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Comparison of pulmonary function parameters changes at different altitudes in female athletes

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ABSTRACT

Purpose: The purpose of this study was Comparison of pulmonary function parameters changes at different altitudes in female athletes. Methods eleven voluntary Female athletes, (age; 22.27±0.65yr), (weight; 57.00±6.31kg), (Fat%:20.81± 3.2 1) (Height; 160.54± 3.7cm and vo2max: 40.65±1.00) were selected to this study on spirometric parameters. Each subject was informed consent form. Respiratory function was assessed in participants before ascending at baseline (1400 meter) and after ascending at 3600 meter in savalan Mount and sea level (3 day's interval between with a Spiro lab II). Spirometric parameters r changes were compared using ANOVA for repeated measure with Bonferroni (post hoc) statistical analysis computations were performed by spss and p≤0.05 was considered significant. Results: spirometric parameters(FVC,FEV1,FEF25-75%,PEF,PIF,MVV, and VC) at altitude(3600 m) were significantly increased . PIF, FEV1, FEF25-75%, MVV was not significantly different between 3600m level and 1400m level. Conclusion: acute ascent to altitude above 3600m lessens airway resistance that facilitates expiratory airflow and increase majority Spirometric parameters

Keywords: Altitude, Lung function, Spirometry, Female athletes, Sea level.

INTRODUCTION

Most of the researches and studies about the physiological responses of human body to the physical activities have been done in the sea level or low altitude. But, when this changes, the physiological responses of the body may change, also. High altitude is one of this parameters where barometric pressure decreases and consequently the partial pressure of oxygen decreases.

Decreasing of partial pressure of oxygen (PO2) prevents the emission of blood to the tissues. This shortage may have not a considerable effect on performance in rest state, but, it will be important in physical activity situations. [1]

Shortage of oxygenation to the body cells causes the human performance drops. [2] Respiration system, that its main duty is to provide the possibility of gas exchange between inside and outside of the body, enables the human body to replace the blood CO_2 with fresh O_2. At high altitude, due to the limitation of oxygen emissions from the air to the blood, oxygen transfer will be disturbed. Therefore, the activity of respiration system increases and this may cause some disorders. [1, 3]

Hypoxia play a significant role in lung function in morbidity related to high-altitude exposure. Due to low barometric pressure lung function changes at high altitude may worsen the severity of hypoxemia beyond that expected. [3,4] In addition, ventilatory studies at simulated altitude in hypobaric chambers have shown decrease in forced vital capacity (FVC) and sometimes decrease in forced expiratory volume in 1 second (FEV1) or maximal midexpiratory flow rate (FEF25-75%).However, actual field and participant conditions acute ascend to high altitude differ from those of chronic state or more controlled experiments. [5, 6, 7]

Altitude changes affect the lungs function, but it is not completely clear why and how this happens and this is the subject of the recent numerous researches[8, 9] Wagner et al (1987) believed that with diminishing the air density during the ascending, expiration and lung discharge will be easier[10].

Whereas at high altitude, the lung ventilation have a good Correlation with the consumed energy cost and also, the power and endurance of respiratory muscles have the basic role in the ventilation, so this may be affected by high altitude conditions. This has also been pointed out in some researches that the tiredness of diaphragm, as a result of lungs ventilation increase, may affect the respiration in high altitude and the lungs performance. On the other hand, there is a contradiction on the published results concerning the effect of the altitude on the lung performance. [11, 12]

For example, Shamara and Brown (2007), during their research about 7 male adults, have shown that immediately after the altitude change between 3450m to 5350m, MVV and, FEV1 and during the first 24 hours, FVC have a significant increasing.

Welsh et al (1993) have reported that with altitude increasing, FVC decreases and FEV1 has no changes comparing to the base altitude. [13] Fort V and et al (1997) have also showed that FVC and MVV increase and FEV1 decreases. [14]

The results obtained by Faramoushi (2012) showed that by ascending to 3600m altitude, FVC of male athletes (5.08 ± 0.62) has a significant increase comparing to the base altitude (4.93 ± 0.53) and sea level (4.92 ± 0.52). But, there is not a significant difference between the base altitude and sea level. ($p>0.05$) [15].

