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Comparing the effect of aerobic exercise in clean and polluted air on the responses of interleukin-6 and Reactive Protein-C in the active people.

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Abstract

Background: Athletes and people participating in sports activities are at risk due to the inhalation of pollutants. This study aimed to compare the effect of one session of aerobic exercise in clean and polluted air on the response of some inflammatory factors in active people.

Methods: 10 active men with at least three years of regular exercise training were selected. Their blood samples were collected on two separate days, in polluted air with an air quality index (Air quality index, or AQI) of 120 in the alert state (orange) and 59 days later in clean air with an AQI of 52 in a clean state (yellow), before, immediately after conducting a block field test, with an intensity of 69-55% of maximal heart ratem, and 24 hours after the activity in a sitting position, on the chair and from a left brachial vein, to determine the amounts of IL-6 and C-reactive protein by ELISA method. Analysis of variance with repeated measures was used.

Results: The levels of IL-6 immediately after exercise and 24 hours after exercise in polluted air showed a significant increase compared to clean air. Although C-reactive protein levels increased after exercise with exposure to high concentrations of pollutants, this increase was not statistically significant.

Conclusion: Aerobic exercise subjected to a high concentration of pollutants compared to clean air causes a significant increase in serum levels of some cardiovascular disease predictive factors, such as interleukin-6 and C-reactive protein.

Keywords: Polluted air, Pollution index, Interleukin-6, C-reactive protein, Aerobic exercise

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Introduction

Environmental pollution is one of the human health problems in industrialized and developing countries. Studies have shown that exposure to air pollution and inhalation of air pollution along with disease progression, including cardiovascular disease, respiratory problems, and even death (1). Air pollutants can be divided into two main categories: primary pollutants that are directly produced and include carbon monoxide, sulfur oxides, nitrogen oxides, hydrocarbons, and solid particles. Secondary pollutants are created through interactions between primary and environmental pollutants, including ozone, acetyl nitrate proxy, Aldehydes, sulfuric acid, and sulfates. Dark clouds or smoke seen in many of the world's most populous cities usually include both pollutant categories (2). Pollution caused by vehicles is known as the primary source and includes a mix of pollutants (3). Many pollutants arrive quickly and without vital deformation in blood, and their harmful effects have been shown in the blood, brain and bone, spleen, and lymph nodes (4). In addition, studies show that the effects of air pollutants, notably lead, may result in impaired body function, including the cardiovascular system, through the production of free radicals and, thus, increased lipid peroxidation (1). In the study of Peters and colleagues, 691 patients with myocardial infarction exposed to traffic for 1 hour had an increased risk of a heart attack in the ratio of 2.92 indices (5). The most worrying issue is exacerbating the harmful effects of air pollution during exercise because, according to metabolic needs increase, the amount of air that enters the respiratory system will be several times and may even be more than 20 times (6). In addition, an increase in the airflow rate carries the pollutants to the depths of the respiratory system (3), and extreme sports increase the number of breathing, the change of breathing from the nose to mouth, and as a result, the ability of the nose for treating pollutants will be reduced (7).

Time spent exercising is essential in creating the side effects caused by pollutants on athletes. Ultra-marathon runners and other participants in long endurance events, such as walking and cycling, are more likely to be exposed to the harmful effects of pollutants (8). In athletes that exercised for 30 minutes to 2 hours in the exposure of 0.3-0.2 parts per million (ppm) ozone, a significant association has been seen between the concentration of this gas and lung function reduction during training courses (9). Inflammation, cell death, and oxidative stress are the main mechanism of biological effects caused by air pollutants (10-11). In the study of Bahrami et al., on female endurance runners, in polluted and clean air, the bilirubin levels in polluted air showed a 22 percent increase compared to clean air, and the increase was significant ($p< 0.001$). Haptoglobin levels were reduced by 23.86 percent after exercise in high concentrations of pollutants, but this reduction was not statistically significant ($p<0.09$) (12).

