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Assessment of air pollution in exercise centers and health risks

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Abstract

Background: In recent years, Tehran has faced major problems with air pollution for many reasons, and this issue has become a critical point in most of the days. However, less attention has been paid to the indoor air pollutants in exercise centers and their possible health effects. In this research, it was tried to briefly describe the characteristics and chemical composition of the aerosols present in the exercise centers of Tehran.

Methods: Sampling was carried out by a high volume sampler with a value of 1.5 m^3/min. Fiberglass filters were used to sample aerosol particles. The samples were then studied by scanning electron micrograph (SEM) method.

Results: The results showed that average concentration of aerosol particles in the indoor and outdoor sports halls was 125 and 162 μg/m^3, respectively. Therefore, there was a minor difference in the aerosols concentration inside and outside the sports venues during the competition period and in the presence of athletes. Also, chemical composition and morphology of the aerosol particles showed that there was a minor difference between the atmospheric particles inside and outside the exercise centers. Major elements found in the $PM_{2.5}$ aerosol were Si, O, C, Mg, Ca, Mn and K. In general, common major crustal elements found in the atmospheric particles over all the sites were Si, Al, and Fe.

Conclusion: It seems that many citizens of the polluted cities exercise indoor because of causes other than outdoor air pollution such as lack of time or appropriate facilities. Thus, it is necessary for all students, athletes, people and other health workers involved in sports and exercise medicine to know briefly about indoor air pollutants and its possible health effects on athletes who exercise in these environments.

Keywords: Air pollution, Athletes, Aerosols, Outdoor

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Introduction

Human and natural resources are the sources of particles diffusion in the atmosphere. Fossil fuels in the transportation sector, factories, and manufacturing industries are the sources of particles diffusion in the human sector (1-3). According to the World Health Organization (WHO), by reducing airborne pollutants from 70 to 20 μg/m^3 in the atmosphere, the mortality rate can be reduced by 15% (4). The aerosol particles in the atmosphere are liquid or solid. Their size varies from a fraction of a micrometer to hundreds of microns. Airborne pollutants such as particulate matter (PM) affect people more than any other types of pollutant. The main components of air suspended particles are sulfates, nitrates, ammonia, sodium chloride, black carbon, mineral particles, and water. In other words, air suspended particles are a mixture of widespread solids and liquids composed of organic and inorganic materials suspended in the air, which chronic exposure to these particles in the air causes cardiovascular and pulmonary disease, and also lung cancer (4). Hence, air pollution is one of the topics about which researchers have concerned in recent years. On the other hand, the most important issue in comprehensive public health is indoor air quality. In other words, indoor air quality is one of the important issues in public health. In fact, the clean environment is essential for human health and well-being, and it has become a global challenge (5,6). The lack of ventilation in this place causes serious damages to athletes. Indoor air pollutants have different sources. A group is the pollutants which are produced inside the buildings (internal pollutants), another group is those which are produced outside the buildings and can penetrate indoor through windows or other pores and openings, joints, and cracks in walls, floors, and ceilings (external pollutants),

and finally, natural radon gas which can go inside the buildings from the ground. Another important factor that should be considered in gymnasiums is poor indoor air quality due to gathering of the large number of people in small buildings that often have poor ventilation (7). In recent years, air pollution has been a major challenge for the citizens of Tehran. The occurrence of dust storms has increased the level of suspended particles in the atmosphere. The main air pollutants in Tehran are CO, NOx, SO2, O2, HC, and PM, accounting for about 85% of the fuel used by transportation vehicles, factories and household heating equipment (8). Tall buildings, air stability and high vehicle density have increased the concentration of airborne pollutants at dangerous levels, making this a major environmental challenge (9). In these conditions, the level of environmental pollutants in exercise centers is very high. It is well accepted that exercising in the outdoor air polluted environment causes more contacts with air pollutant and has possibly more negative effects on athletes' health. However, less attention has been paid to the indoor air pollutants in exercise centers and their possible health effects. Since the many physiological changes such as air inhalation through the mouth, increasing in minute ventilation, air flow rate, and pulmonary diffusion capacity are practically in outdoor and indoor environments are essentially the same, so it can be concluded that exercise in indoor air polluted environment can have the same importance as exercising in an outdoor environment (10). In this research, it was tried to briefly describe the characteristics and chemical composition of the aerosols present in the exercise centers of Tehran.

