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Original Article

The Interactive effect of 12 weeks of aerobic training and the intake of multivitamin minerals supplementation on indicators of male pulmonary function in the expose of urban polluted air.

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Abstract

Background: This study studied the interactive effect of 12 weeks of aerobic training and the intake of multivitamin-mineral supplementation on the indicators of male pulmonary function in the exposure of urban polluted air.

Method: 46 subjects, with an average age of 25 ± 1.2, took part voluntarily and were completely satisfied in this quasi-experimental study. They were randomly assigned to 4 groups: supplement and exercise (11 subjects), exercise (N = 11), supplement (N = 12), and control (N = 12). This Aerobic exercise was carried out with the same and increasing practice protocol for the first and second groups (including the first week of 12 minutes running with 60% heart rate up to the 12th week, progressively 30 minutes running with 85% heart rate reserve) and with supplementation of multivitamin - minerals which were taken as one capsule each day for the first and third groups of the research. In addition, the variables, including FEV1, FVC, FVC/FEV1, PEF, and FEF_{50} were measured once before and after 12 weeks using a spirometry device connected to the computer, and Respiratory symptoms were measured by the Respiratory Standard Questionnaire.

Results: After 12 weeks of intervention, there was a significant increase in the level of functional parameters of the lung in the combined and supplementary groups and a significant decrease in the exercise group compared with the before the time of the study ($p<0.05$). The results showed a significant difference between the groups in the measured variables, which was insignificant between the combined group and the exercise.

Conclusion: The study results showed that 12 weeks of aerobic exercise and consumption of multivitamin-mineral supplementation leads to a significant increase in the levels of male pulmonary function in urban polluted air. Therefore, using the same amount of vitamins and necessary minerals is recommended to improve pulmonary function, and in case of shortage, use antioxidant supplements, such as the multivitamin-mineral supplement.

Keywords: Aerobic exercise activity, multivitamin-mineral supplementation, indicators of male pulmonary function, urban polluted air

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Introduction

Several types of pollutants enter the atmosphere due to human natural and artificial activities on the earth and cause air pollution in cities, especially in large cities and industrial areas. Researches show that the amount of pollutants in the Crowded and industrial cities is 8 times more than the global standard, and contaminates the metropolitan airspace to a radius of 100 kilometers (1). Air pollutants such as particle matters, are capable of reaching the pulmonary respiratory tract. These particles penetrate into the respiratory system through the upper respiratory tract and are deposited on the surface of the lung alveolus. The exposure of people to particle matters leads to asthma attacks and dyspnea. If these particles enter in the lung alveolus of respiratory tract and destroy these mucous membranes, the respiratory system function will be impaired and people may suffer from choking in acute conditions (2, 3).

Epidemiological studies show that increase in particles of the concentration of matter and inhalable toxins in the air increases the number of patients in hospitals, causes acute respiratory complications, reduces respiratory capacity and increases mortality of people (4, 5). Children, the elderly, Asthma patients, obstructive pulmonary diseases, cardiovascular disease, and smokers are vulnerable to air pollution, as respiratory defense is fragile in these people (5). Among people, active individuals and athletes are controversial due to high metabolic requirements and high breathing rate during physical activity, which is some times more than 20 times more than normal situations, and can lead to acute risks for them. (4, 6-9). On the other hand, regular physical activity plays an important role in general health, including the function of human respiratory system. By increasing physical activities, the intensity of breathing will increase and more air enters the lungs. This process may increase the risk of absorption of contaminants through respiration. However, enjoying the benefits of public exercise will be optimal when exercise and physical activity are carried out by considering health considerations, including appropriate environmental conditions (10-12). Therefore, there is a hypothesis that air pollution may limit the effect of exercise on health. Limited studies have reported that aerobic physical activity in polluted environments leads to a reduction in pulmonary function, in a way that exposure to air pollutants results in changes in the function of various systems in the body, including the respiratory system, which leads to various diseases in the body without a reasonable strategy to deal with this problem (4, 11).