Inflammatory indices that affect the immune system when exposed to polluted air can be noted in cytokines such as interleukin-6 (IL-6). IL-6 is secreted from vascular endothelial cells, fibroblasts, and other cells, and along with Endocrine effects, which can affect the hypothalamus and cause acute phase response (APR) that can point out to an increase in the concentrations of C reactive protein (CRP) (10). CRP applied its psychological effect from two main mechanisms, through connection with the activities of monocytes and increased synthesis of adhesion molecules that enlists leukocytes to adhere to the surface of vascular endothelial and, thus, expands and strengthens the process of inflammation in the endothelial tissue of vessels (13). In addition, inflammatory indices interacting with each other develop risk factors for atherosclerosis-associated diseases (10). In the study of Devlin and colleagues, exposure to ozone increased IL-1 significantly after 24 h. It also increased IL-6 and CRP immediately after the exercise, which was not significant (14). For two main reasons, CRP and IL-6 are essential indicators of inflammation in young people and adults. First, numerous reports have been published about the relationship between CRP and IL-6 with diseases in adults (15); second, the CRP and IL-6 in blood circulation are reported to be higher in adults than in the lower age categories (16). Due to fact, studies show that one training session can increase the inflammatory factors (17); on the other hand, exposure to polluted air can be associated with increased inflammatory factors. Therefore, this study aimed to examine the effect of one session of aerobic exercise in active people exposed to high concentrations of pollutants and aerobic exercise in clean and polluted air on the inflammatory indices of interleukin-6 and C - reactive protein.

Material and methods

Athletes referred to track and field at 16:00 with a high concentration of pollutants and exercised according to the protocol based on the Resistance-Exercise Training Protocol of bulk field test. According to the protocol, subjects ran in 400-meter track and field after warm-up. Then subjects performed some stretching for 15 minutes at 69-55% of the maximum heart rate.

Before the start of the exercise protocol, 10 cc of blood was taken from each subject. Immediately after the exercise protocol, blood samples were transported to the laboratory. In addition, 24 hours after the exercise protocol, subjects participated in the laboratory to perform blood sampling. To measure the IL-6 changes used by the ELISA kit (Finland) and CRP (Pars Azmoon, Iran) used by immunoturbidimetric technique. The exercise protocol was performed on a day with clean air and at the same time, and the variables under study were measured.

Participants

This research is cross-sectional and practical in terms of results. This group was chosen in an accessible and meaningful way. Participants in the study were untrained young men, and 10 volunteer participants between them were randomly selected with age (24.9 ± 1.7) years, height (177.1 ± 3.3) cm, and weight (72.9 ± 5.2) kg. The subjects had at least three years of regular exercise. The subjects were clean and had no blood disease, cardiovascular, hormonal diseases, obesity, or blood pressure; none were under treatment or taking certain medications. All subjects completed the consent form and health questionnaire.

How to measure pollutants

In the present study, air pollution was measured on Feb 28th, 2015 that the Air Quality Index (or AQI) was equivalent to 120, meaning the alert status (orange), according to the Isfahan Environmental Protection Bureau data from Pollution monitoring stations in Azadi Square (Pollution monitoring stations adjacent track and field). The clean air in the same place with the air quality index was 52, on May 8th, 2015, which means a yellow status.

Statistical Analysis

Normal distribution of data determined by the Kolmogorov-Smirnov test and analysis of variance with repeated measures were used. Moreover, the Bonferroni post hoc test was used to find significant statistical differences. The significance level in this study was less than 0.05.

Results

AQI of the Air Quality Index on Feb 27th, 2013 (polluted air) and May 8th, 2013 (clean air) is shown in Figure 1. Our results indicated the main air pollutant concentrations in the area of training in PPm, representing a particle of pollutants per million particles of a mixture in two days (Figure 2). Furthermore, the concentration of nitrogen oxides and particulate on Feb 27th, 2013 shows the alert status.

Table 1. Demographic characteristics of subjects

Statistical Indicators	**Maximal oxygen in the polluted air (ml per kg of body weight per minute)**	**Maximal oxygen in the polluted air (ml per kg of body weight per minute)**	**Maximal oxygen in the polluted air (ml per kg of body weight per minute)**	**Body mass index (kilograms per meter squared)**	**Weight (kg)**	**Height (cm)**	**Age (years)**
Average	52.33 ± 1.71	52.33 ± 1.71	51.64 ± 1.84	22.3 ± 2.27	72.9 ± 5.29	177.1 ± 38.3	24.9 ± 1.72