Materials and Methods

The sampling was done at 9 exercise centers in different areas of Tehran by a high-volume air sampler (model TFIA, Staplex's Co., Brooklyn, NY). For this purpose, the filters were first placed in an oven for 24 hr at 105°C for dehumidification. After cooling in a silica gel, the distiller was weighed 0.1 mg and prepared for installation on the sampler. After sampling, the filters were placed in an oven at 105°C for 24 hours for dehumidification. Sampling was performed before, after and in the presence of athletes in the exercise centers. Sampling was done inside the exercise center at a height of 1.5 m from the ground for 2 to 6 hr. Sampling was carried out by a high volume sampler with a value of 1.5 m^3/min. Fiberglass filters were used to sample aerosol particles. The filters were weighed before and after sampling. Due to the fact that this filter collects all particles of interest or of concern has excellent performance in the field of fine particulate filtration, it is therefore considered as an efficient filter. Commonly, the efficiency is 99.95% or higher for a standard aerosol of 0.3 μm diameter. In this way, the total number of aerosol particles was also measured at the sampling time. The samples were then studied by scanning electron micrograph (SEM) method. A very thin layer of gold was deposited on the surface of the samples to make them electrically conductive using vacuum coating unit. The SEM-EDX analyses were carried out using a computer controlled field emission SEM (ZEISS EVO 18 SEM) equipped with a Bruker Quantax 200 EDS with a Peltier-cooled X Flash silicon detector.

Results

At the beginning of the work, the indoor and outdoor average concentration of particles was measured during the competition and in the presence of athletes. Different results were obtained for different locations. In the areas, where the hall was well-ventilated and new, the difference between the indoor and outdoor concentrations increased. But the average concentration of particles was 162 μg/m^3 in the city, while it was 125 μg/m^3 in the exercise centers during the review period. Therefore, there was a minor difference in the concentration of aerosols inside and outside the exercise centers during the competition period and in the presence of athletes, therefore, exercise centers cannot be considered as a healthy place to practice and conduct the competition during air pollution. The average concentration of aerosols in 9 exercise centers in Tehran is shown in Figure 1. In this figure, the effect of outdoor environment on the indoor environment is visible and cannot be ruled out. The conditions that are taking place today in major cities and cities such as Tehran are very dangerous and it is recommended that people do not work in this dangerous environment, especially children, heart and respiratory illnesses, elderly people and even athletes. Also, it seems that many citizens of this city exercise indoor because of causes other than outdoor air pollution such as lack of time or appropriate facilities. Table 1 shows the indoor and outdoor PM concentrations in the filters during 4-day tournament. The outdoor concentrations of these elements were significantly higher than the indoors, except when the outdoor wind speed increased. The higher contributions of the outdoor elements generated by traffic, soil and sea were registered.

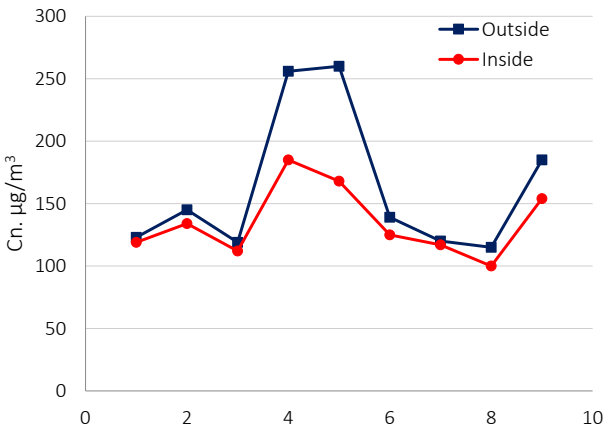

Figure 1. The average concentration of aerosol particles inside and outside the hall.

Table 1. Indoor and outdoor average aerosol concentrations in the study area (μg/m³)

	Time	PM			Time	PM	
		Indoor	Outdoor			Indoor	Outdoor
	09:00	124	146		09:00	143	165
	11:00	130	137		11:00	146	174
T1	13:00	128	142	T3	13:00	152	168
	16:00	142	144		16:00	143	167
	18:00	138	147		18:00	135	167
	09:00	110	134		09:00	138	144
	11:00	115	132		11:00	145	134
T2	13:00	113	140	T4	13:00	152	146
	16:00	123	138		16:00	149	152
	18:00	125	142		18:00	145	144

Abbreviation: PM, particulate matter.