Researchers have made many recommendations to reduce the harmful effects of polluted air, including having an appropriate diet, following the nutritional guidelines and using antioxidant supplements in air pollution (13- 16). Strategies such as the use of drugs and some antioxidants have been introduced to counteract oxidative effects of air pollutants, for example, the consumption of food sources containing vitamins E and D can neutralize the harmful effects of pollutants. since environmental degradation factors, such as air pollution, cause the body not to be able to fight against harmful agents, building and operating cells in the body are destroyed by destructive mechanisms such as free radicals, but antioxidants are molecules that can prevent the action of free radicals and the destruction of vital cells in the body. (13, 17, 18)

According to investigations, observance of the nutritional recommendations in condition of air pollution is important because in conditions of air pollution, all people, especially active individuals, are very vulnerable, in a way that the risks of inhaling pollutants in urban air by different individuals especially those who are involved in physical activities in open and unhealthy places, can be a hazard for health of the participants in such activities (19, 20). Our country is also one of the developing countries that is faced with the problem of air pollution and sport activities are held nationally and in general level in quantitative and qualitative comments in different cities. Conducting a research in the level of pollution similar to unhealthy days in cities and polluted places are necessary to clarify the effects of this air pollution during exercise on health factors and the ability to perform sports activities in the community.

Researchers have always tried to introduce a way to reduce the harmful effects of physical activities in polluted air on the health of people in the community (21, 22). But researches on physical activities, especially in humans, is limited, in a way that a similar study did not simultaneously examine the effects of supplements consumption and exercise in polluted air and many of these issues have not been resolved yet and many questions are remained unanswered. Therefore, considering the existing contradictions, the existence of limited human studies and the need for more accurate information to prepare strategic schemes to prevent the decline in the performance of active individuals and athletes, the present study is to investigate the effects of antioxidant supplementation (multivitamin-Mineral) along with aerobic physical activity in the exposure of urban polluted air on pulmonary function indicators including: checking the FEV_1 (forced expiratory volume in the first seconds), FVC (forced vital capacity), PEF (expiratory peak velocity), FVC/FEV1 ratio, and $FEF_{50\%}$ (forced expiratory flow at 50%) for men and indicates that whether the antioxidant supplements consumption along with exercise can affect lung function indicators in the exposure of urban polluted air or not.

Material and methods

This research is a semi-experimental and pre and post-test design with control group. A total of 46 healthy men between the age of 20 and 30 volunteered to visit before Mehr Falavarjan Stadium at least once a week. They participated in this study with full and informed consent. In their arrival, all of the subjects were acquainted with the purpose and potential risks of the research and completed the satisfaction questionnaire of Involvement in research, physical activity and medical history. Then, they were randomly assigned into 4 groups: the multivitamin supplement consumer with regular aerobic exercises (AE+S=11), aerobic exercises (AE=11), only multivitamin consumer (S=12), and the control group (AE=11) people without aerobic exercises activity and without a supplement consumption were exposed to Mehr Falavarjan outdoor running stadium with polluted air.

On them before the beginning of the study, the subjects of AE+S and S groups were requested to take a multivitamin minerals capsule produced by Iran-Drug Company every day after dinner for 12 weeks in addition to participating in aerobic exercise under the supervision of the researcher. The aerobic exercise group was also requested to participate in aerobic exercises only at the stadium for 12 weeks, three days a week with 60-85% intensity of maximum heart rate. The subjects of the S group consumed a multivitamin-minerals supplement every day after dinner (23). Meanwhile, the group C was also present at the test site without applying any variables on them at that time.

All of the groups (3 sessions from 16:00 to 18:00 every week) were present at the Mehr Falavarjan Stadium for 12 weeks (6 km west of Isfahan city, 5 km west of Sepahan Cement Factory, 8 km away from Esfahan iron foundry Factory and 4 km north west of the lead mine of Goshfil) and the AE+S and AE groups were involved in aerobic exercise with the same and increasing exercise protocol including: The first week of 12 minutes running with 60% heart rate until the 12th week, gradually reaching to 30 minutes running, attained 85% of heart rate - 10 minutes warm up with jugging and stretching exercises and 10 minutes cool down at the end of each session"(24).

