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The Effect of Incremental Aerobic Exercise in Dusty Air on Pulmonary Function Indicators of Non-Athletic Overweight Men

Ameneh Balavi, Hojatollah Nikbakht *, Mandana Gholami, Khosro Ebrahim
Department of Exercise Physiology, Science and Research Branch, Islamic Azad University, Tehran, Iran

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***Corresponding author:**
Hojatollah Nikbakht. Department of Exercise Physiology, Science and Research Branch, Islamic Azad University, Tehran, Iran

Phone: +989121067749

Fax: +982144865121

Email: Hojnik1937@yahoo.com

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Abstract

Introduction: Dust has become one of the serious problems of people, and (more) especially in the cities of western and southwestern Iran. Despite the importance of the issue of dust, little has been done on this phenomenon, and there are many questions about many aspects of this phenomenon. This study sought to investigate the effect of aerobic exercise in dust -filled air and compare it with clean air on non-athletic overweight male using pulmonary function indicators.

Methods: Of the eligible candidates, 30 persons were selected in a targeted and accessible manner. The subjects were given two separate days in the clean and dusty air at the physiology lab of the Islamic Azad University of Sousangerd to perform a daily treadmill incremental aerobic exercise session. A spirometry test was used to determine the pulmonary function indicators before and after an incremental exercise test session in both days of clean air and high dust (with similar humidity and temperature). For statistical analysis of data Kolmogorov-Smirnov test and paired sample t test ($p \leq 0.05$) were used.

Results: Paired sample t test for changes in both airs indicated that there was significant difference in changes of FEV1 ($p=0.004$) and MVV ($p=0.004$) after incremental aerobic exercise between clean and dusty airs, nevertheless there were no significant difference in changes of FVC ($p=0.27$), FEV1/FVC ($p=0.50$) and VC ($p=0.16$) after incremental aerobic exercise between clean and dusty airs.

Conclusion: One session of incremental aerobic exercise in dusty air is associated with decreasing pulmonary function indicators and decreasing pulmonary function capacity.

Keywords: Dusty Air, Exercise, Pulmonary Function

Introduction

In recent decades, air pollution in many parts of the world has increased public concern about health effects (1). One of the most important natural sources of air pollution is dust storms, which annually add 800 trillion grams of mineral suspended particles to Asia (2). More than 17 provinces of Iran are involved in the phenomenon of dust. Undoubtedly, the control of a phenomenon that causes many diseases, including pulmonary, cardiovascular and cancer diseases, will require more effort and cross-regional cooperation with neighboring countries (3). Studies have shown that dust phenomena in recent years have led to many concerns in humans and the environment due to the concentration and run-off of the suspended particles, their continuity, extent and time. In recent years, continuous droughts, decreased precipitation and relative low humidity of the environment, along with the exacerbation of human environmental factors, such as the untapped use of desert water resources, the destruction of niches and the occurrence of war, have caused the drying of some wetlands, including Hoor al-Azim Wetland as well as the desert lakes of Syria and Iraq. The result of such events is the intense spread of dust and soil microstructures (3). In the western and southwestern parts of