There is not the agreement between this result and the results obtained by Deboeck, G and et al (2005) and also, Ziaee and et al (2008). [16, 5]

Decreasing of FVC as a result of ascending to the high altitude has been reported by Mason and et al (2000), Cogo and et al (1997) where the pulmonary edema has been known as the main factor of this decrease. [17, 18]

Mason and et al (2000) have analyzed there studied samples twice a day during an ascending from 2800m to 5300m. Comparing to the results obtained in the sea level, the average of FEV1 obtained at 5300m did not change.

But the results obtained by Faramoushi (2012) showed that at 1400m and 3600m, FEV1 has a significant change comparing to the sea level, but it did not meaningfully change at 3600m comparing to the base altitude.

His research also showed that with ascending from the sea level to 1400m and 3600m, FEF25-75% increased meaningfully, that prove the decreasing of air pressure causes FEF25-75% to increase. PIF (L/S) and PEF that show the maximum stream of respiration and expiration would be greater comparing to the sea level. The reason of this is the decreasing of the air density and of airways resistance at high altitudes.

Most Previous studies have evaluated effect of altitude on lung function at laboratories or by simulating altitude in hypobaric chambers [10, 19, 20]. However, actual high altitude expeditions differ from those in more controlled experiments, and limited data regarding alterations in measurements of lung function in an expedition setting are available [17,21,22]

Following the above mentioned results and considering the shortage of studies done in an acute condition, and of female athletes.

So that purpose of this study was to Comparison of pulmonary function parameters changes at different altitudes in female athletes.

MATERIALS AND METHODS

This research is a semi- experimental study in different altitudes. 110 female athletic students of Mohaghegh Ardabili University. Among them, 11 athletes participated voluntarily in this study. Each volunteer reviewed and signed consent forms approved by the human research review ethics committee of Mohaghegh Ardabili University (Iran), department of physical education, before participating in the study. This research was undertaken in accordance with the Biotechnology, Bioethics and National Ethical Guidelines in Biomedical Research in Iran. [23]

Questionnaires were given to samples to acquire necessary information about their overall health and physical fitness. The mean age of participant was 22.27±0.65 years old; the mean weight was 57.00±6.3 kg and means height 160.54±3.78 cm, $VO_{2\ max}$ 40.65±1 and fat percent 20.81±03.21 (±SD). The required criteria for sample of this research with regard to its specifications include:

-should be no in menstrual cycle
- Range of age: 18-25
-Having no history of Drinking, smoking, drug abusing, opium or doping materials
- having relatively fixed diet during test period (all samples feed from university's food);
- having no history of surgery on ears, eyes and nose.
- None of the samples even climbed more than 2500 m
- All of them reside at least 1-2 years in baseline (Ardabil).

-All samples most to sleep on time at the night of the tests. The samples were tested by physician in university's clinic and all acquired the necessary requirements for this test.

Tests of lungs function evaluation performed in 3 phases i.e. at 3 different altitudes with an interval of 3 days in September. These phases include: First phase: in baseline of Ardabil (1400m, air pressure 710mmHg and temperature 22 $^{\circ}$C, on 14:30 p.m.) Second phase: after 3 days, samples were transferred to Astara (sea level, air pressure 760 mmHg, at 19 $^{\circ}$C on 14:30 p.m.) by a minibus and, following the test, they came back again to Ardabil and, after 3 days of staying in Ardabil, the third phase of test performed. Third phase: this phase of test performed at altitude 3600m in Savalan Mountain at pressure of 580mmHg and 12 $^{\circ}$C on 14:30 p.m.

Altitude, atmosphere pressure and environment temperature were measured by wrist digital altimeter, CASIO, Japan.

First of all, samples were gathered in physiological laboratory of Mohaghegh Ardabili University in Ardabil at 22 C^0 and altitude 1400m and the primary evaluation was performed. Height and body weight, fat percent and vo_2 max were measured.

Then, samples rested for 3 days and avoided any severe exercises between 3phases of test. At the first phase, all samples evaluated in Ardabil city in a physiological clinic of Mohaghegh Ardabili University. All tests of phase 2(sea lelvel) and 3 (3600m) also performed similarly.

