Research on the Status Quo and Optimization Strategy of Indoor Air Quality in Gyms

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Abstract. In order to study the status quo and optimization strategy of indoor air quality in gyms, this paper adopts literature method, expert investigation method, measurement and evaluation method, mathematical statistics method and other methods, and comprehensively uses environmental detection technology to test environmental parameters such as CO₂ content, particulate matter and formaldehyde. The research shows that: CO₂ concentration, pm10 as the extension of time to change, change of 5 gym indexes were no significant differences (p > 0.05), carbon dioxide concentrations with increased with the extension of the gym business hours, spinning room, three oxygen gym, running room space, carbon dioxide concentrations after using spinning room is 3 times more than before use; Indoor formaldehyde, inhalable particulate matter and other indexes of the five gyms tested met the national standards. The highest formaldehyde concentration was 0.0441%, and the lowest formaldehyde concentration was 0.0233%. The concentration of particulate matter increased with the extension of exercise time, and the value-added rate increased from 75.06 - 97.86 per hour.

1. Introduction
At present, the problem of indoor air pollution is common all over the world, especially in developing countries. Indoor air pollutants include four categories: physical pollutants (noise, non-ionizing radiation), chemical pollutants (carbon monoxide (CO), carbon dioxide (CO₂), sulfur dioxide (SO₂), nitrogen dioxide (NO₂)), biological pollutants (bacteria, fungi, dust mites) and radioactive pollutants (radon). Domestic related research. The results show that volatile organic compounds (VOCs) in indoor air are one of the important causes of childhood asthma, childhood leukemia and acquired heart disease in children [1]. Formaldehyde (HCHO) has the most prominent impact on human health in indoor environment, and is one of the clear risk factors of Sick Building Syndrome (SBS). HCHO exposure is associated with central nervous system reactions, irritation symptoms of eyes, nose and throat, and skin allergic reactions [2]. Long-term exposure to CO and CO₂ will cause abnormalities in human nervous system and cardiovascular system, manifested as dizziness, headache, arrhythmia, etc. [3]. New outbreaks, 2020 seems to mark the government and the academic study of atmospheric environment quality is turning to public space within the indoor air quality, the sports fitness leisure enterprises will change the way vulgar management, do the in service, do fine, in entity service depending on high standard, small group work, the principle of low density, air quality, ensure that business sites
disinfection measures, such as workers, the health level of high standard; Therefore, how to control indoor air pollution in gyms, create a good fitness environment for people, and promote people's physical and mental health, has theoretical and practical significance.

2. Research objects and methods

2.1. Research objects

The research object of this paper is the indoor air quality of 5 gyms in Dehong Prefecture.

**Table 1.** Survey of 5 indoor gyms in Dehong Prefecture

| Name of Gym          | Serial number | Covers an area of(m²) |
|----------------------|---------------|-----------------------|
| Ruifeng Fitness Club | A1            | 120-160               |
| Lijian Fitness Studio| A2            | 120-160               |
| CrossFit Workshops   | A3            | 80                    |
| Tianlong Leap Fitness Club | A4 | 80-120               |
| California Health Club| A5           | 120-160               |

2.2. Research methods

2.2.1. Literature survey. In the process of writing this paper, I refer to a large number of literature materials, including relevant books and works, master's and doctoral dissertations, journals and newspapers, professional websites, etc., and literature collection is not limited to the direction of environmental science, but a wide range of disciplines such as climatology, behavioral science, sports science, sociology and so on.

2.2.2. Instrumental measurement and method.

**Table 2.** The instrument used to measure the parameters

| Test parameters     | Test equipment                     |
|---------------------|------------------------------------|
| Co₂                 | CO₂ data recorder: HOBO UX120-006M |
| Formaldehyde        | Interscan Formaldehyde Analyzer 4160 |
| Inhalable particulate matter | TSI Particulate Tester: AMS10 |

2.2.3. Evaluation criteria. According to the public health standard "[4] (GB9668 1996) for the gym health regulations, which established a gymnasium of tiny standard such as climate, air quality, ventilation and sanitary requirements, and the" standard of indoor air quality "[5] (GB/T18883-2002) and the centers for disease control and prevention, expert advice, determine the study of environmental indicators evaluation standard reference is as follows (table 2):

**Table 3.** Gymnasium hygiene standards

| project                          | Standard values |
|----------------------------------|-----------------|
| Co₂(%)                           | ≤0.15           |
| Formaldehyde/(mg/m³)             | ≤0.12           |
| Inhalable particulate matter/(mg/m³) | ≤0.25       |