Iran, this phenomenon has more destructive effects, and the short-lived impoverishment of adverse effects on the environment, economy and health of the inhabitants of these areas, especially in the western and southwestern cities and provinces of Iran such as Ilam, Kermanshah, Khuzestan (3). The health effects of dust events in the short to long term have attracted the attention of scientists. This scientific attention has led to many epidemiological studies in areas exposed to dust. Epidemiological studies have shown that respiratory diseases, cardiovascular diseases, deaths from these diseases, pneumonia, asthma, bronchitis, chronic obstructive pulmonary disease, pulmonary inflammation, ischemic heart disease, hospitalization, visitation in emergency and clinics, as well as the reduction of pulmonary function are related to dust storms (1, 5- 6). Despite the significance of dust phenomenon, there is still a dearth of research in this regard and a bulk of questions are raised on various aspects of this phenomenon. It should be noted that no study has so far been conducted to examine the effect of aerobic exercise in air filled with dust and compare it with clean air on pulmonary function indicators. Given the importance of the phenomenon of dust and its challenges in the community and possible problems of exercise in dusty air and fine-round scare of research in this regard, particularly its effect on pulmonary ventilation, the researchers strived to answer the question whether the implementation of one incremental aerobic exercise session in clean and dusty weather affects the pulmonary function indicators of overweight men or not. Research by Sanuman *et al.* (2000) showed a close and significant relationship between good performance of respiratory and overall health and other causes of death, so that a reduction in forced expiratory volume in one second, (FEV1), was reported as an independent risk factor for death (7). Forced vital capacity (FVC) and forced expiratory volume (FEV) are strong indicators of lung function that are reduced due to obesity and a relaxed lifestyle (8). However, in Hulk *et al.* (2011), study pulmonary function in boys and girls through an aerobic exercise program remained unchanged. In the above-mentioned study, Hulk *et al.* (2011) examined the effect of 12 weeks of exercise on pulmonary function of male and female students, and did not observe any change in pulmonary function tests, except for peak expiratory flow rate (PEFR) only in men (9). The results of studies by Asheau *et al.* (2012) that examined the effect of 12 weeks of incremental and aggressive aerobic exercise on pulmonary function of type 2 diabetic patients showed a significant increase in FVC and FEV1 levels (10). Mohammadzadeh *et al.* (2013) showed that eight weeks of exercise activity, upper limb and combined activity significantly increased the FVC, FEV1, and maximum ventilatory volume (MVV) respiratory indices. Also, maximal oxygen uptake VO_{2max}, total tolume (TV), and end- tidal oxygen tension (PETO2), oxygen ventilation indices increased significantly in the three training groups after 8 weeks proportionate to before exercise. The significant ratio of ventilation (VE)/ maximum ventilatory volume (MVV), which indicates the shortness of breath, was also reduced (11). The phenomenon of dust has long been observed in the western and southern provinces of the country abundantly. Due to the lack of understanding of the effects of this phenomenon on ventilation, pulmonary capacity and pulmonary function, research on this field is felt more. The question is that should in dusty conditions, exercise and physical activity should be excluded from fear of its potential damaging effects? Given that this phenomenon has an effect on the physical activity of the overweight men during physical activity on the ventilation, pulmonary capacity and volume, and the relationship between physical activity and dust with each other and with respiratory function in overweight men, the need for research in this regard expresses.

Methods

The statistical sample of the present study consisted of 30 male students (18- 24 years old) of Islamic Azad University of Sousangerd. They were first informed at the university level. Next, the purpose of the study as well as the method were explained to them. Finally, using their history form and health questionnaire. Some inclusion criteria of the study were included did not have a history of cardiovascular disease, pulmonary disease, abnormalities and smoking and exclusion criteria was included regular exercise at least in the 6 months before the study. The subjects signed a collaboration consent form in research work. The research method was quasi-experimental and applied. Two weeks before the start of the exercise program, the subjects were asked to attend to the center of health and wellness. There, data on age, height, weight, body fat percentage and maximum aerobic power (Table 2) were recorded. In order to match and homogenize the groups, the information gathered from the physical education lab, medical history information, and readiness to start physical activity obtained through health status self-assessment questionnaires. Then, the subjects were given two separate days in the clean and dusty air at the university's physiology lab to perform a daily treadmill aerobic exercise session.

