Rewarding Learning

A2 LEVEL
FACT FILE

Sports Science and the Active Leisure Industry

Unit A2 2:
The Application of Science to Sports Performance

- **Respiratory System – Adaptations to Altitude Training**

sports science

and the active leisure industry

Learning Outcomes

Students should be able to:

- Explore and evaluate altitude training as a method of improving endurance performance:
- Investigate the locations and principles used for altitude training and the benefits and drawbacks this offers athletes.

Course Outline

Background

For over fifty years, endurance athletes have utilised a strategy of moderate altitude (2,000–3,000 m) living and training for the enhancement of sea level racing performance (1). The 1968 Olympic Games in Mexico City (elevation 2240m), saw many endurance athletes run significantly slower than world record times in the `thin air'.

Notably, Ethiopian and Kenyan athletes won most medals in the middle and long distance events, suggesting they were more adapted to these conditions. In the sprints and jumps there were 12 new world records, attributed, mainly, to the 'thinner atmosphere' offering less resistance to these fastest athletes. It is important to note that research (2) suggests that Kenyan and Ethiopian distance-running success may not be based solely on physiological characteristics. Rather, it could be the result of several factors e.g. longer, lighter and thinner limbs; chronic exposure to altitude in combination with moderate-volume, high-intensity training (live high + train high) and a strong psychological motivation to succeed athletically for the purpose of economic and social advancement.

Principles

Altitude training is a method of training used to improve oxygen carrying capacity. It is based on the principle that barometric pressure decreases with distance above sea level. The partial pressure of oxygen in the atmosphere decreases despite the oxygen content of atmospheric air remaining constant. The partial pressure of oxygen in blood will decrease with distance above sea level while the partial pressure in the muscles remains the same. This means that there is a fall in the pressure gradient, and oxygen dissociation from the blood to the muscles becomes more difficult resulting in a decrease in performance. The rationale of altitude training is that after a period of time physiological adaptations will occur.

Barometric pressure and oxygen pressure of inspired air at varying levels		
	Barometric Pressure	**Inspired oxygen pressure**
Sea level	760 mmHg	150 mmHg
2000 ms	596 mmHg	110 mmHg
4000 ms	462 mmHg	85 mmHg
6000 ms	354 mmHg	65 mmHg
8000 ms	267 mmHg	50 mmHg
8848 ms	253mmHg	43 mmHg

Beashel and Taylor (1996) Advanced Studies in Physical Education in Sport. Chapter 4. p. 177

Oxygen levels in the blood	
Sea level	98%
3000m	90%
Above 8000m	Below 50% saturation

Beashel and Taylor (1996) Advanced Studies in Physical Education in Sport. Chapter 4. p. 177

Physiological Effects of Altitude Training

The long-term effects (adaptations) of training at altitude begin to manifest themselves after about 4 weeks and can last for 6-8 weeks after a return to sea level. However, it is also clear that physiological changes vary significantly between athletes. These are examples of the adaptations

that have been seen in athletes following completion of an altitude training programme.

Adaptations:

Kidneys increase erythropoietin (EPO) release - stimulating bone marrow to produce sufficient red blood cells leading to:

- increased number and concentration to transport O_2.
- increased haemaglobin and myoglobin concentration.
- reduced plasma (blood thickens).
- increased tolerance to lactic acid (delayed OBLA).
- increased VO_2 max.
- O_2 carrying capacity of the blood is greatly enhanced.

Drawbacks

The main drawback of altitude training is ironically, its main driver – that is, the lack of oxygen! Whilst, low O_2 levels create the environment to effect the desired physiological changes, it also means athletes have to train at a much lower intensity. Over time VO_2 max can be reduced and detraining or reversibility can occur. Altitude sickness is common during a period of acclimatisation, and runners who are to compete above sea level are advised to spend time at altitude to acclimatise before they compete. The benefits of training at altitude can be offset by the drawbacks and many athletes live above sea level to acclimatise and reap the physiological benefits but train at moderate altitude or sea level. (See **Techniques for Altitude Training** section **LH/TL**).

There are several possible complications related to the process of acclimatisation at high altitude, including altitude sickness. More serious conditions are HAPE (high altitude pulmonary oedema) and HACE (high altitude cerebral oedema). Both are potentially life threatening, but are usually associated with the greater altitudes that mountaineers would reach.

Locations

High altitude training camps can be found all over the world. These are some examples used by the worlds elite athletes.

CNEA de Font-Romeu, France.
https://cnea-fontromeu.fr/performance/

Mammoth mountain, California.
www.mammothtrackclub.com

St. Mortitz, Switzerland. www.stmoritz.ch

Lornah Kiplagat's High Altitude Training Centre in Iten, Kenya. www.lornah.com

Falls Creek, Australia. https://www.fallscreek.com.au/summer/summer-activities/altitude-training/

Techniques for Altitude Training

Live High/Train High

Living and training at altitude presents one major physiological limitation: fatigue! Altitude sickness is common when acclimatising and many athletes are unable to produce the intensity and oxygen flux necessary to create or preserve the physiological changes they want. This can ultimately impact negatively on their sea-level performance. Some athletes have even reported 'losing speed'.

Live Low/Train High

Athletes train in a low oxygen environment, whilst resting in a normal oxygen environment. There are no good studies showing that this technique makes any difference to competitive performance at sea-level. Additionally, training intensity is reduced so some athletes may find that they actually lose fitness using this regime.

Live High/Train Low

Athletes "live high" (in an altitude tent at sea-level) to trigger the altitude induced changes i.e. significant and sustained increase in red blood cell count and then easily "train low" at a familiar and appropriately high intensity. This LH/TL approach, may provide the best protocol for enhancing endurance performance in elite and sub-elite athletes (3). Several investigations have demonstrated that the optimum regime to enhance post-altitude sea-level endurance is an altitude exposure of 28 consecutive days at moderate altitude (2,500m) with a daily exposure of 22 hours or more.

Altitude Tents

As stated earlier, athletes can reside and train at lower elavations (avoiding the need to travel to great altitude) and use an altitude tent, known as Altitude Simulation Tents or Hypoxic Tents (4). These small living areas can promote some of the positive adaptations of living at altitude, while allowing the athlete to train at an elevation which is oxygen rich.

Additional work

1. Compare and contrast the different approaches to altitude training that athletes use: i.e. live low – train high; live high – train high; and live high – train low.
2. Create a table and list athletes who use altitude training; include their sport, the camp they use, its location and its elevation.
3. As a proprietor of a health club design a flyer to promote your own training camp outlining the scientific rationale and the expected benefits.
4. Produce a newspaper article from the perspective of a journalist who wants to highlight the dangers and drawbacks of altitude training.

References

1. Chapman, R.F. et al. (2014) '*Timing of return from altitude training for optimal sea level performance,*' Journal of Applied Physiology, 116(7), pp. 837–843. https://doi.org/10.1152/japplphysiol.00663.2013. Accessed: 21.12.2023.
2. Wilber RL, Pitsiladis YP. *Kenyan and Ethiopian distance runners: what makes them so good?* Int J Sports Physiol Perform. 2012 Jun;7(2):92-102. doi: 10.1123/ijspp.7.2.92. PMID: 22634972. Accessed: 07.01.2024.
3. Khodaee M, Grothe HL, Seyfert JH, VanBaak K. *Athletes at High Altitude. Sports Health*. 2016 Mar-Apr;8(2):126-32. doi: 10.1177/1941738116630948. PMID: 26863894; PMCID: PMC4789936.

Websites

4. https://hypoxico.com/pages/altitude-training Accessed: 21.12.2023.

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