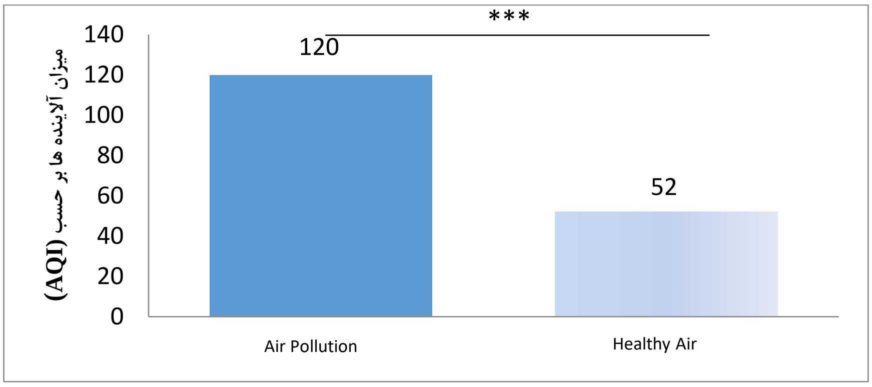

Figure 1. Air quality index value in two days of study

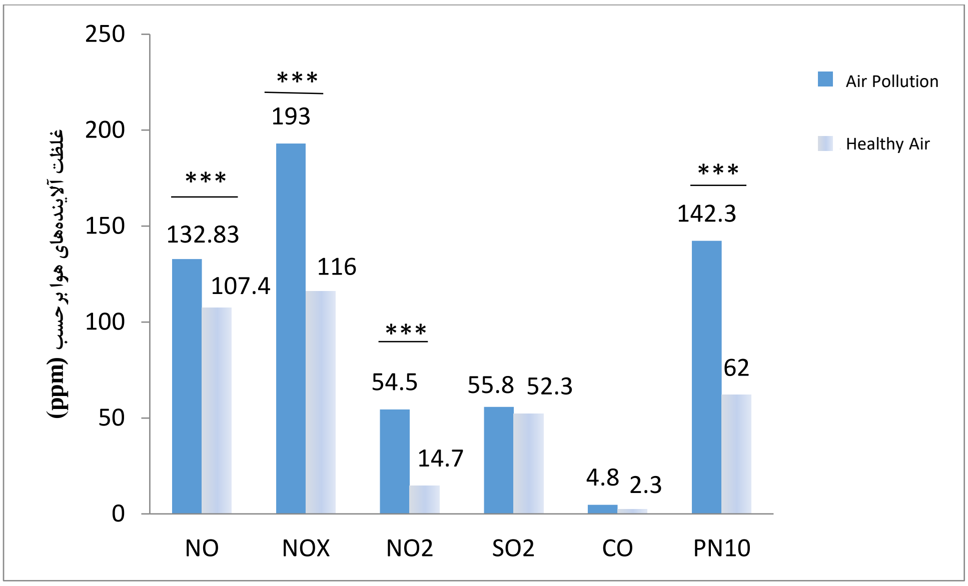

Figure 2. The concentration of pollutants in two days with polluted and clean air

The mean age of subjects was 24.9 ± 1.72 years, and the average height, weight, and index body were respectively 177.1 ± 38.3 cm, 72.9 ± 5.29 kg, and 22.3 ± 2.27 kilograms per square meter. Based on the results of this study, the average concentration of IL-6 in subjects before, immediately, and 24 hours after aerobic exercise in polluted air were 0.43 ± 0.32, 0.53 ± 0.33, and 0.11 ± 0.07 pg/ml, respectively, and in clean air, the concentration of IL-6 was, 0.05 ± 0.02, 0.07 ± 0.03 and 0.09 ± 0.03 Pg ml, respectively. As can be seen, the amount of IL-6 in polluted air increased compared to clean air; the increase was statistically significant ($p<0.001$), as shown in Table 1. In addition, due to a significant difference in the variable IL-6, the Bonferroni post hoc test was used to infer the differences shown in Table 1. As can be seen in Table 1, there is a significant difference between polluted air and clean air before, immediately, and 24 hours after exercise.

The average CRP concentration in subjects before, immediately, and 24 hours after aerobic exercise in polluted air were 2.29 ± 1.66, 2.35 ± 1.65, and 2.12 ± 1.55 Mg/l. In clean air, the CRP concentration was 1.82 ± 1.44, 2.09 ± 1.55, and 1.58 ± 1.04 Mg/l. CRP values in polluted air showed an increase compared to clean air, but this increase was not statistically significant ($P<0.82$), as shown in Table 2.