The spirometry test was performed using the German CUSTO MED BTL mobile Spirometers Machine. Spirometry test was performed to determine pulmonary function, pulmonary capacity and volume before and after an incremental activity session in both clean air and dusty air so as to examine the effects of dust particles and incremental aerobic physical activity on the indicators pulmonary function of the subjects. The implementation of the spirometry test included a two-stage test. In the first stage, the subject began to take a normal inhalation and exhalation and did a single deep inhalation and exhalation with the test taker signal. In the second stage, the subject began a short and fast stretching, and did a single deep inhalation and exhalation with the test taker signal. Furthermore, pulmonary tests were measured and recorded under the supervision of a general practitioner and laboratory expert. Each subject performed three spirometry tests, where the best and most accurate test was recorded. Since the body's condition at the time of the test has a significant effect on the volume and pulmonary capacity, all subjects were tested at the same time as the test was performed. So that all subjects sat on the chair and relied on it and it was tried to get the subjects to a good position to do the test. Also, before the tests were executed, the implementation method and the performance of the subjects for the test execution were fully explained. They were practically displayed how the test was executed, and the subjects were asked to test several times before the actual implementation and repeat it experimentally to get familiar with how it was performed. For incremental exercise protocol, one session of incremental aerobic exercise was performed according to Balk treadmill test. At first, an experimental test was performed on one of the subjects and the necessary adjustments were determined in terms of severity and intensity. Subjects were advised to refrain from intense activity 48 hours before the tests. The test was performed on a treadmill and under the supervision of a helper. The initial speed was 3.2 mile per hour (5.47 kilometer per hour) with a zero slope. The slope was then increased by 2% over a period of one minute. Then, for each minute, 1 % was added to the slope. The test speed remained constant until the end of the test. The test continued until the exhaustion of the subject (12- 13). The first session of incremental aerobic exercise was performed in high concentrations of dust particles, the day when the concentration of the microspheres was sustainable in one of the 3 days and the air quality index (AQI) was in the orange (average of AQI=121) alert status and the second session of incremental aerobic exercise was done in the clean air when the air quality index was clean (average of AQI=49) and dust free (at 20°C and 40- 45 % humidity, which was the same every two days) and at the same time. Air quality index is the newest method for assessing respiratory air quality in urban communities. The Air Quality Index (AQI) represents how clean the air is. The lower the index is, the better the quality of the air. The AQI provides a number which is easy to compare between different pollutants, locations, and time periods. The purpose of the AQI is to help you understand what local air quality means to your health. To make it easier to understand, the AQI is divided into six levels of health concern (Table 1). The first session of incremental aerobic exercise was performed in high concentrations of dust particles, the day when the concentration of the microspheres was sustainable in one of the 3 days and the air quality index was in the orange alert status and the second session of incremental aerobic exercise was done in the clean air when the air quality index was Green.

Table 1. Air quality index values

Air Quality Index (AQI) Values	Levels of Health Concern	Colors
When the AQI is in this range:	..air quality conditions are:	as symbolized by this color:
0-50	Good	Green
51-100	Moderate	Yellow
101-150	Unhealthy for Sensitive Groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 500	Hazardous	Maroon

To measure Vo_{2max} index, the YMCA balk test was used (31). First, on the Ergometer screen, the word test was selected. Then, with the test plate appeared, information about the subject's age, the upper limit of the pulse rate (derived from 220- age), and the weight and sex of the subjects were entered into the bicycle monitor. The exercise protocol was performed during a 10-minute period with three different pedal strengths. So, one minute was considered as a stage of readiness. At this point, the person must walk in the direction of the bike's speed of 60 rpm. This number was recorded on the bicycle display. If this setting was not made, the subject experienced little or no speed. At the end of this period, three consecutive three-minute work load was performed. The pedal resistances were automatically adjusted at the end of every three minutes based on the pulse rate of the subject. In this case, the initial load was considered to be 1.0 kg and if the pulse rate of the subject at the end of the first three minutes was less than 90 beats per minute, the load of 2.5 kg was considered and if the pulse rate was between 90 and 110 beats, the load of 1.8 kg was applied and if the pulse rate was more than 110, then the load of 1.2 kg for the second stage (the second three minute) was applied. The workload of the third stage (the third three minutes) was also set to the same. After 10 minutes, the bike was relaxed, and the ergometer monitor, in addition to calculating the maximum aerobic power in milliseconds per minute, recorded how much each person was tracking per minute, along with the amount of work load. For statistical analysis of data Kolmogorov-Smirnov tests and paired sample t test ($p \leq 0.05$) were used. Data was analyzed using SPSS software version 21.

