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Acute Effects of Altitude Fallowing a Exhaustive Exercise Session on the Vo2max, HRmax and Blood Pressure in Athlete Students

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ABSTRACT

This study is aimed to study of the acute effects of altitude after a session of incremental exhaustive exercise on the maximal oxygen consumption (Vo2max), maximal heart rate (HRmax) and blood pressure of the athlete students of Shahid Chamran University in Ahvaz. Therefore, 10 male students of Shahid Chamran University in Ahvaz were selected as sample with an average age of 25.6±3.4 and an average weight of 66.34±6.58 kg. The subjects performed the modified Astrand protocol in the city of Ahvaz (sea level) and then, in the city of Shahrekord (Height). The Vo2max was measured through the time of the protocol implementation for each individual. The blood pressure was recorded before and after the protocol implementation and maximum heart rate was recorded after the protocol implementation. The study results showed that the Vo2max of the subjects significantly decreased at a height higher than sea level. In addition, the HRmax significantly increased in a height higher than sea level. On the other hand, the changes in the systolic and diastolic blood pressure of the subjects were not statistically significant. Generally, according to the obtained results it can be said that at a height higher than sea level, the cardiovascular responses to the exercise change due to the decrease of the partial pressure of oxygen.

Key words: Altitude, maximal oxygen consumption, heart rate, blood pressure

INTRODUCTION

Today, lots of sport participants are involved in exercises at heights. This group includes from the climbers who have climbed high peaks to the skiers who exercise recreationally on holidays. In addition, sports competitions are occasionally held at heights (Drust and Waterhouse, 2010). Exercise at heights is often performed by the competitive athletes in a wide range of sports, believing that it will improve athletic performance at sea level (Adamos *et al*., 2008). Such activities with their own conditions, are associated with changes in the ambient pressure, so that the ambient oxygen concentration will decrease by the increase of height. This partial pressure of oxygen creates altitude hypoxic conditions which cause the hypoxic physiological responses in the body (Milledge, 2000). Ascending high altitudes is a known pressure to alter the physiological and metabolicactions (Mazzeo, 2005; Mazzeo *et al*., 2001). When the stress induced by physical activity is added to these conditions, these physiological and metabolic responses will get more intense (Mazzeo, 2005; Mazzeo *et al*., 2000).These developments are associated with changes in breathing pattern, heart rate and blood pressure and affect the performance of athletes (Milledge, 2000). For example, Mollard *et al*. (2007) showed the significant decrease of vo2maxin both athletes and non-athletes in order to find an increasing sport in height in bicycle ergometer test at heights of 2500 and 4500. Also, (Katayama *et al.*, 2000) showed theincrease of systolic blood pressure in the athletes at an altitude of 4,500 meters while the diastolic blood pressure did not change significantly. In another study of art (Benoit *et al.*, 2003) Henri showed the significant decrease of maximum heart rate in 3 groups of athletes with different vo2max. However, this reduction in the trained athletes was greater than the other groups.

Generally, by the development of sport and physical activity, the evaluation of the physiological effects of altitude on various systems of body has become greatly importance. Despite the studies conducted on altitude physiology, there are still major questions. Since today, sports competitions are held throughout the world and in different geographical locations. Moreover, altitude is one of the factors influencing the results of sporting events, particularly endurance races. The present study aims to investigate the acute effects of altitude on Vo2max; maximum heart rate and blood pressure after the incremental exhaustive exercise.

MATERIALS AND METHODS

Subjects: Ten soccer players participated in this study with at least two years of regular physical activity (3 sessions per week) and Vo2max of 38 to 48 milliliters per kilogram of body weight per minute, average age of25.6±3.4 years,average height of 178±10.8, the average weight of 66.34±6.58 kg and theaverage BM of 22.11±1.76 kg m^{-2}. Maximal aerobic capacity (Vo2max) of the subjects was calculated by the modified Astrand treadmill protocol. Then, in order to participate in the study, the subjects were introduced to the exercise protocol, measurement tools and laboratory environment through a session.

Methodology: To collect the data on sea level, the subjects first conducted the modified exercise Astrand protocol (Astrand, 1965) in the physiological laboratory with air temperature of 22 to 25°C, humidity of 38 to 42% and air pressure of 760 mm Hg. Then, the subjects were transferred to conduct exercise protocol related to the altitude with air pressure of 596 mmHg (altitude 2066 m). The study inclusion criteria of the volunteers are the intended Vo2max, including the lack of drugs and supplements, not smoking and normal health.

Measurement of variables: Astrand test was used to measure the maximal oxygen consumption. The test was first conducted at the speed of 85 km h^{-1} and a slope of zero percent on a treadmill. After 3 min, the slope of the treadmill was increased by 2.5% and then its slope was increased by 2.5% per 2 min and the test was continued until the subject was unable to continue anymore. The test period of time was measured and recorded by minute and up to two decimal places from the start to at the end of the test. Then it was used according to the following equation (Eq. 1) as a fraction of a minute in order to estimate the maximal oxygen consumption:

$$\text{Maximal oxygen consumption} = (1.44\times\text{time by min})+14.9999\ (\text{mL kg}^{-1}\ \text{min}^{-1}) \qquad (1)$$

Blood pressure was measured using pressure gauge (Laica). Before doing the test, the pressure gauge was fastened to the left hand of the subjects while they were sitting and their right hand was in line with their heart and their resting blood pressure was measured. Then, the subjects performed an exercise test and immediately after testing, they located in the sitting position again and the blood pressure was measured. Heart rate was recorded before and after the exercise test and in the sitting position, using Polar heart rate monitor.

