

Monitoring the dustiness of the gymnasium

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Abstract. This article presents an experimental study of the concentration of fine dust in a covered sports facility using the example of a sports gym using a HANDHELD-3016 aerosol particle counter. The monitoring data of indoor air was analyzed and graphically presented in graphs of the integral function of the distribution of dust particles over the diameters. The concentration of fine dust at different time intervals during the training of the sports section was compared. The dependence of the distribution of dust particles over the measurement heights on the intensity of the workout was studied. Recommendations on improving air quality in a sports-type room during classes were provided. Changes in the indicators of external respiration during the training session was analysed.

1. Introduction

Numerous studies of air monitoring have shown that athletes and people who regularly exercise outdoors or indoors are exposed to high short-term particle concentrations characteristic of the urban environment. Exposure to atmospheric particles is associated with various adverse effects on human health, including heart and respiratory problems. A better understanding of the physiological reactions of the body to the effects of particles in the air during sports activities is a key issue in assessing the dustiness of a sports room and describing the corresponding health effects of an athlete.

A rational way to adapt the external respiration system to physical activity is to increase the rate of respiration and the depth of breathing. Moreover, the intensity of external respiration is more dependent on the depth of breathing and to a lesser extent on the frequency of respiration.

Risks to the health of athletes during training in the gym can be aggravated by an increase in the amount of pollutants inhaled due to increased minute ventilation, when a large fraction of the inhaled air through the mouth passes through normal nasal filtration mechanisms, and the increased airflow rate when inhaling penetrates deeper into the respiratory tract. Exercise in a dust-polluted room can lead to the deposition of fine particles in the athlete's lungs. [2]

During the training session of the sports section in a covered sports facility on the example of a gymnasium:

- explore dustiness;

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- to identify the dependence of the change in the concentration of fine dust particles SPM2.5 and SPM10;
- develop mathematical models for evaluating and describing the concentration and dispersion of dust in the air of a sports hall;
- study the dynamics of indicators of external respiration.

2. Presentation of the main research material with full rationale of the scientific results.

To determine the concentration of certain sizes of dust particles, air in the sports room was studied using a HANDHELD-3016 aerosol particle counter at a height of 0.1, 1.3, and 2 m from the floor.

The obtained measurement data were analyzed in accordance with the adopted Supplement No. 8 to HS (Hygiene Standards) 2.1.6.1338–03, which was put into effect in 2010. In Russia, the corresponding “Maximum Allowable Concentrations (MAC) of pollutants in the atmospheric air of populated areas” have been established (table 1). [1]

Table 1. Standards for suspended particles in the populated areas. atmospheric air.

<i>Name of substance</i>	<i>MAC, mg/m³</i>		
	<i>Maximum single, MAC m.s.</i>	<i>Daily average, MAC d.a.</i>	<i>Annual average, MAC a.a.</i>
Measured particles PM10	0.3	0.06	0.04
Measured particles PM2,5	0.16	0.035	0.025

In the countries of the European Union, the situation with regulation is different: regulation of these particles has been going on for more than 20 years and the norms are becoming more stringent from year to year (table 2). [1]

Table 2. EU air (concentrations) level limits as of 01.01.2015

<i>Name of substance</i>	<i>MAC, mg/m³</i>
	<i>Maximum single, MAC m.s.</i>
Measured particles SPM10	≤ 0.05
Measured particles SPM2,5	0.0085-0.0180

When conducting a study of the dustiness of a sports room, the following graphs were obtained of the integral function of the distribution of dust particles by diameter. [3]

(1)

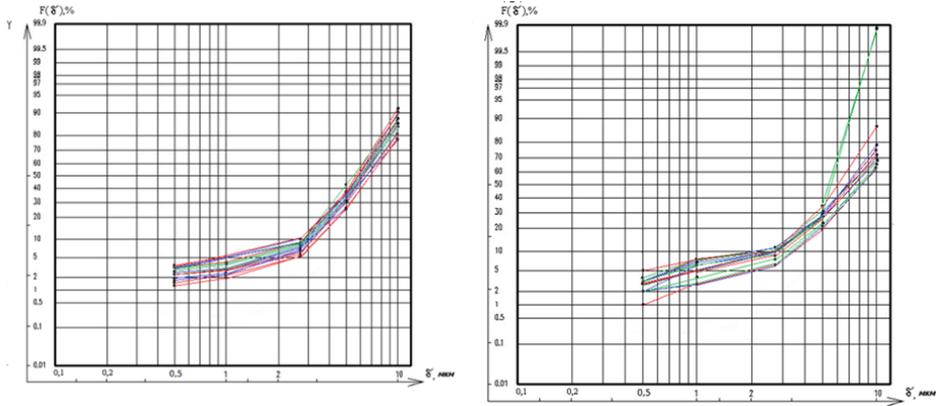


Fig. 1-2. The integral function of the distribution of dust particles by diameter before (1) the start of training athletes and after the end of the session (2).

