Simulated Altitude Training

In this presentation we explore simulated altitude training or SAT for short. Not for elite sports performance but for everyday people, keep fit enthusiasts and also the health and fitness benefits to the general population.

Background

From as early as the 1960s and 1970s, sports scientists and athletes have been experimenting and taking advantage of the performance benefits of real and simulated altitude training. Today, with the increased budgets for professional sport, there is greater depth of knowledge in nutrition and exercise physiology. Professional teams such as SKY pro cycling openly discuss the importance of marginal gains and the benefits of altitude training for their athletes.

Can everyday people benefit from this sport and performance dominated training principle?

Can altitude training help combat sedentary lifestyle, obesity and related diseases?

Obesity and related illness such as type 2 diabetes are important public health problems worldwide. Low-calorie diets, programmes of physical activity and behavioural therapy are common strategies to lose weight in the obese patient. Could our environment be adding to this problem? Studies show that the risk of obesity and related illness are higher in sea level dwellers (1). Could an increase of altitude by 2000m (6561ft) or intermittent exposure to higher altitudes lead to reduced body mass index, improvements in aerobic condition and a reduction of obesity related illness such as heart disease and type 2 diabetes?

Altitude explained – The environment and physiological response

The air we breathe is a mixture of gases. Nitrogen is the most prominent with roughly 79%, then Oxygen at 20.9% and a mixture of other smaller gasses making up our atmosphere. As we ascend a mountain and/or go to a higher altitude, the air is described as becoming thinner with less available molecules per breath. This is due to lower atmospheric (air) pressure. Simulated altitude systems focus on the most important molecule, oxygen, essential for energy production and life itself. By reducing the percentage of available oxygen, altitude rooms simulate altitude conditions without lowering air pressure. This is called a Normobaric (sea level) Hypoxic (low oxygen) environment. Altitude rooms can be set at sea level (20.9% O_2) through to 5000m (11.5% O_2).

Benefits

The goal of SAT is to stimulate adaptation to hypoxia. Hypoxia is a term used to describe a drop in blood oxygen levels. These adaptations are multisystemic with haematological (Blood) and Endocrine (Hormonal) responses working to help the body maintain normal oxygen delivery to the cells for energy production.

Improved aerobic condition and endurance

Research geared towards endurance athletes and improved performance at sea level often quote the Erythropoietin (EPO) Response. Stimulated by hypoxia, the kidneys express EPO signalling the bone marrow to produce more red blood cells (oxygen carrying cells). (4,5)

Research suggests that adaptation to hypoxia through SAT offers a major benefit to aerobic condition and improved endurance, this results in improved oxygen delivery and utilisation without increasing the muscular skeletal load or exercise time. (2,3)

Health and Well-being

The results of adaptation to hypoxic conditions of altitude have been well documented especially in the field of sports performance. However, research suggests that theses adaptations also have potential medical applications for heart protection and the cardiovascular system. (6) The adaptations are also found to enhance the positive outcomes of exercise, reduce metabolic risk factors and improve glycaemic control.(7,8,9) Physical exercise and even deep breathing produces endorphins (chemicals in the brain that act as natural painkillers) improving your ability to sleep, which in turn reduces stress. SAT has the potential to reduce levels of psychological stress and anxiety without the impact stress or muscular skeletal load associated with high intensity exercise.

Weight control

Evidence of increased weight loss in the non-athletic population has been shown in several studies. One study (8) showed a reduction in triglycerides and body fat levels suggesting greater lipid oxidation following a 4 week (60 min 3 x per week) moderate intensity protocol at 15% O_2 (3000m) compared to the normoxic control group. The control group worked at the same cardiovascular level but with more intensity (impact). Similar results were seen in a low intensity walking study (10). Key here is the occurrence of metabolic stimulus at a lower mechanical load, valuable to obese persons starting an exercise programme who may also be exercise impaired. Other hypoxic stimulated responses include the increased production of the hunger suppressing hormone Leptin and enhanced glucose transportation. (7, 11, 12,)

Muscle gain

Unlike real altitude, because of the intermittent nature of SAT, it is possible to keep quality exercise with combined hypoxic and sea level protocols, thus limiting muscle atrophy. Possibly the most exciting recent theory is that SAT could not only help maintain or stimulate muscle growth, but, with the right protocol, it could be more productive than sea level resistance training by stimulating growth with less muscular skeletal load. This could be of great benefit to older clients or clients returning from injury or illness. Resistance training during acute exposure to hypoxia before returning to normal sea level conditions has been shown to provide a positive impact on training and adaptive response (13). Resistance training in hypoxia (13% O_2) caused greater increases in lactate (an indication of exercise intensity), epinephrine, norepinephrine, and growth hormone. (14) These findings suggest that resistance training under SAT induced hypoxia caused greater hormonal responses and greater increases in muscular endurance than that under normoxic conditions.