All of the measurements were performed for all the participants at the same time and in the same conditions, in a way that the variables were measured once 24 hours before the beginning of the first session and once 48 hours after the end of 12 weeks' aerobic physical activity in the urban polluted air from all groups. Air pollution values were estimated as a pollution standard index (PSI) from an average of 36 sessions of activity over 12 weeks' exposure to the polluted environment, according to the reports from the Environmental Organization and the Meteorological Office of Isfahan province, as well as gained data from the pollutant measurement device (TSI- Dust Trak 8520) which was built in the United States with the assistance of Isfahan Process Monitoring Company (25).

Measuring Pulmonary Function Indicators

Measuring Pulmonary functional parameters was performed in two stages (pre and post-test) with completely similar conditions with the aim of measuring some of Pulmonary Function Indicators Contains FEV_1 (forced expiratory volume in first seconds), FVC (forced vital pressure with capacity), PEF (expiratory peak velocity), The ratio of FVC/FEV_1 and $FEF_{50\%}$ (forced expiratory flow at 50%) for each subject in a sitting position with using a spirometry device connected to a computer made in the German company (Jagger - Masterscope Rotary). This test was performed at least 3 times per subject and the best results were recorded for analysis (26).

Statistical Analysis

Descriptive statistics techniques were used to diagnose and categorize data and determine the mean and standard deviation of data. Kolmogorov Smirnov test was used to determine the natural distribution of data and inferential statistics, dependent t test for intra-group comparison of variables and variance analysis with frequent measurements for comparison between groups. The LSD post hoc test was also used to compare the group pairs. The 22nd version of SPSS software was used for data analysis, and EXCEL software was used to plot the graphs. A significant level ($p < 0.05$) was considered.

Results

The mean and standard deviation of the physical characteristics of the subjects in the four research groups, such as age, height, weight, BMI, are presented in Table 1.

Table 1. Physical and physiological characteristics of subjects

Groups	Variables			
	Age (Year)	Height (Cm)	Weight (Kg)	BMI
AE+S	24.63±1.52	176.45±5.56	74.18±2.56	23.85±1.08
AE	25.45±1.43	173.27±1.43	75.01±2.82	23/91±1.26
S	25.33±2.42	175.75±4.75	73.51±3.31	23.82±0.84
C	25.21±1.66	174.75±4.71	72.58±2.53	23/77±0.75

The mean and standard deviation of the air quality of the test site performance based on the pollution standard index (PSI) are shown in Table 2.

Table 2. Mean and standard deviation of the air quality of the test site performance during 36 sessions

Air quality classification	Range	Number of sessions (days)	PSI	Total PSI
Clean Air	0-50	-	-	127.58±2.85
Healthy air	50-100	8	88.25±4.12	
Unhealthy for certain groups	100-150	22	132.47±3.46	
Unhealthy for the public	150-200	6	162.18±2.28	
Very unhealthy	200-300	-	-	
Dangerous	300	-	-	

Table 3-7 shows the values of pulmonary function indicators by means of t-test mean and standard deviation in the research groups. The results suggest that after 12 weeks all the indicators of lung function, in groups of AE+S and S, increases significantly (other than from FVC/FEV_1 in which this increase was not statistically significant) and decreases significantly in AE compared to the time before the study ($p<0.05$). However, analysis by ANOVA showed significant difference between the groups in levels of lung function indicators, this difference was significant between groups AE+S with AE and C significant, but not significant between AE+S with group C.