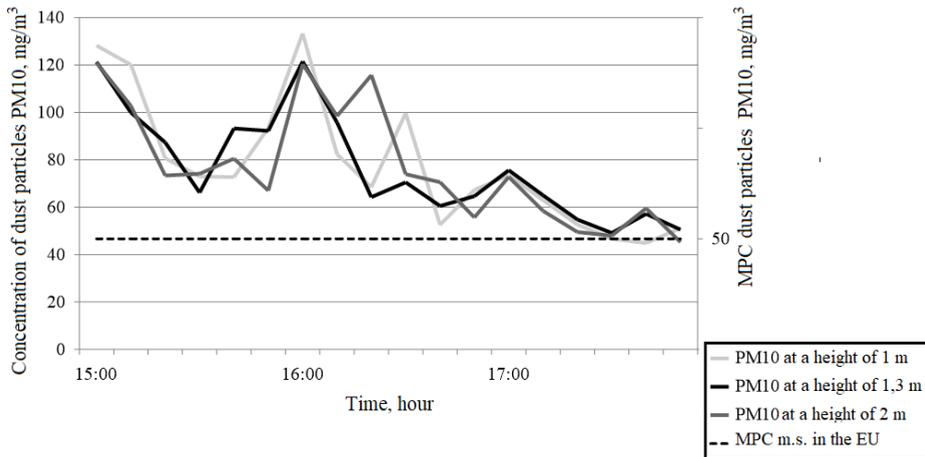


Fig. 3. The concentration of fine dust particles of the SPM10 fraction during the training of the sports section.

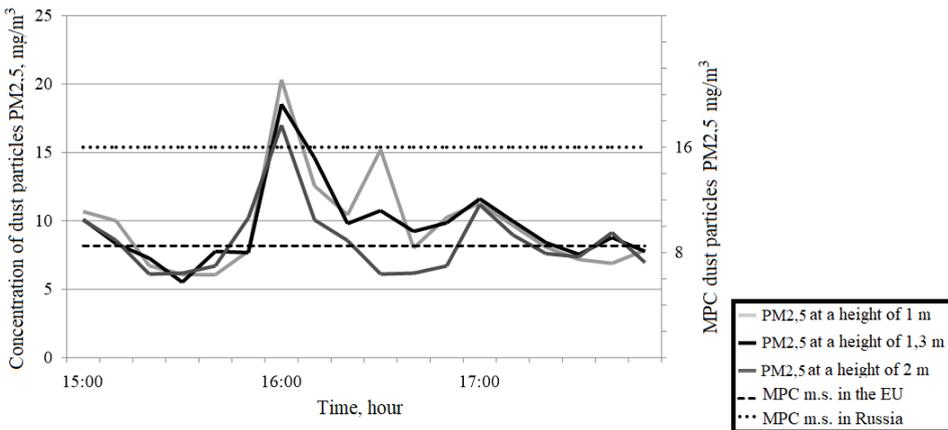


Fig. 4. The concentration of fine dust particles fraction SPM2.5 during training.

To compare the dustiness of the sports hall, floor plans were created with an indication of the measurement zone and the average dust concentration at all measurement heights (fig.5a, fig.5b)

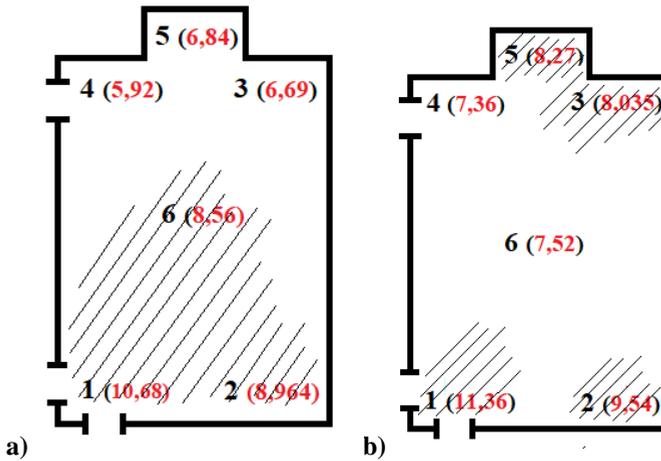


Fig. 5 (a,b). The layout of the sports room, taking into account the average concentration of fine dust SPM2.5 at all measurement heights, before (a) and after (b) the training.

