LLTH approach athletes breathe hypoxic air during their usual exercise training, while living near sea level. Today, the LHTL intervention is probably recognized as the "gold standard" for maximized normoxic exercise performance gains in athletes [11].

The duration of residence / training at altitudes has also been considered a major factor dictating what is the preferred AT method to implement. Although there is no clear consensus today in the scientific community, in individual athletes, the success of altitude training may require living high enough (>1800 m), for enough hours a day (>12-14 hours / day), for a sufficient period of time (>15 days), in order to sustain an erythropoietic effect of hypoxia; (~250-300 h) [4].

High altitude illnesses

There have been cases during events such as mountain races, athletes may experience very rapid ascent to high altitudes, which places them at high risk for developing altitude illness [12]. At any point 1-5 days following ascent to altitudes ≥2500 m, individuals are at risk of developing one of three forms of acute altitude illness. Acute mountain sickness (AMS), a syndrome of nonspecific symptoms including headache, lassitude, dizziness and nausea; high-altitude cerebral oedema (HACE), a potentially fatal illness characterised by ataxia, decreased consciousness; and high-altitude pulmonary oedema (HAPE), a non-cardiogenic form of pulmonary oedema resulting from excessive hypoxic pulmonary vasoconstriction which also can be fatal [13]. Risk factors for developing high altitude illness include previous history of high altitude illness, a faster rate of ascent, higher elevation, poor hydration, increased intensity of physical activity, and individual variability [12] .

Slow ascent to altitude is the hallmark of prevention for all acute high altitude illnesses. Guidelines recommend that once above 2500 m, altitude should be increased at a rate of 400 m to 500 m per day [14, 15]. Duration of an effective acclimatization also depends on the athlete's residing altitude and the altitude to which the athlete plans to ascend.

The athletes may be at lower risk for these illnesses at lower elevation less than 2000 m, at the proposed centre in Nuwara Eliya. Still appropriate measures should be in place as some individuals who are highly susceptible to acute altitude illness may become symptomatic at altitudes <2500 m [13]. Acute mountain sickness (AMS) can be more common in the lower elevations. The athletes of poor subjective sleep quality is should be cautious as insomnia can become a risk factor for AMS.

Recent advances in altitude training

With the advancing research, new approaches like intermittent hypoxic interval-training (IHIT) and living high-training low and high (LHTLH) (16) techniques have been developed. They can improve physical performance, and can be specifically tailor-made for team-sport use, in order to better resist fatigue in the more intense periods during a game or towards match-end [4].

Currently, high altitude training is not only reserved to endurance athletes as in the past. Different sports will use different methods depending on whether the athletes are looking to improve blood carrying capacity (LHTH, LHTL) or up-regulate muscle adaptations (LLTH). The recent innovative methods like "Repeated Sprint Training in Hypoxia (RSH)" or "Resistance Training in Hypoxia (RTH)" are likely to induce peripheral muscle adaptations and postpone fatigue [17]. These methods provide different platforms of endurance training which can be altered to suit different situations in sports. It also has been used to promote injury recovery and rehabilitation among athletes [5].

A few recent studies have shown that high altitude training can benefit cardiorespiratory (heart and lung function) fitness and metabolic health [18] . This may favour translation of latest research findings into effective therapies and clinical practice for diseased populations (diabetes, obesity, heart disease, cancer). High altitude training is now used for physical activity management and injury prevention using innovative interventions. Also these interventions should be well planned as prognosis related to high altitude training is based on individuals' medical condition, general physical fitness and susceptibility to high altitude sickness [13, 19].

An overview of other altitude training centres in the world

Several terrestrial altitude training sites exist around the world that offers relatively comfortable living and training conditions to athletes of all performance levels and to their coaching teams. It is crucial to identify those sites (especially the geographically closest ones to Sri Lanka) which may directly compete with the Nuwara Eliya facility for offering altitude training opportunities to athletes. As there are no renowned or reputed training centers in South Asia at the moment, the reasons for not having altitude training centres have to be identified. It may be beneficial to study the reasons that led to failure of the altitude training project in Kerala, India in order to avoid similar mistakes occurring in Sri Lanka.

There are several world-renowned training centers. The most famous within the sporting community are (by ascending altitude): Premanon (1200 m in France); Thredbo (1350 m in Australia); Crans-Montana (1500 m in Switzerland); Albuquerque (1500 m in USA); Potchefstroom (1550 m in South-Africa); Snowfarm (1560 m in New Zealand); Pretoria (1750 m in South Africa); Boulder (1780 m in USA); Ifrane (1820 m in Morocco); St. Moritz (1820 m in Switzerland); Font-Romeu (1850 m, France); Colorado Springs (1860 m, USA); Kunming (1860 m, China); Belmeken (2000 m, Bulgaria); Eldoret (2100 m, Kenya); Flagstaff (2130 m, USA); Sierra Nevada (2320 m, Spain); Iten (2350 m, Kenya); Addis Ababa (2400 m, Ethiopia); Bogota (2640 m, Colombia); Quito (2740 m, Ecuador) and La Paz (3600 m, Bolivia).

