The Physiological Effects Of High Altitude On The Human Body

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Introduction

General Choi notes in the Taekwon-Do encyclopedia (page 34 of the 1999 edition) that "during training the student should constantly develop mental and physical discipline, and the following activities should be considered an integral part of this training". One of the activities General Choi subsequently lists is Mountain Climbing (Dung San).

As the General states "this form of exercise not only develops important leg muscles, but also nourishes the spirit and promotes a feeling of victory and triumph". Mountain climbing at high altitude does however have significant physiological effects on the human that can be significant and adverse to the degree of being fatal. Few people are aware of the effects of altitude and this lack of knowledge contributes to many of the problems experienced by people ascending to high altitudes. These problems can be effectively avoided by following basic guidelines.

This essay will explain the effects of altitude, what the symptoms of normal acclimatization to altitude are, and what symptoms of Altitude Sickness that people having difficulty acclimatizing display. The essay will also provide guidelines for Taekwon-Do students who may travel/trek/train at altitude that if followed will effectively reduce their susceptibility to adverse physiological effects.

What Is High Altitude?

The term "high altitude" generally refers to altitudes of greater than 2000 metres above sea level. As height is gained above this altitude the density of oxygen in the atmosphere decreases and the density of carbon dioxide in the atmosphere increases. This is because of the drop in barometric pressure as altitude increases. As an indication, at an altitude of 5000 metres oxygen density is 40% less than at sea level.

As less oxygen is available the human body's systems begin to function differently to normal. These changes in functioning manifest themselves as symptoms of acclimatization to altitude. These symptoms will now be addressed.

Symptoms Of Acclimatisation To Altitude

As mentioned previously, at high altitudes barometric pressure is lower meaning oxygen densities are lower than usual and carbon dioxide densities are higher than usual. The human body compensates for the decreased levels of oxygen available by increasing its heart and exhalation rates to rid itself of the increased amounts of carbon dioxide being inhaled.

Normal symptoms of acclimatization to altitude are as follows:

- Increased appetite - this is due to the increase in the body's base metabolic rate while exercising at altitude. Put simply, the body must work harder at altitude therefore it requires more energy intake in the form of food.
- Increased bladder activity - as carbon dioxide levels are higher at altitude there will be higher than normal levels of carbon dioxide in the bloodstream. A byproduct of this higher than usual concentration of carbon dioxide is an increase of sodium bicarbonate in the bladder and body. In order to excrete the increased levels of sodium bicarbonate more frequent urination than normal is required.
- Insomnia
- Slight swelling of the feet and/or knees - to similar levels as to what can be experienced on international flights.
- Breathlessness after exercise - breathlessness should be only temporary ie 1-1.5 minutes more than usual for exercise of a similar intensity at sea level. Prolonged breathlessness indicates that a person may be experiencing Acute Mountain Sickness, or AMS (see below).

Most people ascending at a safe rate will usually experience the above symptoms. A safe rate of ascent is generally considered to be no more than 300 metres per day for altitudes above 3000 metres. This means that a person should not sleep in a location more than 300 metres higher than their previous nights resting place. For altitudes between 2000 and 3000 metres the rate of ascent can be relaxed slightly to 400 metres per day. Below 2000 metres there is no significant risk of AMS at any rate of ascent.

In some cases the rate of ascent may not be able to be controlled by the individual. In Taekwon-Do, a student from New Zealand attending a camp held in Colorado will fly from sea level in New Zealand to an altitude of above 2500 metres within 24 hours. More altitude is then gained rapidly to reach the training camp from the airport. In such a situation no strenuous physical activity should be undertaken for at least two to three days after arrival to allow the body time to adjust to the rapid increase in altitude. It would be desirable for a week to be allowed for acclimatization before attempting strenuous training.

Because urination frequency increases while at altitude, 3-4 litres of fluid should be consumed daily to prevent dehydration. The best method of monitoring the bodies hydration level is to monitor urine colour. Clear urine indicates that the body is well hydrated while dark yellow urine indicates dehydration. Vitamin supplements which turn urine dark yellow should not be taken at altitude as they make monitoring hydration levels through urine colour very difficult.

The following symptoms indicate that a person is experiencing mild AMS:

- Headaches both while exercising and at rest that will not go away if Aspirin is taken.
- Breathlessness at rest, and extreme fatigue after exertion.
- Decrease in appetite commonly accompanied by attacks of nausea.
- A resting heart-rate of more than 100 beats per minute.
- Irritability and/or mood swings.

A mild case of AMS indicates that fluid is beginning to accumulate in parts of the body where it does not belong - in the brain, in the lungs, or in both. A person experiencing any of the above symptoms should not under any circumstances ascend. A day(s) rest at the same altitude commonly results in a case of mild AMS disappearing and a safe ascent being possible.