Table 3. Mean and standard deviation FVC values before and after 12 weeks

Groups	FVC values		T value	Significant
	First stage (pre-test)	Second stage (post-test)		
AE+S	4.12±0.34	4.91±0.63	-3.96	0.003*
AE	4.39±0.63	3.83±0.42	1.90	0.041*
S	4.16±0.45	5.05±0.71	-2.80	0.017*
C	4.35±0.50	4.17±0.77	0.09	0.962

** The significance level is $\alpha \leq 0.05$*

Table 4. Mean and standard deviation FEV_1 values before and after 12 weeks

Groups	FEV_1 values		T value	Significant
	First stage (pre-test)	Second stage (post-test)		
AE+S	4.02±0.57	4.73±0.73	-2.65	0.024*
AE	4.38±0.83	3.74±0.45	2.32	0.043*
S	4.16±1.85	5.12±0.84	-3.92	0.002*
C	4.17±0.61	4.13±0.22	0.09	0.926

** The significance level is $\alpha \leq 0.05$*

Table 5. Mean and standard deviation FEV_1/FVC values before and after 12 weeks

Groups	FEV_1/FVC values		T value	Significant
	First stage (pre-test)	Second stage (post-test)		
AE+S	0.89±0.09	0.92±0.14	-0.43	0.67
AE	0.91±0.06	0.86±0.07	1.18	0.62
S	0.88±0.16	0.95±0.05	-0.94	0.36
C	0.90±0.13	0.89±0.04	1.12	0.28

** The significance level is $\alpha \leq 0.05$*

Table 6: Mean and standard deviation $FEF_{50\%}$ values before and after 12 weeks

Groups	$FEF_{50\%}$ values		T value	Significant
	First stage (pre-test)	Second stage (post-test)		
AE+S	5.13±0.45	4.32±0.92	-2.72	0.021*
AE	4.06±0.96	4.69±0.48	1.28	0.028*
S	5.33±0.69	4.38±0.74	-1.99	0.072*
C	4.67±0.38	4.70±0.89	0.37	0.718

Table 7. Mean and standard deviation PEF values before and after 12 weeks

Groups	PEF values		T value	Significant
	First stage (pre-test)	Second stage (post-test)		
AE+S	6.42±0.75	7.19±0.90	-3.64	0.003*
AE	6.89±1.20	6.15±0.68	1.33	0.021*
S	6.39±1.29	7.97±1.24	-4.64	0.001*
C	6.74±0.68	6.49±1.05	0.54	0.596

** The significance level is α≤ 0.05*

The results of the standard respiratory questionnaire (respiratory symptoms including cough, throat tightness, wheezing and shortness of breath) are shown in frequency and percentages in Table 8.

Table 8: Frequency and percentage of respiratory symptoms before and after 12 weeks

Respiratory symptoms		AE+S=(n=11)		AE =(n=11)		S=(n=12)		C=(n=12)	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent
Cough	before	2	18.18	1	9.09	2	16.16	1	8.33
	after	4	36.36	5	45.45	1	8.33	1	8.33
Sputum throat	before	1	9.09	1	9.09	2	16.16	0	0
	after	2	18.18	4	36.36	0	0	1	8.33
Wheeze	before	0	0	0	0	0	0	0	0
	after	2	18.18	3	27.27	0	0	0	0
Shortness of breath	before	0	0	0	0	1	8.33	0	0
	after	2	18.18	4	36.36	0	0	1	8.33

There was a significant difference between the variables of intra-group and out-of-group by using ANOVA analysis. In Table 9, intra-group and intergroup changes in the values of pulmonary function indicators of four groups are shown. The results of the findings show that the values of pulmonary function indicators have increased in two groups of AE+S and S, decreased in the AE group and remained unchanged in the control group. These results were statistically significant (P≤0.05). The difference between groups by using the LSD test shows that there was no significant difference between the AE+S group that performed regular aerobic exercises and used supplementation with the AE group that followed only the exercises and the group C but with the group S, changes in the values of functional parameters were significant.

In addition, the AE group, which only had regular aerobic exercises, had a significant decrease in the values of functional parameters with the S group and the C group. The results also show that there was a significant increase in the values of functional parameters between the S group and the C group.