Table 2. IL-6 and C - reactive protein concentration in clean and polluted air

Variable	Before exercise	Immediately after exercise	24 hours after exercise	Before exercise	Immediately after exercise	24 hours after exercise
	clean air			polluted air		
IL-6 (pg/ml)	0.05 ± 0.02	0.07 ± 0.03	0.09 ± 0.03	0.43 ± 0.32,	0.53 ± 0.33	0.11 ± 0.07
CRP (mg/l)	1.82 ± 1.44	2.09 ± 1.55	1.58 ± 1.04	2.29 ± 1.66	2.35 ± 1.65	2.12 ± 1.55

Discussion

In this study, IL-6 amounts showed an increase before, immediately after, and 24 hours after aerobic exercise in polluted air, compared to clean air, and the increase was significant ($p<0.001$).

IL-6 is secreted from vascular endothelial cells, fibroblasts, and other cells in response to microbes and other cytokines, particularly TNF-α and IL-1 (18). IL-6 is the first cytokine that increases the following exercise in the blood, which may increase up to 100 times (19). Research showed that the amount of IL-6 during exercise spinning in circulation increases in intensity and duration of exercise (20). Oxidative stress and inflammation are the effective mechanisms of air pollutant effects (22-21). Following tissue injury, infection, inflammation, and burns, the acute phase response (APR) starts with a chain reaction that act as a group that eventually avoids further damage, supports the body, eliminates the infectious factors, and activates healing processes (23). Devlin and colleagues observed that levels of IL-6 and CRP have increased significantly after exposure to ozone pollution, and a return to its initial level was done after 24 hours (14). In a study by Zaldivar and colleagues on 11 clean volunteers, after 30 minutes of heavy cycling exercise, a significant increase showed in IL-6 levels of exercise (24). In addition, Gray and colleagues' research, after an hour of cycling exercise, up to 90% lactate threshold resulted in a significant increase in IL-6 and returned to the initial level after 5.1 hours (20). The increase in IL-6 immediately after exercise is probably the result of acute inflammatory responses that expand and increase rapidly and remain for a short time. This short period is probably due to the short half-life of inflammatory mediators because of regulatory cytokines such as TGFβ (which limits the inflammatory response). Typically, systemic responses are short-term responses, and acute phase protein will be characterized by a rapid change (26-25). Local response to inflammation or injury causes cytokines clashes such as IL-6, which are released during inflammation (17). The inflammatory response involves the production of large quantities of acute-phase proteins derived from the liver, such as CRP (28-27).

C - reactive protein (CRP) is a non-glycoside polymer protein consisting of five identical sub-units. CRP is one of the acute phase factors, which means the proteins produced to cope with the influx of foreign antigens by the liver (29). Chronic low-grade inflammation will be displayed by increasing concentrations of CRP and increasing general levels of some cytokines, including IL-6. Several reports have examined various signs of inflammation in different population groups and have approved the relationship between general low-grade inflammation on the one hand and metabolic syndrome, diabetes type 2, and atherosclerosis on the other hand (11-10). In adults, high levels of CRP are due to smoking, obesity, and cardiovascular disease (31-30). In this study, CRP levels before, immediately after, and 24 hours after aerobic exercise in polluted air did not significantly increase compared to clean air ($P<0.82$). Brazil and colleagues have found evidence about the increasing concentration of CRP, which in its normal range may indicate cardiovascular disease and diabetes (16). CRP reference values are from 0 to 10 MgL, but there is evidence that cardiovascular risks increase when CRP levels increase above 3 mg per liter. Yen et al. have studied the relationship between CRP and multiple cardiovascular risks and found a strong association between high CRP and cardiovascular risk. Subjects above 3.5 were exposed to cardiovascular mortality risks four times more than those with less than 1.3 (32).

Since studies related to certain pollutants leave their infancy behind, scientists are still seeking findings to identify the effect of air quality on sports activities and everyday functions. For example, a recent study showed that physical activity, exercise in polluted air, and exposure to high concentrations of pollutants could lead to increased levels of interleukin-6 and C-reactive protein in sports persons, including complications such as an increased risk of cardiovascular disease.

Stress resulting from sampling, sample size, fluid intake, and athletes' nutrition affect the rheological responses (Rheological) of blood, so their complete control in this study was impossible. Other limitations of this study were the physiological conditions of the subjects.

Conclusion

Air pollution is a severe and constant threat to the environment and the health of athletes. Exposure to pollutants, possibly through changes in the oxidation/antioxidant process of the body, causes the development of inflammation and thus increases the incidence of cardiovascular events. Therefore, it makes simple behavioral changes such as avoiding strenuous physical activity on days when high pollution levels are recommended.

Competing interests

There is no competing interest to disclose

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