Research on Physical Damage of Outdoor Physical Exercise Based on Environmental PM2.5 Detection

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Abstract. The components of PM2.5 are complex and changeable and are easily affected by seasons and climate. Prolonged exposure to high concentrations of PM2.5 can easily induce inflammation in the cardiovascular system, respiratory system, immune system, and genitourinary system. In severe cases, it can cause cell mutations to induce cancer. The paper adopts the literature method, from PM2.5, risk perception, public physical exercise behaviour, outdoor environment exercise behaviour differences, etc., in recent years, my country's public risk perception under PM2.5 environment Review with outdoor exercise behaviour research. Research results show that inflammatory damage, oxidative stress, and immune response caused by PM2.5 are important molecular biological mechanisms that cause human injury in outdoor sports people. The enhancement of human respiratory rate and changes in breathing methods during outdoor sports can cause PM2.5 to cause greater damage to the respiratory system, cardiovascular system, nervous system and immune system of the population.

Keywords: Environmental PM2.5 value, outdoor sports, health, injury.

1. Introduction
With the full development of my country's "National Fitness Program", the concept of "Health First" has begun to take root in the hearts of the people. However, it is accompanied by the deteriorating ecological environment, such as the negative impact of the Lanzhou "lung-injury running" competition or exercise in the harsh environment, and the PM2.5 that affects air quality has gradually become a hotly discussed and prominent issue. For environmental issues, various localities have taken corresponding measures to implement PM2.5 monitoring. For example, on February 16, 2012, Zhengzhou and Kaifeng, Henan Province, carried out PM2.5 monitoring simultaneously, and gradually started monitoring work throughout the province; February 22 China News Network reported that 17 cities in China started PM2.5 data monitoring [1]. These indicate that environmental factors have become one of the important factors that residents must consider when doing physical exercise. At present, people lack scientific and reasonable guidance when conducting physical exercises, and are unfamiliar with the relevant knowledge about meteorological conditions affecting physical exercise. Most people have not realized the seriousness of the health damage that may result from this. Therefore, to carry out relevant research on the impact of meteorological conditions on the
physical exercise of the general public, especially urban residents, is of far-reaching significance not only for people's scientific physical exercise, but also for the development of national fitness programs.

2. The composition and morphological structure of PM2.5
PM is the general term for particles suspended in the air, and fine suspended particles with a dynamic equivalent diameter ≤ 2.5 μm in the air are called PM2.5. The chemical composition of PM2.5 is very complex, and its toxicity to the human body is related to the chemical composition [2]. There are two main forms of PM2.5, solid and liquid. The solid PM2.5 element involves almost all the metal and non-metal elements and transition elements in the periodic table. The organic matter of liquid PM2.5 mainly includes CH4 and NMHC. Because PM2.5 has the characteristics of strong toxicity, long residence time in the air, large specific surface area, small diameter and long transportation distance, it can directly reach the alveoli, and a large number of toxic substances attached to the surface are deposited in the lungs through breathing and enter the blood circulation.

3. The harm of PM2.5 to outdoor physical exercise groups
3.1. PM2.5 induces cardiovascular system diseases in outdoor physical exercise groups
A survey in Tokyo showed that for every 10μg/m3 increase in the atmospheric content of PM2.5 caused by automobile emissions; the mortality rate related to cardiovascular-related diseases would increase by 12.7%. The American Cancer Society and the Harvard Six-City Study "The joint study concluded that every 10μg/m3 increase in PM2.5 will increase the mortality of heart disease and coronary heart disease by 12% to 14%. The outdoor exercise group exercise time is basically two periods in the morning and evening, and the heart sympathetic excitability in the morning High, the coronary artery tension is also high, coupled with the effect of the toxic substances in PM2.5, leading to the highest incidence of cardiovascular disease in the middle-aged and elderly exercise groups during the period from 6 o'clock to 12 o'clock; outdoor exercise groups are doing sports During exercise, pulmonary blood flow and pulmonary ventilation increase sharply for a time. Pb, As, CR and polycyclic aromatic hydrocarbons (PAHs) contained in PM2.5 enter the blood through the blood barrier, and some harmful substances can cause the increase in fibrinogen in the blood and the increase in the content of coagulation factors lead to an increase in blood viscosity. At the same time, it also reduces the ability of haemoglobin to carry oxygen, resulting in insufficient oxygen supply to the body [3]. In severe cases, insufficient oxygen supply to the heart and brain may cause cardiovascular disease; The increase in fibrinogen in the blood and the increase in the content of exogenous coagulation factors, and the inner wall of the blood vessel with heavy metal parts are extremely vulnerable, which causes the fibrin under the skin to be exposed and rough, and the platelets and fibrin in the blood are extremely It is easy to attach to the blood vessel wall to form thrombus. In addition, the toxic heavy metals contained in PM2.5 have an impact on the autonomic nervous system, directly acting on the pulmonary nerve reflex arc and myocardial ion channels, leading to an imbalance in the autonomic nerve control of the heart, increasing blood pressure. The increased heart rate greatly increases the cardiovascular and cerebrovascular morbidity and mortality of the middle-aged and elderly exercise groups in outdoor exercise groups.