Ascending while displaying symptoms of mild AMS results in an extremely high probability of a person developing severe AMS, which manifests itself as High Altitude Cerebral Edema (HACE) and/or High Altitude Pulmonary Edema (HAPE).

HACE results from a build up of fluid in the brain. A person suffering from HACE will suffer from a loss of coordination and balance, slurred speech and a significant decrease in reaction time. A good way of testing whether a person is suffering from HACE is to require them to walk in a heel/toe fashion in a straight line for several metres, or to require them to tie a basic knot. This can be in their bootlaces if trekking, or for the TKD student in dobok may be tying the knot in the belt.

HAPE results from a build up of fluid in the lungs. HAPE is characterised by a dry, hacking cough, frothy spittum, and an inability to regain breath for several minutes after exertion.

Any person displaying signs of HACE or HAPE should descend in altitude immediately. HACE and HAPE can lead to unconsciousness and death within 12 hours if symptoms are ignored. A person suffering from AMS may not have the ability to think clearly and may have to be forced to descend. Even if someone is willing to descend they should never be allowed to descend alone. Usually a descent of 3-500 metres will result in a sign of improvement in a HAPE/HACE sufferer. A sick person should be made to descend until they are completely free of all symptoms. A reascent can always be made when the person feels better.

In the event that a person is unable to descend for any reason, a decompression bag can be used if available. These bags simulate pressures of lower altitudes and the patient inside benefits significantly. These bags should only be used in the event of an emergency - the safest option is to get the patient to a lower physical altitude.

Physical Fitness And AMS

Most students of Taekwon-Do are physically fitter than the average person. Physical fitness at seal level however does not equate to physical fitness at altitude. An overweight, unfit person at sea level may acclimatize to altitude better than a well conditioned Taekwon-Do student, as each person differs in their ability to acclimatize. As an example, two weeks after winning the 1995 World Triathlon Championship Mike Pigg had to be evacuated by helicopter from a popular trekking route in Nepal suffering from HACE as a result of ascending too quickly for his body's ability to acclimatize.

If travelling at high altitude in a group, it should thus not be expected that everyone in the party will acclimatize at the same rate. Children are more susceptible to AMS and should be watched closely by adults as they may not be able to adequately explain the symptoms they may be experiencing. It is very risky to take infants to high altitude, as they cannot tell you at all when they are not feeling well.

Previous time spent at altitude does not result in the body becoming "conditioned" to altitude, meaning that ascents can be made more rapidly. As soon as a person descends to low altitudes the body must begin the acclimatization process afresh when ascent is reattempted.

People should not plan to go to high altitude if they have a known heart disease or have difficulty in breathing at sea level. Pregnant women are recommended to stay below 3600 metres. People suffering from other chronic medical conditions should consult their doctor before planning any ascent to high altitude.

The physical benefits of spending time at altitude, once acclimatized, are significant when a person returns to sea level. The body becomes accustomed to operating efficiently using smaller amounts of oxygen when at high altitude. Once returned to lower altitudes, where significantly more oxygen is available in the atmosphere, the body's ability to intake and process oxygen during exercise is greatly enhanced resulting in significant gains in aerobic and anaerobic fitness levels. Altitude training is commonly undertaken by top athletes in order to boost their fitness at sea level. Artificial means of simulating high altitude such as hyperbaric chambers or artificial oxygen supplies with low oxygen content are also available for athletes looking to increase fitness.

Drugs And Other Substances

Sleeping pills, sedatives and alcohol should not be used at altitude as they tend to inhibit the bodies breathing processes and can lead to the onset of AMS in an otherwise healthy person.

It is not recommended that drugs are taken as a means of preventing AMS. It is far better to rely on a well planned slow ascent. Any person interested in taking drugs with them to altitude to help treat potential AMS should consult their doctor about Acetazolamide (Diamox), nifedipine, and dexamethasone. Any prescribed drugs should not be taken indiscriminately however, as their side effects can be lethal.

Summary

If a person is not doing well at altitude it is likely that they will be experiencing mild AMS. The person should rest at the same altitude until they feel better, and ensure that they take on plenty of fluids. If the person is getting worse at the same altitude, they should descend to a point at which they feel well again. Acute Mountain Sickness is entirely preventable if the guidelines presented in this essay are followed.

References

- Choi, 1999. Taekwon-Do (fifth edition). International Taekwon-Do Federation, Canada.
- Lecture given by volunteer international medical staff of the Himalayan Rescue Association, Manang, Nepal. October 1997.
- Authors own experience at high altitude in China, Tibet and Nepal. 1997