Results

Physical and physiological characteristics and pulmonary function of subjects are shown in Tables 2 and 3, respectively. Using Kolmogorov-Smirnov test, it was determined that the distribution of all variables in the research was normal; therefore, parametric tests used for statistical computations. In this study, all descriptive data were presented in the form of mean ± standard deviation. Paired sample t-test results and the difference between pre-test and post-test data indicated that incremental aerobic exercise in clean air causes a significant decrease on FEV1 (p=0.001), MVV (p=0.001), FEV1/ FVC (p=0.001), FVC (p=0.001), VC (p=0.01) of overweight men. Paired sample t-test results and the difference between pre-test and post-test data indicated that incremental aerobic exercise in dusty air causes a significant decrease on FEV1 (p=0.03), MVV (p=0.03), FVC (p=0.004), VC (p=0.03) of overweight men, nevertheless FEV1/ FVC ratio (p=0.81) decreased after dusty air activity, but these changes were not statistically significant (Table 3). Paired sample t test for changes in both airs indicated that there was significant difference in changes of FEV1 (p=0.004) and MVV (p=0.004) after incremental aerobic exercise between clean and dusty airs, nevertheless there were no significant difference in changes of FVC (p=0.27), FEV1/FVC (p=0.50) and VC (p=0.16) after incremental aerobic exercise between clean and dusty airs.

Table 2. Physical and physiological characteristics of subjects

Variable	Mean ± Standard Deviation
Weight (kg)	83.38±7.13
Body Fat (%)	22.39±3.17
body Mass Index (kg/m2)	27.006±1.21
$VO_{2\ max}$ (ml/kg/min)	3.508±38.12
Height(cm)	175.27±7.904
Age (years)	21.16±2.13

Table3. The results of paired sample t-test for comparison the effects of incremental aerobic exercise in dusty and clean air on pulmonary function

Variable	Air condition	Time		Paired sample t test for pre and post in each air	Paired sample t test for changes in both airs
		Pre-test	Post-test		
FVC	clean air	4.69±0.72	4.57±0.67	t=5.91, p=0.001*	t=1.10
(l)	dusty air	3.77±0.47	3.65±0.52	t=3.15, p=0.004*	p=0.27
FEV1	clean air	3.97±0.58	3.69±0.54	t=5.56, p=0.001*	t=3.314
(l)	dusty air	3.17±0.54	3.06±0.47	t=2.18, p=0.03*	p=0.004*
FEV1/FVC	clean air	0.84±0.047	0.806±0.074	t=4.29, p=0.001*	t=0.54
(%)	dusty air	0.03±0.006	0.02±0.07	t=0.23, p=0.81	p=0.50
MVV	clean air	159.11±23.28	147.84±21.68	t=5.68, p=0.001*	t=3.11
(l/min)	dusty air	126.36±21.98	122.75±10.94	t=2.13, p=0.03*	p=0.004*
VC	clean air	4.71±0.75	4.53±0. 58	t=2.63, p=0.01*	t=-1.42
(l)	dusty air	3.87±0.52	3.65±0.59	t=2.16, p=0.03*	p=0.16

Abbreviations: Vital Capacity = VC, Forced Expiratory Volume in First second=FEV1, Forced Vital Capacity=FVC, maximum ventilatory volume=MVV.
* =The difference is statistically significant