For Lungs function's parameters measurement at first, Spirolab II (made in Japan) and equipped with monitor and printer (model Cat No. PSA 1600) was adjusted by an expert, and then the required instructions were provided to samples. During test performance we blocked the samples nose with clips to stop airways and the operator entered the required information of samples (height, age, gender, weight and race) in apparatus. Then, the samples stood or sit in an arm chair in a way that their ribcage was flat. Then samples put an aseptic plastic bag on their mouth and blew in it. This test included 3 stages according to American Thoracic Society (ATS) standards. All samples repeated the test phases 3 times and the best results were recorded by apparatus expert and then were analyzed.

The spirometry test performed in 3 stages:
1. FVC test: Via this test, we can measure FVC (L), FEV1 (L), FEV1 percent, FEF25-75% (L/s) and FIV1 (L) parameters and obtain flow volume curves of PIF (L/s) and PEF (L/s).
2. VC test.
3. MVV test.

Data are presented as mean (SD) to determine the distributions and analyses of data, Kolmogorov-Smirnov test and ANOVA for repeated with Bonferroni (post hoc) statistical analysis computations performed by SPSS software version 16 performed and $P \leq 0.05$ was considered significant.

Table1. Physical and physiological characteristics of subjects

Variables	*Mean±SD*
Number	11
Age (yrs)	22.27±0.65
Height (cm)	160.54±3.78
Weight (kg)	57.00±6.31
Vo2max (ml/kg/m)	40.65±1.00
Fat (%)	20.81±3.21

RESULTS

Physical and physiological characteristics of female athletics are presented in table 1.

Table 2. The changes in mean values for lung function parameters in 3 different altitudes by spirometry test in subjects

Different levels of altitude / Spirometry factors	Sea level	Ardabil(1400m)	Savalan(3600m)	
FVC(lit)	3.28±0.63	3.37±0.08	3.61±0.16 † *	P≤0.05
FEV1(lit/S)	2.96±0.36	3.27±0.47 †	3.22±0.50 †	P≤0.01
FEF_{25-75}(Lit/S)	3.53±0.61	4.00±0.78 †	4.25±0.85 †	P≤0.01
PEF(Lit/S)	6.65±1.12	7.29±1.26	8.22 ±0.84 † *	P≤0.01
PIF(Lit/S)	4.83±1.16	6.20±1.15 †	6.39±1.39 †	P≤0.01
VC(L)	2.71±0.45	2.67±0.45	2.88±0.41 †*	P≤0.05
MVV(L/min)	112.22±13.73	121.00±16.57 †	119.90±16.28 †	P≤0.01

† Significant difference in compare with sea level
** Significant difference in compare with 1400m*

ANOVA for repeated with Bonferroni (post hoc) statistical analysis computation test indicates that FVC and VC have a significant increase in 3600 m in compare to Ardabil and sea level ($P \leq 0.05$), and MVV at 3600 m (119.90L/min) and base level (Ardabil: 121.00 L/min) in compare to sea level shows a significant difference ($P \leq 0.01$) In compare to 3600 m and Ardabil its negligible but this amount in 1400m more than 3600m.

The observed difference obtained and the mean is indicated from FVC test (FEV1, PIF, PEF, FEF25-75%) in 3 different altitudes shown in Table. 2.

DISCUSSION

This study provides the comparison of the effects of acute changes of altitude on lung function parameters on the natural conditions of the female athletes.

Due to the existence of standard pressure and temperature at the sea level, one of the examinations of this study was done at this level.

In fact, in the past, the quantitative studies have not been done at the actual condition, especially on female athletes, and it has usually been studied by simulation of atmospheric air and oxygen pressures [5, 8, 15] where environmental and personal factors have been disregarded.

Because the environmental factors such as; air humidity, wind speed, air temperature and athletes hydration level are out of control and may cause the results of spirometry tests, this study has been done in summer and without raining.

