



## High altitude training and effect of high altitude on physical performance of an athlete

Dr. Naresh Kumar

Associate Professor of Physical Education, Govt. Girls College Rewari, Haryana, India

### Abstract

The competitive sports in modern era requires utmost efforts to achieve peak performance. The impairment in aerobic power at altitude is in large part due to the drop in partial pressure of inspired oxygen that accompanies the biometric pressure. On the other hand, the decreased air density that accompanies the drop in biometric pressure also reduces aerodynamic resistance, which can be beneficial to certain athletic performance. The substantial effect of altitude on athletic performance were exemplified by the number of world records broken in track and field during the 1968 Olympic games held in Mexico city.

**Keywords:** High altitude training, physiological concepts, respiratory system, cardiovascular system

### Introduction

Man in action is frequently exposed to environmental conditions that might be classified as atypical, if not abnormal. The physiological concepts discussed until now have dealt with the body's response to normal exercise and training. But optimal conditions do not always prevail; the day may be excessively hot and humid, or cold; the clothing or uniform may be in adequate; or the individual may journey into unusual environmental circumstances, such as high altitudes or under water.

In all such situations the organism must adjust to a set of conditions that tends to alter normal physiology in significant ways. The performer finds that without acclimatization-a period of adjustment to the rigors of the environment his performance may be impaired. The body has a remarkable ability to compensate either wholly or partially to environmental conditions if given the opportunity. This does not mean that complete success will always be experienced. While it might be argued scientifically that a slight, to the athlete in competition it might well be the difference between winning and losing a contest. Moreover, there may be an additive effect when the performer competes in extended running, swimming,

cycling, or the like, as compared with shorter events. Thus, the potential length of exposure is an important factor when considering the effects of adverse environmental conditions.

### Altitude

Recent advance in space technology and the burgeoning participation in international sporting events around the world have brought into the limelight some of the acute effects of altitude. Beginning with the early experimentation with balloon flights and continuing with mountain climbing, man (and woman, too) has gained notoriety and considerable respect by such feats as the dramatic ascent to the summit of Mount Everest, an elevation of 29,028 feet above sea level. The 1968 Olympic Games, held in Mexico City at an altitude of 7,347 feet above sea level, focused attention on the potential reduction in physical performance that can accrue from exercising at altitude, and also pointed clearly to the role of acclimatization as a means for adjusting physiologically to these rigors.

Even with a steady ascent to high altitude with its systematic reduction in barometric pressure, the effect on arterial oxygen saturation is somewhat modified. In other words, the drop in alveolar  $P_{O_2}$  of 37mm Hg.

**Table 1:** Effect of altitude on various gas pressures

Altitude (Ft.)	Barometric Pressure	Atmospheric $P_{O_2}$	Alveolar	%Arterial Saturation	Alveolar $P_{CO_2}$
0	760	159	104	97	40
10,000	525	110	67	90	36
20,000	350	73	40	70	24

The environment of high altitude differ from the sea level in the following aspects:

1. Atmosphere pressure is low at high altitude,
2. Partial pressure of oxygen ( $P_{O_2}$ ) is low
3. Environmental temperature is low (It decreases by  $2^{\circ}C$ .) for every m.
4. Wind velocity is high
5. The acceleration due to gravity decreases by 0.3 cm/Sec<sup>2</sup> for every 1000m.of altitude.

At 10,000 feet cause but a slight decline in the arterial blood saturation, as compared with the more precipitous reduction at 20,000 feet. This can be understood better by referring to

Figure 64 (in Chapter 8), the oxygen hemoglobin dissociation curves. As pointed out, the arterial end of these curves is quite flat, which means that with a reduction in  $P_{O_2}$  the percentage of oxygen bound to hemoglobin remains high, and it may actually.

Change the oxygen-hemoglobin dissociation curve, as will be discussed below. At any rate, the affinity of hemoglobin for oxygen works in favor of the individual and helps explain why relatively slight elevation above sea level (Up: to several thousand feet) can be handled with ease.