3.2. PM2.5 induces inflammatory damage to the respiratory system in outdoor physical exercise groups
Outdoor exercise groups, especially those who exercise under high PM2.5 concentration, their respiratory system will inhale a large amount of gas containing various components into the respiratory system during gas exchange [4]. Compared with the upper respiratory tract, the lower respiratory tract is affected by PM2.5. The harm will be even greater: the toxic components in PM2.5, such as pathogenic bacteria, viruses, and heavy metal dust attached to the lower respiratory tract and alveoli, will act on the tube directly or indirectly after being attached to the wall of the tube following the gas exchange. Epithelial cells and macrophages on the mesh wall and alveoli, which cause
epithelial and interstitial hyperplasia, accelerate the fibrosis of lung epithelial cells, reduce or disappear the self-tension of the alveoli, and the body's venous blood cannot flow through the fibrotic alveoli. Carrying out gas exchange, while fibrosis promotes the thickening of tissues, which ultimately leads to the decline of the local immune system of the respiratory system and induces inflammation; in addition, because the body performs deep breathing during exercise, this accelerates the PM2.5 Inhalation of the atmosphere, the various toxic components contained in the gas will enter the alveoli for a long time, which will cause the rapid release of lung tissue inflammatory factors and changes in biochemical components, and the secretions in the respiratory tract will increase, coughing, lung wheezing, and pus Clinical symptoms such as sputum will be manifested; once again, alveolar macrophages will swallow these external particles after inhalation of particulate matter, and at the same time release active oxygen free radicals, and these free radicals can reduce the serum anti-protease activity, indirectly. The permeability of the cell membrane is enhanced, and the ability to filter and remove PM2.5 toxic particles is greatly reduced, which can easily cause inflammatory damage to the lungs and respiratory tract or other physiological diseases [5].

4. Data analysis and pre-processing of the sports risk assessment model under severe PM2.5 exceeding standards

4.1. Sports risk assessment and constraint parameter analysis

Under the pollution of PM2.5 in the air, outdoor sports activities will cause the count of white blood cells in lung infection to increase. In the process of lung infection, the most harmful to human body is not PM2.5 particles themselves, but PM2.5 particles. The large amount of viral chemical substances adsorbed on the surface, the impact of PM2.5 on human health, is essentially the surface of PM2.5 particles, which adsorbs various invisible virus particles and chemical substances in the air. These substances will affect Human health causes major harm. For example, on the surface of PM2.5, some carcinogen molecules are adsorbed, and when inhaled into the human body, it will have a carcinogenic effect on the human body [6]. The adsorption of heavy metals will cause heavy metal harm to the human blood. Therefore, the result of the damage depends on what the adsorbed substance is. Construct a constraint parameter model for sports risk assessment under severe PM2.5 exceeding standards, the ambiguity tightness index of outdoor sports risk assessment under severe PM2.5 exceeding the standard is $R_{T_1}, R_{T_2}$, and the constraint function is satisfied:

$$F_J = \sum_{k=1}^{n} X_{j,k} \cdot Q_j = \sum_{k=1}^{n} (X_{j,k})^2$$  \hspace{1cm} (1)

The expression of fuzzy decision parameter model for outdoor sports risk assessment under severe PM2.5 exceeding standard is:

$$z(t) = s(t) + js(t) \otimes h(t) = s(t) + j \int_{-\infty}^{\infty} \frac{s(u)}{t-u} du$$

$$= s(t) + jH[s(t)]$$  \hspace{1cm} (2)