BMI: Body Mass Index (BMI) was manufactured using Body Composition Analyzer of Olympia Modelmade by Jawon Company of Korea.

Statistical method: Correlated T was used to calculate the intra group changes. The mean and standard deviation of the data were also used to draw tables and graphs. All the statistical operations were conducted at significance level of $\alpha = 0.05$ by usingversion 16 SPSS software.

Study results: The research results showed that the rate of changes in the maximal oxygen consumption (Vo2max) and the maximal heart rate (Hrmax) in the study subjects were significantly different in two levels of sea level and altitude, so that Vo2 max decreased ($p<0.001$) while HRmax increased ($p<0.037$). On the other hand, the changes in systolic and diastolic blood pressure were not significant ($p<0.403$ and $p<0.758$).

DISCUSSION

The study results indicated the significant reduction of Vo2 maxin altitude compared to sea level in the subjects. These results are consistent with the results of Mollard *et al.* (2007), Padilla *et al.* (1998), Allemann *et al.* (1998) and Gore *et al.* (1998). When ascending to high altitude, barometric pressure reduction leads to a decrease in the partialpressure of oxygen in the respiratory air (P_IO_2). As it can be seen in the figure, a sequence of physiological events begins that leads to a decrease in the partial pressure of oxygen of arterial blood (P_aO_2) and arterial oxygen content (C_aO_2) (Mazzeo, 2005; Mazzeo *et al.*, 2001).

$$\text{Hypoxia} \rightarrow P_IO_2 \rightarrow P_AO_2 \rightarrow P_aO_2$$

The sequence of events that led to a decrease in partial pressure of O_2 of arterial blood (Mazzeo, 2005).

The result of these changes leads to the decrease of hemoglobin saturation with oxygen (Mollard *et al.*, 2007); consequently, the maximal oxygen consumption will be reduced (Naeije, 2010); Bartsch and Saltin (2008) suggest that the reduction of the partial pressure of oxygen of arterial blood (P_aO_2) and consequently, decrease in the arterial blood oxygen saturation (SaO_2) will be mostly released because of limitation during the exercise at altitude which is due to the low pressure of alveolus oxygen (PaO_2) and increase of pulmonary blood flow during exercise.This reduction in endurance-trained athletes will behigher because of their higher maximum cardiac output (Bartsch and Saltin, 2008).

In this study, the maximum heart rate was increased in athletes. Form that aspect it is consistent with the findings of Wyss *et al.* (2003); Yamamoto *et al.* (1996). On the other hand it is inconsistent with the findings of Mollard *et al.* (2007) and Benoit *et al.* (2003). One of the reasons for the increase of heart rate at the beginning of arrival at altitudes can be the increase of excitability of sympathetic nervous system. The studies show that as arriving at altitudes, blood catecholamine concentration increases which will stimulate the heart function (Allemann *et al.*, 1998; Antezana *et al.*, 1994). Mason (2000) argues that a short term stay higher altitudes than sea level, will result in the increase of heart rate and cardiac output both at rest and during exercise with certain intensity. Staying at altitudes for a week or more, the resting and exercise heart rate will be reduced and reaches almost its previous level (Milledge, 2000). Reduction in the maximum heart rate at altitudes is due to the increase of VAG Tune (Boushel *et al.*, 2001) and probably due to the down regulation of beta-adrenergic receptors (Favret and Richalet, 2007). Increased heart rate in this study may be due to the short-term stay (less than 24 h) at altitude and lack of providing any altitude adaptation.

In this study, systolic blood pressure showed a slight increase compared to the sea level but it did not reach a significant level. These results are consistent with the findings of MacDonald *et al.* (2002) and Katayama *et al.* (2000). When the body is exposed to hypoxia for a short time, blood pressure will not change or will increase slightly (Naeije, 2010; Faoro *et al.*, 2007). Blood pressure increase during the altitude adaptation can be justified by the sympathetic nervous system activation (Naeije, 2010; Maignan *et al.*, 2009). On the other hand, decrease in ambient temperature at heights will in turn lead to the vasoconstriction and thus, increase of blood flow, cardiac output will also increase to compensate for reduction of the arterial blood oxygen levels (Katayama *et al.*, 2000) which results in the increase of blood pressure.

In this study, high diastolic blood pressure did not change so much. Palatini (1994) suggested that the changes in diastolic blood pressure are limited during exercise and in other words it has remained unchanged or decreases slightly (Palatini, 1994). Lack of increase in diastolic blood pressure compared with systolic blood pressure, can be caused by more dilation (decrease in the peripheral vascular resistance) of active muscles vessels. It should be noted that the increase of diastolic blood pressure to 25 mm Hg or more, is considered an abnormal response to the exercise and is one of a few signs indicating that the exercise test should be stopped (MacDougall, 1994).

Overall, the most important result obtained from this study, was decrease of the maximal oxygen consumption of subjects which occurred by ascending to high altitudes. Since Vo2max is considered one of the most important factors of cardiac-respiratory capacity of endurance athletes and has a significant impact on their success, coaches and this group of athletes should consider this point and plan their training programs so that minimal damage would be incurred to the athletic performance of athletes during athletic endurance events at high altitude.

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