On the other hand, the samples of this study were female athletes and therefore their menstrual cycle might affect the results obtained. Change of estrogen and progesterone level in menstrual cycle due to the changes of the ventilation responses. Hence, the entire tests were done 3-8 days after the menstrual days of the samples. [1,3]

In this study, FVC at 3600m (3.61 L) had a significant increase in compare with Ardabil level (3.37 L) and sea level (3.28 L) that is in good agreement with the results obtained by Sharma and Brown (2007).

The samples of their study were 7 male and 2 female athletes. Their results showed that at

3450m and during the first 24h, FVC increased about of 9% and then, had a significant decrease. Moreover, upon the ascending to 5350m, FVC increased about of 21% (4.16±1.13 to 5.07±0.29). FVC increasing that has been also showed at this study could be the results of airways resistance and air density decrease at high altitude.

The increasing of adrenalin hormone at high altitude may have an important role at the decrease of airways resistance. The increasing of this hormone activity causes a decrease at reversibility of lungs and dilatation of the vessels, and consequently airways resistance decreases. [1-4] This mechanism could justify the results obtained by Faramushi and co-workers (2012) and also, Deboeck G et al (2005), where VC (L) had a significant increasing at high altitude. But, whereas their samples were male athletes, VC obtained is greater than that of this study because respiration volume and capacity of men greater comparing to that of women (about 25%). VC is used to measure the volume of lung and is rarely connected to the power and stamina of the respiration muscles. Because VC increases at high altitude, the volume of lung increases also. [3, 5,18]

FEF25-75% had also a significant increasing at this study. It shows that the decreasing of atmospheric pressure causes FEF25-75% to increase. This is in good agreement with the results of Deboeck G et al (2005) where the main reason of this observation was known to be the decrease of airways resistance as a result of surfactant discharge.

MVV (L/min) is a dynamic and scientific method for measurements of respiration muscles capacity and indeed, is a test for evaluation of human respiration system. It did not have a significant increase at 3600m (119 L/min) comparing to that of Ardabil (121 L/min). Despite of decreasing of airways resistance at high altitude, the tiredness of respiration muscles, especially diaphragm as a result of the ventilation increasing and onerous nature of this test, could be the main reason of MVV consistency that has also been shown by Shamara and et al.

But, MVV showed a significant increasing comparing to the sea level. As it has been shown by Forte Va and his colleagues(1997) and also by Faramushi et al(2012), the reason of this increase is the deference of pressure between 3600m and sea level, where the air density and airways resistance decrease and consequently, the air could stream inside and outside the lungs. On the other hand, by increasing the sensitivity of carotids bodies, estrogen and progesterone hormones cause the lung ventilation increases at female. [3,21] Due to some restrictions, we would not be able to measure and control the variation of these hormones, so it is possible the level of these hormones at some samples increased at high altitudes and consequently the MVV level increased comparing to the sea level.

Mason and et al (2000) showed that the average of FEV1 has no changes at 5300m comparing to the sea level. But the present study showed that FEV1 has a significant increasing at 1400m and 3600m comparing to the sea level.
Besides, PIF (L/S) and PEF that show the maximum stream of respiration and expiration, became greater at sea level as a result of air density and airways resistance decreasing at this level(1,2,15). The same results obtained at the present study.

CONCLUSION

Several major reasons for the changes as indices of lung function at high altitude. Low air density and increasing the hormone adrenaline, which in total due to airways resistance reduce. Also tiredness of respiration muscles. In addition to these cases, hypoxia may be a decrease in surfactant discharge and increase at reversibility of lungs, airways resistance decreases. Of course it has been not confirmed in humans. Increased activity of the hormone adrenaline at high altitude has been reported repeatedly that induce to decrease of airways resistance So decrease of resistance airways and tiredness of respiration muscles as a mentioned, it would be affected parameters of lung function at high altitude. Most of the parameters of lung function significant increase at 3600m in compare with sea level that major reasons may be decrease of airways resistance due to low air density, increasing adrenaline hormone and may decrease of surfactant discharge. Also Among women, changes in sex hormones may affect lung function and ventilation. Periods of menstrual in women Induce to change these hormones. For this reason, in this study all samples were selected out of Periods of menstrual (3-8 days after the menstrual days) to Hormones progesterone and estrogen are few changes as possible.

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