Table 9. Results of intra-group and intergroup changes using ANOVA

effects	df	F value	Significance
intra-group Original effect	9	380.50	0.000*
intra-group Interactive effect	27	5.98	0.000*
Intergroup effects	3	12.74	0.000*

** Significance level accepted for intra-group and inter group changes P<0.05*

Discussion

The respiratory system is the first organ of the human body that is in direct contact with air pollution and the lungs are a member of the body responsible for absorbing air oxygen and removing carbon dioxide from the blood. This is due to several reasons: firstly, during physical activity, pulmonary ventilation and gas release capacity in the lungs increase and allow higher levels of particle matters and polluted gases enter the body; secondly, during Physical activities, especially high-intensity activities, polluted materials and particle matters enter directly the lower airways and lungs without passing through the nasal mucous membrane that can absorb and trap air pollutants because breathing is mainly done through the mouth. For this reason, during physical activity, some air pollutants such as particles matter, ozone and nitrogen oxides, even at low concentrations, cause lung damages which occurs only at high concentrations of these pollutants when resting. (27-29).

Despite the positive effects of exercise on the health of body and soul, it should be considered that exercising in polluted air will exacerbate the negative effects of air pollution on humans. The results of this study showed that exercise and physical activities in urban air pollution caused a significant decrease in pulmonary function indicators and respiratory capacity as a result of increasing metabolic needs and increasing respiratory rate several times more than the normal level, which is consistent with the results of most researches (4, 25, 30-33). However, the resultant changes in the FVC/FEV_1 ratio were not significant, which is probably due to the low number of subjects (6, 34). Researchers believe that any kind of pollution, including air pollution caused by temperature inversion due to increased pollution and air displacement, pollution from environmental pollutants such as pollutants from incomplete fuel such as particle matters, lead and ..., threaten the health of people living in metropolitan areas, especially, athletes a lot (1, 2). Particle matters in urban polluted air are a mixture of solid particles and liquid droplets that are less than 10 micrometers in diameter and can penetrate the upper airway through the lungs and cause serious health problems for people. It has been shown that during exercise, the amount of deposition of particle matters in the lungs is directly proportional to the amount of pulmonary ventilation per minute, and in comparison to superficial and quick breathing, deep and slow breathing, causes a higher rate of these particles to precipitate in the lungs. The deposit amount of particle matters which are less than one tenth of a micron in the lung, is reported to be about 5 times more than the resting condition during moderate-intensity physical activities. Many of these polluted particles are removed from the nose by small hair-like appendages; however, very small particles can enter the lungs and precipitate in the lungs for several weeks, months or years, and affect the lungs function and prevent the process of treatment and the development of respiratory illness by destruction of the lungs (35-38).

In the present study, it has been shown that physical activity in urban polluted air can increase respiratory tract complications such as dyspnea, wheezing, Sputum throat and cough, among people, which was consistent with other studies conducted in this field (39, 40). As most researchers have shown, carbon monoxide (CO), which is an important air pollutant enter the bloodstream through the lungs and lead to chest pain and respiratory symptoms such as shortness of breath and burning of the respiratory tract, especially during exercise (41).The pollutant of sulfur dioxide (SO_2), causes reactions in most systems of the body, stimulates the mucous membranes of the respiratory tract, increases the resistance of lung airflow, causes chest pain, increases the respiratory movements rate, increases chronic pulmonary diseases, especially bronchitis, coughing, and reduces respiratory capacity even at very low concentrations (42). The effects of nitrous oxide (NO_2) on humans are also entirely limited to respiratory effects, which have been reported to have consequences such as nasal cavity discomforts, respiratory failure and increased acute bronchitis (43, 44). Ozone pollutant also causes symptoms such as coughing, shortness of breath, airway shrinkage, and respiratory disorders. It has been proved that ozone leads to irritation of the respiratory tract, reduction of pulmonary function and exacerbation of asthma, increase of asthma patients' reactions to allergies, inflammation and lung destruction and increase the risk of respiratory infections. Exposure to ozone with a concentration of 100 ppb can significantly reduce the pulmonary function (decreasing FVC, FEV_1 and FEF_{50}, etc.) and increase the airway resistance in athletes who exercise with lung ventilation at a rate of 70 liters per minute. Exposure to ozone with a concentration above 120 ppb has adverse effects on human health. Symptoms include nasal and throat irritation, coughing, wheezing, shortness of breath and disability to breathe deeply due to pain or pressure in the chest, nausea, and headache. In athletes, it has been reported that the pulmonary function reduces with the increase of exercise intensity, which has been associated with increased airway resistance (45, 46).