Discussion

The analysis of the samples showed that there were physiochemical differences in aerosol particles in sports centers in and outside the city center. Hence, in urban areas, elements (except predominant elements) such as chlorine, calcium, iron and particles rich in silicon, aluminum, potassium and magnesium were determined. The findings indicate the presence of soil particles in this regional case study. A SEM image of the aerosol particles in the study area is shown in Figure 2. Also, analysis of SEM images of PM<1 micron showed that these particles are spherical, crystalline, transparent and irregular. On the other hand, in the images of SEM, it was observed that particles were 2.5 microns in size, and had an irregular, cluster and spherical shape. In the studied images, calcium was considered as the dominant particle among others, which can be considered as a calcium carbonate form associated with calcite phase. An example of the chemical composition of aerosol particles in the sports centers located in the western regions of Tehran is shown in Table 2. The main elements of $PM_{2.5}$ include silicon, oxygen, magnesium, calcium, manganese and potassium. These elements were observed in different samples proportions. In general, the main elements of the main shell of atmospheric particles at all stations were silicon, aluminum, and iron. Mineral particles are usually derived from natural sources, including the recovery of roads dust (crust dust). Other particles produced and distributed in the city by human activities, such as combustion of fuel by vehicles, industries and factories, roads and urban development, and wearing metals, present in the sports halls due to its inadequate ventilation. On the other hand, the lack of ventilation in some gyms is a real challenge to the problem. The condition was also more severe in older sports halls with high burnout.

These particles are generally recognized by their coarse and irregular shape. Based on these results, different concentrations of zinc, titanium, iron and carbon elements along with aluminum and silicon were observed throughout the region, especially in the central regions of

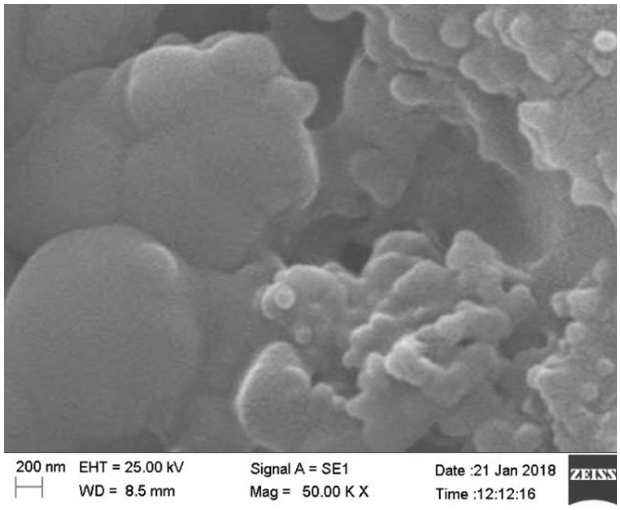

Figure 2. SEM image of aerosol particles in the size range of $PM_{2.5}$.

Table 2. Concentrations of elements of aerosols in the size range of $PM_{2.5}$ in a sports hall

Elements	Weight (%)
C	23.46
O	46.51
Na	4.14
Al	1.92
Si	16.39
K	1.72
Ca	1.92
Zn	1.91
Ti	2.03

the study area. This can be referred to as a gray source. There was also the presence of pollution sources in the composition of particles. The SEM image of a particle is shown in Figure 3. Also, Table 3 shows chemical composition of these particles. These particles can be related to construction, regional transportation of the urban areas, agricultural activities (burning plants), natural dust, as well as the activity of sand production workshops. The particles are mainly composed of feldspar (calcium, silicon and aluminum) and clay (aluminum, iron and silicon), mainly originating from crust, but they can also lead to erosion of construction materials and production of road dust caused by transport. Other elements were present in a small concentration of alumino-silicate particles, which include magnesium, sodium, titanium and zinc. According to the reports from Department of Environmental and Air Quality Control Company subsidiary of Tehran municipality, in most of the days, pollutants in the atmosphere of the area are close to the critical level and sometimes crossed it. Due to the large volume of construction in different parts of Tehran and lack of management of the activities of sand plants,