Improved sleep and stress management

When stress affects the brain, with its many nerve connections, the rest of the body feels the impact as well. So it stands to reason that if your body feels better, so does your mind. Exercise and other physical activity produce endorphins—chemicals in the brain that act as natural painkillers—and also improve the ability to sleep, which in turn reduces stress. Meditation, acupuncture, massage therapy, even breathing deeply can cause your body to produce endorphins. And conventional wisdom holds that a workout of low to moderate intensity makes you feel energized and healthy.

Technology

Altitude rooms were once only accessible through Universities, research facilities or Institutes of Sport. Increased demand has led to the development and improvement of technology such that altitude rooms are accessible to the population at large.

Improvement in technology has resulted in more energy efficient systems which minimise installation and running costs. Altitude room configurations include both passive and active training areas with multiple zone technology enabling flexibility of services offered and optimum member access both of which can enhance business value and income.

Methods

There are numerous protocols and training methods. Some passive, some active, with combined protocols showing the greatest benefits. (2,3) The various protocols and hypoxic dosage produce a range of physiological responses. Including: improved oxygen delivery to the tissues and energy producing cells, increased metabolism and calorific expenditure, enhanced hormonal responses leading to improved growth and a greater tolerance to exercise intensity.

Passive intermittent hypoxic exposure

Originally conducted through mask based systems, technology has improved and developed so that clients can now enjoy the comfort of altitude lounges and hotel rooms. Passive exposure provokes physical responses similar to exercise and has the potential to reduce levels of psychological stress and anxiety without the impact stress or muscular skeletal load associated with high intensity exercise. Passive sessions can be conducted several times throughout the week. Sessions commonly last between 60 to 90 minutes or longer sleeping sessions will add to the hypoxic dosage. Clients will also benefit from performing good breathing techniques at altitude. Monitoring of blood oxygen levels and heart rate with a pulse oximeter will highlight change and show adaptation to the altitude environment.

Active intermittent hypoxic training

Active sessions conducted in an altitude room will enhance the positive effects of physical exercise. Sessions tend to be shorter in duration with reduced mechanical load. Exercises such as light cardiovascular, functional body weight or resistance exercises are possible.

References

1. Lhamo Y. Sherpa, Deji, Hein Stigum, Virasakdi Chongsuvivatwong, Dag S. Thelle and Espen Bjertness. Obesity in Tibetans Aged 30–70 Living at Different Altitudes under the North and South Faces of Mt. Everest. Int J Environ Res Public Health. Apr 2010
2. Robertson, E., Saunders, P., Pyne, D., Gore, C., Anson, J. (2010). Effectiveness of intermittent training in hypoxia combined with live high/train low. Eur J Appl Physiol. 110(2):379-87.
3. Millet, G., Roels, B., Schmitt, L., Woorons, X., Richalet, J. (2010). Combining hypoxic methods for peak performance. Sports Med. 40(1):1-25
4. Bartsch, P. Saltin, B. (2008). General Introduction to altitude adaptation and mountain sickness. Scand J Med Sci Sports. Aug;18 Suppl 1:1-10
5. Saunders, P. Pyne, D., Gore, C. (2009). Endurance training at altitude. High Alt Med Biol. 10(2):135-48.
6. Robert T. Mallet Myoung-Gwi Ryou Arthur G. Williams Jr. Linda Howard H. Fred Downey b1-Adrenergic receptor antagonism abrogates cardioprotective effects of intermittent hypoxia. 2006
7. Shu-Man Chen1, Hsueh-Yi Lin2, and Chia-Hua Kuo. Altitude Training Improves Glycemic Control
8. Haufe S, Wiesner S, Engeli S, Luft FC, Jordan J. (2008). Influences of normobaric hypoxia training on metabolic risk markers in human subjects. Med Sci Sports Exerc. 40(11):1939-44
9. Aritz Urdampilleta & Pedro González-Muniesa & María P. Portillo & J. Alfredo Martínez. Usefulness of combining intermittent hypoxia and physical exercise in the treatment of obesity
10. Nikolaus C. Netzer, Roland Chytra, and Thomas Küpper Low intense physical exercise in normobaric hypoxia leads to more weight loss in obese people than low intense physical exercise in normobaric sham hypoxia 2004
11. Ambrosini G, Nath AK, Sierra-Honigmann MR, Flores-Riveros J. (2002). Transcriptional activation of the human leptin gene in response to hypoxia. Involvement of hypoxia-inducible factor 1. J Biol Chem. 13;277(37):34601-9
12. Wang B, Wood IS, Trayhurn P. (2008). Hypoxia induces leptin gene expression and secretion in human preadipocytes: differential effects of hypoxia on adipokine expression by preadipocytes. J Endocrinol. 198(1):127-34
13. Nishimura A, Sugita M, Kato K, Fukuda A, Sudo A, Uchida A. (2010). Hypoxia increases muscle hypertrophy induced by resistance training. Int J Sports Physiol Perform. 5(4):497-508
14. Kon M, Ikeda T, Homma T, Akimoto T, Suzuki Y, Kawahara T. (2010). Effect of acute hypoxia 13% on hormonal responses to resistance exercise. Med Sci Sports Exerc. 42(7):1279-85.