Sri Lankan context

A systematic needs assessment through a baseline survey or through a research of a similar calibre will be mandatory to decide on the scope of the high altitude training centre for Sri Lanka. This will also allow the funds to be used cost effectively and will maximize the benefit to the athletes. The country will also gain international recognition as having an excellent AT centre catering to athletes of all kinds.

Nuwara Eliya, the site selected to construct the High Altitude Training Centre (HATC) is important. The elevation of 1,868 m (altitude) at Numara Eliya, the selected area, with a mean annual temperature of 16°C (61°F) [20] is ideal. The average rainfall of 2000-2100 mm should be taken into consideration in preparing training schedules.

With the recent development in AT methods, the proposed project features the inclusion of an Environmental Chamber (where temperature, humidity and / or hypoxia-hyperoxia levels are controlled) allowing near sea level (normoxia) or more severe hypoxic training sessions to be completed on-site. It should be highlighted that Kandy, the hill capital of the country, is located around 1-2 hours way from planned HATC Nuwara Eiya. Training at lower elevations (500 m) can be performed in Kandy. Use of hypoxicators at low elevations (e.g. Kandy) is an available option, where athletes can combine training at lower and higher elevations. This will provide the opportunity for advanced hypoxic training to Sri Lankan athletes and also offer unique training for international athletes.

In addition to the hypoxic stimuli, the international athletes will want to heat acclimatize as well, since many competitions in Asia will be held in hot environmental conditions in the future.These heat / humidity pre-acclimatization strategies will serve to prepare them very effectively for the harsh environmental conditions (30-35°C / 30-40% relative humidity) that they will often face when competing in South Asia [21].

The distance from the international airport and the nearest hospital and transport facilities available are important points to consider.

Requirements and Recommendations

Considering that the general requirements are met, the proposed Sports Medicine Human Performance and Research Centre at HATC should feature the following services / installations to suite the international standards:

1. Medical and sports science unit
2. Rehabilitation and recovery unit
3. Human performance centre with an environmental chamber
4. Research and academic unit
5. Reception with common area and data management space

General requirements

1. The human and infrastructure resource requirements should be decided following a detailed needs assessment guided by the future plans of Ministry of Sports (MOS) Sri Lanka. The space, number of staff needed and the qualifications of the staff will depend on the findings from this needs assessment.
2. All these proposed units should be integrated with the research and academic unit with regard to data handling. Sustainable collaboration should be there with a local university of good repute through preferably a Memorandum of Understanding (MOU). Collaboration with international resource centres would be very advantageous for the future international athlete attendance.
3. There is a need for a satellite centre in Colombo to test athletes at sea level.
4. It is strongly recommended that an environmental chamber is built within the human performance centre. This would clearly make the Nuwara Eliya facility unique in the world and open doors for a range of innovative heat / hypoxic training methods which can be offered to international athletes.
5. All facilities should be accredited according to international standards. It is essential to adhere to accepted protocols from the design stage itself.
6. There is a need to identify other high-altitude training centres in the region (especially the nearest ones) which may directly compete with the Nuwara Eliya facility for altitude training. At present, there are no centres in the South Asian region. However, it is important to find the reasons for the failures (for e.g. Kerala, India), and learn from previous experiences.
7. Focus should be to have specialist service provision for a maximum of 30-40 elite / international athletes at a time to maintain high standards. The profile of athletes who are going to use the Nuwara Eliya facility will have to be clearly defined.
8. A human resource plan has to be discussed in advance. There is a need to establish clear job descriptions of different service / care providers (e.g. sports physicians, physiologists, clinical and research scientists, strength and conditioning coaches, sport science managers, nutritionists, physiotherapists, trainers, etc.)

Summary

Different types of AT have been used to enhance the endurance performance of athletes. Recent advances in AT has implemented innovative methods to extend the benefits of physiological adaptations to improve strength, power, promote injury recovery and rehabilitation in athletes. In addition, it has been shown that AT is a useful therapy in injury prevention and management of certain medical conditions.

There are no renowned HATCs in South Asia and the proposed Nuwara Eliya facility for AT is an ideal set-up as it has unique features such as high elevation, ideal temperature and proximity for low elevation areas within a short travel time. A detailed need and feasibility assessment should be carried out when developing this project, with initiation of sustainable local and international collaborations and quality assurance, allowing for integration with academic and research units.

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