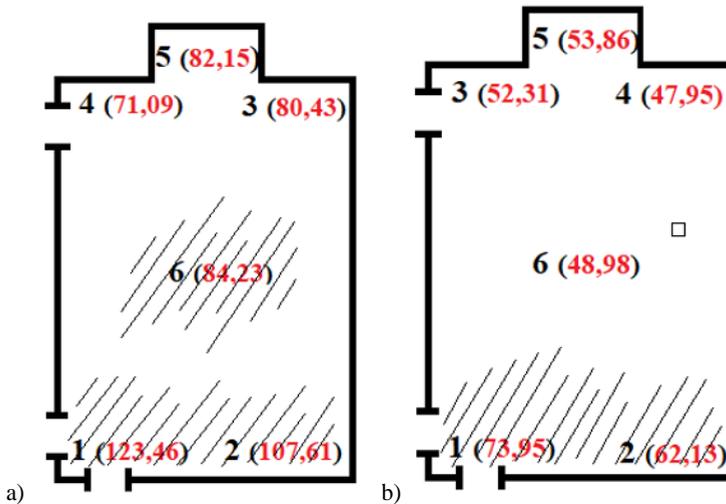


Fig. 6 (a,b). The layout of the sports room taking into account the average concentration of fine dust SPM10 at all measurement heights before (a) and after (b) the training.

To assess the apparatus of external respiration, we used the following indicators [4]:

- RR - respiratory rate (number of times per minute);
- VCL - vital capacity of the lungs (l) - using a spirometer;
- MBV - minute breathing volume (l) - using a spirometer.

External respiration was measured before the start of training (rest), at the peak of physical activity (stress) and after training (after stress).

The graphs (Fig. 4-5) clearly show the dependence of the concentration of particles with a diameter of 2.5 (SPM2.5) and 10 (SPM10) on the duration of the training. The concentration of fine PM2.5 particles, regardless of the measurement height, varies from 6 mg / m3 to 21 mg / m3 during a workout. At the beginning of the training, dust content by

particles with a diameter of 2.5 (SPM2.5) was approximately the same at all measurement heights. A sharp increase and the maximum concentration of dust particles of fraction 2.5 (SPM2.5) was recorded in the middle of the session, when the athlete's breathing intensity is highest, and the volume of air inhaled by the lungs increases several times in comparison with the resting state. In the second half of the lesson, the dust concentration of the SPM2.5 fraction increases only at a measured height of 0.1 m, dustiness with fine particles at a height of 2 m has decreased by about half. At the end of the training, the dust content of the hall with dust particles of diameter 2.5 is slightly less than at the beginning of the training of the sports section. The highest concentration of dust with a diameter of 2.5 (SPM2.5) at the end of the session is observed at a height of 2m.

With a long training time and increased stress intensity, the concentration of finely dispersed particles with a diameter of 10 (SPM10) increases at all measurement heights, the highest concentration of particles of the PM10 fraction is fixed at a height of 0.1 m in the middle of the session. The highest concentration of dust at the end of the workout is observed at a height of 2m.

The layout of the sports room, taking into account the average concentration of fine dust particles before and after training, indicates an uneven distribution of fine particles in the air of the room. The PM2.5 and PM10 fractions contaminated with fine dust turned out to be the zones in which the activity of the athletes was the most intense.

The response of the respiratory system of athletes to physical activity is presented in table 3.

Table 3. Dynamics of external respiration

External respiration	RR (number of times per minute)	VCL (l)	MBV (l)
rest	9,7±0,5	4,8±0,35	10,4±0,8
stress	18,3±1,7	5,5±0,83	21,2±1,6
after stress	10,3±0,6	5,0±0,48	12,7±0,3

As can be seen from the table. 3 RR at the peak of physical activity increased 2 times; VCL indicators increased slightly. The most pronounced changes in MBV indicators. After the training session, all digital values approached the indicators of rest, which indicates the adequacy of physical activity to the physical capabilities of athletes. [5]

3. Conclusions on this study and prospects for further development of this direction

The concentration of fine dust particles SPM2,5 and SPM10 exceeds the norms of maximum permissible concentration limits established in Russia and the EU during the entire training session. The obtained data analysis indicates insufficient ventilation of the room. Monitoring the dustiness of the gym and the dynamics of external respiration indicators, demonstrating the high intensity of the respiratory system showed an unconditional risk of increasing respiratory diseases of athletes by settling in the lungs of fine dust particles present in the sports hall during training.

References

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