Because of this variations some scientists did not support the idea of holding Olympic at Mexico city. After Mexico

Olympics some coaches have started altitude training. The aim of the training is:

To stimulate the aerobic energy release system, so that the athlete can endure more hypoxic condition and his efficiency of oxygen transport system can be further enhanced. The effect of such training can be explored in the competition, at sea level.

### Acclimatisations

Whenever a person is exposed to high altitude some adaptive processes start in the body. Partial pressure of oxygen at an altitude of 2500m. is about 76mm. of Hg. as compared 103mm. of Hg. at sea level.

### In such conditions

Blood supplied to the lungs is 90 percent saturated as compared to 97 percent saturation at sea level.

- It causes impairment of diffusion capacity of the lungs.
- To overcome this, following changes occur in the body in various systems;

### Respiratory system

Breathing becomes faster and deeper i.e. hyperventilation starts during rest and exercise. Hyperventilation washes away carbon dioxide from the body. Low carbon dioxide level further stimulate the respiration.

### Cardiovascular system

The hematological changes further enhance the transport of oxygen from lungs to the tissue.

- a. Hemoglobin concentration increases upto 30%.
- b. Red blood cell increases & cause hemoconcentration.
- c. Cardiac output increases, this increase in cardiac output amounts to 1% at an altitude of 5500 mm.
- d. Heart rate at maximal and submaximal exercise is increased.

### Long term adaptation

Within 2-3 weeks, cellular level changes occur:

- a. Increased mitochondrial enzymes.
- b. Increase in hemoglobin formation.
- c. Increase in myoglobin.

All these changes help in the oxygen transport and utilization at the cellular level.

### Time of acclimatization

It depends on the height of altitude 3 to 4 weeks are required for adaptation at 3000 m. the general suggestion is acclimatization for competitive events should be longer as the altitude becomes higher.

### The importance of training at altitude

Physiologists and coaches have tried to find out whether, an individual trained at moderate altitude shows a considerable increase in physical work capacity and also the performance, whether these changes persist for a period till the competition?

#### a. Aerobic process

The training at altitude results in increased level of hemoglobin, red blood cells, blood volume, mitochondrial enzymes, as a result of this  $VO_2$  max is improved.

Majority of scientists have reported controversial findings.

They did not find any effect of training on  $VO_2$  max at high altitude. Although, changes in heart rate at basal, rest and recovery have been found. These changes are comparable to vigorous training at sea level.

Again some scientists have show the improvement in the maximal aerobic capacity by simulated altitude training. It is not described that how much was the effect of altitude alone.

The effect of high altitude acclimatization remains only for 1 to 2 weeks. If the competitions are held within that period, the athlete may have slight edge for oxygen transport system. Athletes may have advantages only if the competitions are held at high altitude.

#### b. Anaerobic process

Blood lactate concentration remains higher at the sub maximal work load at high altitude as compared to the sea level. However, the maximum concentration of lactic acid remains almost same as at sea level. It indicate that anaerobic process starts at relatively lower work load.

Maximum oxygen debt is same at sea level and at high altitude.

### Performance at an altitude

Because of the differentiate in environmental conditions performance in certain events may be higher. Even many Olympic records were set in Mexico.

1. Because of low gravity, performance in jumping, throwing is better.
2. Because of low air resistance, performance in sprint event is better.
3. Performance decreases in distance runner (1500 m & above)

### Effects of high altitude on physical performance

#### a. Decrease in total barometric pressure

It is well known that as we ascent to higher and higher altitudes, the total barometric pressure decreases because of the decreased weight of the atmosphere (Table). Since the force of gravity is somewhat smaller at high altitude than at sea level, the energy required to lift the body as in the poie vault and high jump would be theoretically decreased. As most authorities recognize, however, the practical effect on physical performance is probably quite small.