In the above formula, $a(t)$ is the oxygen ventilation equivalent for outdoor sports. The cardiopulmonary function of outdoor sports under severe PM2.5 exceeding standard is tested under the relative infection index, and the risk index evaluation sequence $z(t)$ is obtained to analyse the risk of outdoor sports under severe excessive PM2.5 standard. Development trend, carry out statistical analysis of sports risk, and use a multivariate statistical characteristic equation to describe the fitting state model of outdoor sports risk when PM2.5 is seriously exceeded:
\[
\begin{pmatrix}
X \\
p(X)
\end{pmatrix} = \begin{pmatrix} a_1, a_2, \ldots, a_n \\
p(a_1), p(a_2), \ldots, p(a_n)
\end{pmatrix}
\]

(3)

Among them, \(0 \leq p(a_i) \leq 1\) for \(i = 1, 2, \ldots, n\) and \(\sum_{i=1}^{n} p(a_i) = 1\) represents the autoregressive statistical characteristic parameters of outdoor sports risk under severe excessive PM2.5 standards. Quantitative evaluation is carried out by analysing the solution vector of the statistical equation, which provides a parameter input basis for outdoor sports risk assessment [7].

4.2. Comparison of template parameters for outdoor sports risk assessment

The template parameter comparison method is used to test the cardiopulmonary function and respiratory system function of outdoor athletes [8]. Through the discrete analytical processing of the data, the information entropy of the distribution characteristic of outdoor sports risk under severe PM2.5 exceeding the standard is obtained as:

\[
H(X) = E(I(a_i)) = -\sum_{i=1}^{n} p(a_i) \log_2 p(a_i)
\]

(4)

Through the above analysis, the data collection and distributed structure reorganization of the outdoor sports risk quantitative assessment under severe PM2.5 exceeding standard were realized, and the high-order cumulant of the outdoor sports risk assessment data sequence \(x\) under severe excessive PM2.5 standard was obtained using the random analysis model the expression form is:

\[
C_{\text{or3}} = \frac{\langle (x_n - \bar{x})(x_{n-d} - \bar{x})(x_{n-2d} - \bar{x}) \rangle}{\langle (x_n - \bar{x})^3 \rangle}
\]

(5)

Among them, \(x_n\) represents the statistical elements of outdoor sports risk information under severe PM2.5 exceeding standards, \(d\) represents the sampling statistical time lag item of outdoor sports risk constraint indicators, \(D=2d\), \(\bar{x}\) represents the principal component factor of the air quality index (AQI), \(\langle x_n \rangle\) Represents the average value of \(x_n\).

5. Experimental verification

In order to test the actual application performance of the model in realizing the outdoor sports risk prediction assessment under severe PM2.5 exceeding standard, simulation experiments were carried out. The experiment used MATLAB and Visual C++ simulation tools for data analysis, and the test sample set of outdoor sports risk under severe PM2.5 exceeding standard the collection time was from September 30, 2016 to October 30, 2017. The test subjects were 100 outdoor enthusiasts, including 60 males and 40 females. Each enthusiast performed outdoor running under different air pollution indexes. Exercise, cycling and aerobics, etc., test the cardiopulmonary function of outdoor athletes, and the test results are shown in Figure 1.
Figure 1. Outdoor exercise cardiopulmonary function test results

Taking the data collected in Figure 1 as a sample, the risk assessment of outdoor sports is carried out, and the result of the exponential curve distribution of the assessment is shown in Figure 2. Analysing Figure 2 shows that the method used for outdoor sports risk assessment

Figure 2. The risk assessment curve of outdoor sports in an environment where PM2.5 exceeds the standard

The accuracy of the estimation is better, and further statistical data analysis shows that when the PM2.5 index is less than 300 and greater than 100, perform one-month continuous outdoor exercise to obtain the maximum oxygen uptake and heart rate stability test results Analysis has shown that long-term outdoor sports activities in an environment where PM2.5 exceeds the standard will have a certain infection effect on the lungs, leading to sinus arrhythmia and lung infections, affecting health and creating health risks.

6. Conclusions
The survey and research on the risk perception of PM2.5 among outdoor exercisers has further enriched the related research on risk perception in PM2.5 environment and outdoor exercisers. On the
one hand, residents’ perception of environmental protection awareness such as PM2.5 is through various media. Compared with the previous one, it has been greatly improved; on the other hand, due to the existence of certain perception ability, the public outdoor exercise group can reduce the safety risk rate during exercise. However, it is found through the literature that the ability and methods of most people to perceive risks are relatively single. It is recommended that future studies find more media that enhance the public’s risk perception ability, so that the public exercisers can more effectively recognize the PM2.5 environment and outdoor exercise behaviours. Knowing, to make the public exercise people more scientifically and rationally improve their knowledge of exercise time and other risks in order to achieve the goal of real health. This is also the problem to be studied and the goal to be achieved in the follow-up.

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