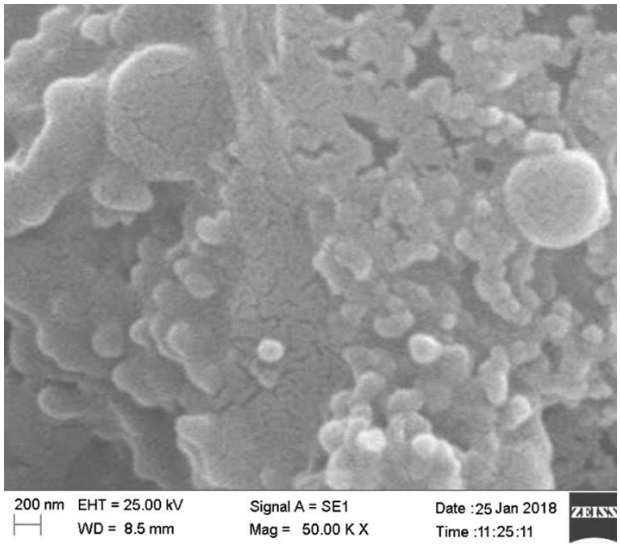

Figure 3. SEM image of aerosol particles in a sports hall located in the central regions of the study area.

Table 3. Concentrations of elements of aerosols in a sports hall located in the central regions of the study area

Element	Weight (%)
C	36.59
O	47.01
Al	1.72
Si	4.22
Ca	7.43
Ti	1.01
Fe	2.02

the level of suspended particles is high in this area. Since the factories are located in the direction of the prevailing wind in the region, hence, the emission of particles from these sources is always one of the main sources in the formation of pollutions in the atmosphere of Tehran. According to the evidence, pollutants produced in these areas affect the whole city of Tehran. It seems that in the studied area, especially in the polluted areas, lack of proper management of the sports facilities can lead to the pollution of sports halls. As a result, athletes may be at risk for health problems.

There is, in fact, a relationship between the exposure to intense concentrations of suspended particles and the increase in daily and annual concentrations. Also, if the concentrations of these pollutants are reduced, while other factors are fixed, the associated deaths are reduced, indicating that by reducing the concentration of suspended particles, the community health can be improved. Some researchers have observed the health effects of air suspended particles even at very low concentrations, which means that there is no threshold for the suspended particles to reduce the adverse health effects (11). The WHO estimates that if the average annual concentration of PM_{10} in the world is reduced from the current value of 70 $\mu g/m^3$ to the guidance level of 20 $\mu g/m^3$, the air-pollution-related deaths will decrease by about 15%. Several studies have shown that exposure to air suspended particles is associated with health effects such as cardiovascular and respiratory diseases (11,12). Researchers have shown that PM_{10} is associated with hospitalization due to respiratory disease. Also, $PM_{2.5}$ has a strong relationship with heart and respiratory diseases. Ultra-fine PM penetrates into the lower parts of the respiratory system and lungs, causing many cardiopulmonary and respiratory disease (13-16).

Conclusion

The study of the chemical composition and morphology of suspended particles in the atmosphere of Tehran revealed two important findings. Firstly, during the time of air pollution, even indoor sports facilities are also affected by pollution. Secondly, there is a pollution-related health risk for people at this time in the outdoor sports centers. It is well accepted that exercising in the outdoor air polluted environment causes more contacts with air pollutants and has possibly more negative effects on athletes' health. However, less attention has been paid to the indoor air pollutants in exercise centers and their possible health effects. Studies have shown that surface contamination of the city has a direct effect on the indoor environment quality. Therefore, it is not recommended to go to gyms for racing and physical activity on the polluted days, because damage to the athletes' health in indoor sports centers is 22% less than that in outdoors. Considering the average total particle concentration, the possible damage to the athletes' health in indoor sports centers is by 60% more than the outdoors. Depending on the indoor physical conditions and physical activity, volatile air enter into the lungs and respiratory system for respiration. Hence, extreme activity in indoor polluted, probability of exposure to airborne pollutants is far greater than when people are slowly operating in the outdoor environment. Since the effect of air pollution in the indoor and outdoor environment is the same during training, therefore, in large and industrial cities like Tehran, children, elderly people, cardiac and respiratory patients and even normal athletes It is better to stay at home and not have intense physical activity. Thus, it is necessary for all health professionals involved in sports and exercise medicine to know briefly about indoor air pollutants and its possible health effects on athletes who exercise in these environments.

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Competing interests

The authors declare that they have no competing interests.

Ethical issues

The authors hereby certify that this manuscript is the original work of the authors, all data collected during the study are as stated in this manuscript, and no data from this study has been or will be published elsewhere separately.

Authors' contributions

All authors were equally involved in the collection, analysis, and interpretation of the data. All authors critically reviewed, refined, and approved the manuscript.

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