Discussion

The effect of incremental aerobic exercise session in clean and dusty air on FVC non-athlete overweight men showed that FEV1 values and MVV significant decreased after incremental aerobic exercise in dusty air than in clean air. Although FVC and FEV1 / FVC ratio decreased after dusty air activity and VC levels, these changes were not statistically significant. The amount of air pollution by a person in general depends on the total pollution of harmful contamination, which is usually determined by the duration of exposure and the concentration of chemicals. In addition, to reduce the effects of air pollution, vulnerable groups are advised not to exercise in contaminated air. The second is that more contaminated air may be inhaled because of the effect of exercise intensification on the amount of lung volume and increased respiratory rate during the exercise (15). Epidemiological studies also show that ischemic heart disease, respiratory diseases such as asthma, rhinitis, pneumonia, pulmonary dysfunction, daily mortality, and hospital admission increase within 2 days after the occurrence of dust (16). Rayon Cowan *et al.* (2010) argued that intense periodic exercise, due to increased demand for respiration, prompted repeated respiration of the lung and reduced airway resistance and improved pulmonary function by reducing the contraction of smooth muscle in the lungs (17). According to the guidelines of the American Pulmonary Disease Association, lung function tests include VC, FVC, FEV1, and PEF. Most likely, FVC, which is a dynamic pulmonary volume, is reduced in patients with moderate to severe chronic obstructive pulmonary disease (COPD). Moreover, spirometry test is a golden standard for the diagnosis, assessment, and monitoring of chronic pulmonary disease, and is currently the preferred method for adults to demonstrate airway obstruction in asthma diagnosis (19). The FVC should be predicted to be more than 80 % and the limiting diseases should be reduced (19). FEV1 represents total lung capacity, airway obstruction, loss of lung reversibility, and unusual insufficiency of respiratory muscles. FEV1 values are reduced in both obstructive and limiting diseases and is recommended as a powerful factor for measuring chronic pulmonary disease (19). The variable range of FEV1 is very low in various repetitions in a COPD patient (170 ml) (19). FEV1 is a unique test of respiratory function that is affected by several factors (6). In their findings, Price and colleagues (2015) showed changes in tracheal resistance index (FVC, FEV1, FEV1 / FVC, PEF). In the present study, the pattern of changes in FVC in clean air and in dusty air showed a significant decrease. However, the comparison of FVC values in dusty air to clean air showed a non-significant reduction. The respiratory indicators measured in this study were the most important dynamic respiratory indicators that have so far been studied. The FVC includes the current volume plus inhalation and exhalation storage volumes. High-pressure vital capacity is one of the dynamic pulmonary volumes that depended on age, physical activity, body composition, and health status (21). And usually it is about 80% of the individual's vital capacity. Measuring this index provides useful information on the strength of respiratory muscles and lung function (21- 22). FVC is one of the dynamic pulmonary volumes that depends, and is also affected by respiratory muscle strength and the degree of chest compilation (23). In a study in line with this study, Poorzasz *et al.* (2005) found that a significant increase in FVC and FEV1 was observed in the study of 24 patients with lung diseases for 7 weeks with a high intensity intensive training program (24). In the findings of Pereira *et al.* (2008), obesity was thought to reduce pulmonary function indicators such as FVC and FEV1 (26). In Azizi *et al.* (2005), obesity was identified as a risk factor for asthma. Obesity and other factors have a negative effect on pulmonary function by decreasing the strength of the respiratory muscles, increasing the resistance of the airways, reducing the volume of lungs (25). However, in Hulk *et al.* (2011), there were no significant changes among the training groups in all respiratory indices (9). Shaw *et al.* (2010) concluded that aerobic exercise had no significant effect on the improvement of FEV1, FVC, and VO_{2max}. These researchers showed the lack of duration and intensity of exercise as the reason for observing these findings (28). Also, the pattern of FEV1 changes in clean air and in dusty air showed a significant decrease. Comparison of FEV1 values in dusty air to clean air showed a significant decrease. Based on the investigations, FEV1 has been introduced as an independent predictor of longevity and instrumentation as an assessment of general human health (8- 19). Reduction of FEV1 is a reflection of a decrease in total lung capacity, obstruction of the airways, loss of lung reversibility and unusual inadequate respiratory muscle growth. Thus, with the improvement of the strength of the respiratory muscles, FEV1 also increases. In mild asthma, it is likely that FEV1 is lower than the air flow obstruction. The FEV1 / FVC ratio remains normal (or even elevated) in the limiting disease and obstructive diseases (19). Mulley *et al.* (2003) observed that lipid deposition in humans reduced levels of gastrointestinal tract and reduced pulmonary volume. In obese individuals, fat deposits in the abdominal wall, chest and respiratory tract lead to limitation in pulmonary parameters. The accumulation of adipose tissue gradually decreases the elasticity of the respiratory muscles and the compartment of the chest and increases respiratory and energy intake for pulmonary ventilation. The reduction in expiratory volume by pressure in one second was introduced as a risk factor (30). Shower (2010) and Kalpana *et al.* (2011) Researches, obesity may interfere with mechanical functioning of the airway and neuromuscular function, and that the syndrome of respiratory air volume reduction in obese subjects is increased Also, showed that rapid and shallow breathing occurs due to the overweight and obesity phenomenon (4- 14). The pattern of FEV1 / FVC changes in clean air showed a significant decrease and a decrease in dusty air was not significant. However, the comparison of FVC values in dusty air relative to clean air showed a non-significant reduction. The FEV1 / FVC ratio is a precise criterion for diagnosing airway obstruction and an appropriate indicator for limiting airflow. In addition, among respiratory function indices, FEV1 / FVC ratio is the best predictor of respiratory capacity improvement during exercise (18). The FEV1 / FVC ratio shows the respiratory capacity as well as the airflow resistance that depends on age and body size in adults and is between 13 % and 55 % in women (21). Most of this is in children. Reducing this index indicates an increase in airway resistance and a reduction in ventilation efficiency (21- 22).