On the other hand, this research clearly shows that people who do physical activity in the environment with high concentration polluted and consume nutritional supplements like multivitamin-mineral supplement at the same time, not only their respiratory system functions disorderly, but their pulmonary parameters improves fairly. This is confirmed by some studies in this field (48-54). According to research results, nutritional supplements including the supplement used in this study (multi-vitamin-mineral), are rich in vitamins and minerals that are needed and essential for the body, including vitamins A, B , C, D and E, as well as minerals such as calcium, phosphorus, magnesium, zinc, etc. (13,14). Researchers have focused on the antioxidant role of vitamins in the diet of athletes, especially vitamins C, E and A, in reducing the effects of harmful pollutants on the body, and recommended that athletes use enough foods containing vitamins in their diet and in case of inadequate consumption or shortage use supplements (55). One of the nutritional recommendations is drinking milk in the case of air pollution, because milk regulates release of pollutants and Toxins neutralize due to the presence of phosphorus, magnesium and calcium. Moreover, since vegetables and fruits are rich sources of vitamins, using various kinds of them is a way of counteracting and reducing the effects of harmful air pollutants because the human body can use antioxidant compounds, including healthy and useful food sources and different types of Vitamins to counteract or eliminate the destructive effects of free radicals naturally, but in cases of lack of adequate antioxidant and nutritional substances, the need for these substances is fullfilled by a nutritional supplement (54).

Nutritional supplements like the multivitamin-mineral supplement used in this study, are antioxidants that play a vital role in the health of the human respiratory system. The multivitamin supplement is effective in improving the function of the lungs since it contains essential vitamins and minerals. These nutrients can effectively prevent the onset of inflammation of the respiratory system and cause the deactivation of free radicals in polluted air and reduce the destructive effects of particles matter in polluted air due to their antioxidant, anti-cancer and anti-inflammatory properties (14, 55). The available pollutants have adverse effects by attacking the cells of the body, especially the tissues of the respiratory tract. Normally, the immune system protects the cells from all external damage, but environmental degradation factors, such as air pollution, cause the body to fail to fight, as a result the building and operation of the cells of the body will be destroyed by destructive mechanisms such as free radicals. On the other hand, antioxidants are molecules that prevent the action of free radicals and prevent the destruction of vital cells in the body. The consumption of antioxidants provides a condition for the body to eliminate harmful free radicals easily (56-59). It has also been shown that the consumption of vitamin E and antioxidant supplements in animal models, reduces some of the harmful effects of pollutants by fighting against the oxidation mechanism of the pollutants. The results of most researches in this field are consistent on experimental animals in polluted air with the consumption or injection of nutritional supplements with the current research. But at this moment, a definitive opinion on the effects of these supplements on the improvement of the athlete's performance can't be expressed, and further studies in different environmental conditions, with different levels of pollutants, different human groups are nutritional recommendations or dietary supplements consumption are needed (60-62).

Conclusion

Observing nutrition recommendations is very important in the context of air pollution, because everyone is vulnerable to air pollution. Applying nutritional advice is not only for children, the elderly or patients, but all individuals, especially active individuals, should follow these guidelines so as not to be damaged in the polluted air. One of the nutritional recommendations in the context of air pollution is the consumption of food rich in vitamins and minerals, or the consumption of supplements, because their substances prevent the absorption of lead and heavy metals in polluted air. In general, exercising is recommended away from sources of pollutants and low traffic areas because the concentration of many air pollutants decreased exponentially with the increase of distance from sources of pollutant production. In the absence of clean air without pollutants, considering the role of vitamins and antioxidants in reducing the effects of harmful pollutants on the body, the athlete's diet should be fully paid attention to. Athletes should consume enough fresh fruits, vegetables or supplements in their diet, in the case of inadequate consumption or shortage.

Competing interests

There is no competing of interest to disclose

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