#### b. Decrease in partial pressure of oxygen

Although the percentage of oxygen in the atmosphere (20.93% remains the same regardless of altitude (the number of oxygen molecules per unit volume decreases, however, which means that in order to receive the same number of molecules in a given breath of air at high altitude that we receive at sea level, we must take in more air) the decreased barometric pressure causes the partial pressure of oxygen ( $P_{O_2}$ ) to be decreased (Table 8-1). The decreased oxygen pressure at high altitude decreases the arterial oxygen saturation of blood (Table) which. In turn, decreases the amount of oxygen available to the working tissues. Physiologically, the decreased  $P_{O_2}$  is the most critical factor of high altitude because the individuals work capacity depends largely upon his ability to take in and utilize oxygen rapidly.

### c. Decrease in density of air

In addition to the diminished pressure of oxygen in the atmosphere, there are additional features of the high altitude environment that should be mentioned. For example, the decreased density of the air reduces the resistance of the airways to the flow of air into and out of the lungs. This permits greater volumes of air to be taken in during work with no significant increase in ventilation cost. The reduced density of the air acts in favor of those performances in

which air resistance is a factor (Sprint-type activities, jumping, pole vaulting, weight throwing, and other high velocity events which are powered largely by anaerobic metabolism) In the 1968. Olympic games in Mexico City, it was determined by The United States: Ballistic Research Laboratory that the four weight throwing events had theoretical advantages of: 6cm. for the shot put: 53 cm. for the hammer throw: 69 cm. for the javelin and 162 cm. for the discus.

**Table 2:** Effect of attitude on barometric pressure, atmospheric and alveolar oxygen concentrations, and arterial oxygen saturation.

Altitude (ft)	Barometric pressure (mm Hg)	Atmospheric Po <sub>2</sub> (MM Hg)	Alveolar Po <sub>2</sub> (MM Hg)	Arterial oxygen saturation (%)
0	760	159	104	97
10,000	523	110	67	90
20,000	349	73	40	70
30,000	226	47	21	20
40,000	141	29	8	5

Note that barometric pressure reflects the force of earth's gravity acting on the atmosphere: therefore the atmospheric pressure is greatest at the surface of the earth and gradually gets smaller as one moves to higher altitudes.

When the arterial oxygen saturation of the blood drops to somewhere between 25 and 50%, unconsciousness generally occurs. Because of this, pilots and mountain climbers are required to use oxygen at altitudes over 20,000 feet.

### d. Cooler and dryer air

The air is generally cooler and dryer at high altitude. Although the cooler temperature makes work more pleasant, and in fact, can help performances involving prolonged exertion, the dryer air can also increase the water loss from the respiratory tract which may contribute to the dehydration of exercise.

Also, dryness of the throat is often experienced by athletes as a result of the dry air.

### e. Sunburn and snow blindness

It is uncommon for skiers and mountaineers to experience sunburns and snow blindness at high altitude. The reasons for this is because solar radiation is much more intense at high altitude than at sea level and because the skin tends to be dryer (due to the fact that the winds generally blow harder at higher elevations) at high altitudes. Skin burns at high altitude are also related to the decreased density of the air.

### Conclusion

The reduction in barometric pressure at high altitude reduces the partial pressure of oxygen so that the arterial blood will not be fully saturated. The density of air is decreased, so in order to compensate, the individual may hyperventilate. Hypoxia (lack of oxygen at the tissue level) increases resting heart rate and cardiac output, pulmonary ventilation, systolic blood pressure, and blood lactic acid. Resting oxygen consumption does not affect athletic performance involving endurance events deteriorates. Heart rate increases during exercise at altitude, although maximum heart rate is decreased, which is the pattern followed by total cardiac output. Pulmonary ventilation is elevated during exercise over sea-level values, and aerobic capacity is reduced. Short-term anaerobic performance is unaffected by altitude, but lactic acid rises more readily and at lower work loads. Acclimatization's results in an increase in pulmonary

ventilation, an increase in the amount of hemoglobin and number of erythrocytes, and a decrease in the alveolar-arterial gradient for oxygen.

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