However, in each individual, if the value is above 70 %, the probability of blockage is effectively eliminated. If the patient has an incomplete ventilation constraint, FEV1 and FVC both decrease, but FEV1 / FVC are relatively normal (more than 75 %) (19). Astorino *et al.* (2013), intensive exercise training was said to have a more effective effect on moderate intensity exercises on FEV1, FVC, FEV1 / FVC indices (27). However, Donham *et al.* (2010) suggested that there was no difference in the degree of influence on respiratory volume between intuitive training and continuous endurance training (29). Also, the pattern of MVV changes in clean air and in dusty air showed a significant decrease. Comparison of MVV values in dusty air to clean air showed a significant decrease. Among respiratory maneuvers, MVV is more likely to be seen as a dynamic ventilation test, in which MVV reductions are observed in neuromuscular and cardiovascular patients, and those with obstructive airway strictures. Therefore, the amount of MVV depends on the individual's capacity and ability to exercise, as well as the limitations of the shortness of breath. In a healthy adult, the MVV value is 40 times that of FEV1. Ventilation that can be obtained in a resting position, the biggest minute ventilation at the time of exercise in adults, including men and women, is about 75 % MVV. This indicates that the ventilation capacity during the exhausting activity is not more than the maximum permitted value (20). Since MVV is the largest minute the pattern of VC changes in clean air and in dusty dust showed a significant decrease. However, the comparison of VC values in dusty air relative to clean air showed a significant increase. The results of this study are consistent with some of the results of the previous studies but inconsistent with some others (21- 22). This may be due to the non-randomness of the methods, the use of different training plans and procedures or the maximum exercise protocol, the use of patient subjects or subjects with pulmonary duct obstruction, or the lack of homogeneity of subjects in terms of age and sex. At the end it should be noted that changes in pollutants on test day, type of daily physical activity of subjects, the structure of the mucosa and respiratory tract of the subjects, the body structure and subjects anthropometric, the habit of how to inhale and exhale are some of research limitations of the present study. Also, it proposes future researches review the effect of physical activity in dusty air and its impact on the immune system, examine the effect of physical activity in dusty air and its effect on insulin resistance index and review the effect of exercise in clean and dusty airs in patients with mild asthma or COPD.

Conclusion

In general, the results of this study suggest that one session of incremental aerobic exercise in dusty air is associated with increasing pulmonary function indicators and decreasing pulmonary function capacity. An incremental aerobic exercise session seems to be associated with increased airway resistance and reduced pulmonary function, after exposure to dusty air.

Ethical issues

In this research, oral or written consent was received to observe the ethical issues from all subjects. All ethical considerations were revisited and approved in Islamic Azad University Sousangerd Branch.

Authors' contributions

The authors did not have any conflicts of interest which may unfairly affect their decision to publish the article

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