2.2.4. Data processing. SAS 8.0 statistical software was used to conduct statistical processing on the test data, and independent sample T was adopted as the statistical method Test, one-way analysis of variance, correlation test, significant level P<0.05, very significant level Was P<0.01, and the data were expressed as mean ± standard deviation (M±SD).
3. Research results and analysis

3.1. Current situation of air quality in Dehong Prefecture

Table 4. Ratio of each air quality grade in Mangshi from 2016 to 2020

| Year | Optimal | Good | Light pollution | Moderate pollution | High levels of pollution |
|------|---------|------|-----------------|--------------------|------------------------|
| 2016 | 72.84%  | 26.54% | 0.00%           | 0.00%              | 0.62%                  |
| 2017 | 42.19%  | 54.15% | 2.66%           | 1.00%              | 0.00%                  |
| 2018 | 55.33%  | 38.90% | 5.19%           | 0.85%              | 0.00%                  |
| 2019 | 14.17%  | 74.17% | 10.83%          | 0.83%              | 0.00%                  |
| 2020 | 11.34%  | 75.25% | 12.76%          | 0.65%              | 0.00%                  |

Table 5. Statistical table of pollution days in each month from 2016 to 2019 in Mangshi City

| Year | January | February | March | April | May | June | July | August | September | October | November | December |
|------|---------|----------|-------|-------|-----|------|------|--------|-----------|---------|----------|----------|
| 2016 | /       | /        | /     | /     | /   | 1    | 0    | 0      | 0         | 0       | 0        | 0        |
| 2017 | 0       | 0        | 3     | 5     | 3   | 0    | 0    | 0      | 0         | 0       | 0        | 0        |
| 2018 | 0       | 1        | 11    | 6     | 0   | 0    | 0    | 0      | 0         | 0       | 0        | 2        |
| 2019 | 0       | 0        | 3     | 11    | 0   | 0    | 0    | 0      | 0         | 0       | 0        | 0        |
| 2020 | 0       | 0        | 4     | 13    | /   | /    | /    | /      | /         | /       | /        | /        |

According to the daily air quality data of Mangshi from June 2016 to April 2020, the time characteristics of AQI in Mangshi were analyzed. Firstly, the pollution days of Mangshi were statistically analyzed, and the results are shown in Table 1. It can be seen that the pollution of environmental air quality in Mangshi is mainly concentrated in March, April and May every year. The number of days of pollution in February and June is 1 day, and the number of days of pollution in December is 2 days, and there is no pollution in the rest months. Further analysis of the temporal variation characteristics of the air quality index (AQI) shows that the annual AQI gradually decreases from June, reaches the minimum value in August and September, and then gradually increases, and reaches the maximum value in April and May of the next year. Ambient air quality in Mangshi is mainly affected by ozone, PM10 and PM2.5, among which PM10 has the largest impact, more than 50%. Sulphur dioxide, nitrogen dioxide, carbon monoxide can meet the first standard of the "Environmental Air Quality Standard" (GB3095-2012).

3.2. Gym air quality detection

Indoor air quality problems at prestigious sports events have made the front pages of newspapers in the United States in recent years. For example, during the US Swimming Championships in Minneapolis in 2007, USA Today reported that several prominent US swimmers' performances dropped below their normal level because of air quality problems at the venue. Brendan Hansen, the world champion in the 200-meter breaststroke at the time, missed his world record by a full second, and he blamed the indoor pool where the race was held as a "dead house." With the further improvement of people's requirements for air quality, people begin to pay more and more attention to the air quality of places where they often exercise.

3.2.1. CO2. If the concentration of CO2 is too high in the atmosphere, it will be harmful to human health. CO2 belongs to respiratory central stimulant and is physiological. Indoor is affected by crowd density, ventilation condition and crowd activity. When it goes beyond a certain range, it is not only for people The increase of CO2 concentration is positively correlated with the total number of indoor bacteria, C0 and formaldehyde concentration. Make indoor air pollution more serious. Therefore, many countries regard indoor CO2 concentration as a comprehensive monitor to evaluate air cleanliness. Measuring indicators. Often in an unventilated room, people feel unwell not because of the lack of oxygen, but because of the increase in CO2. When the indoor CO2 concentration is below 0.07%, it belongs to clean air, and the human body feels good at this time. When the concentration is 0.07 - 0.10%, it belongs to
ordinary air. At this time, some sensitive people will have bad odor. When the concentration is between 0.10 -0.15%, it belongs to the air Critical air, which is the deterioration of other properties of indoor air, the human body begins to feel uncomfortable: a concentration of 0.15-0.20% genus In light air pollution: more than 0.20% is considered as serious air pollution: when the concentration is between 0.30-0.40%, people's breathing will deepen, headache, tinnitus, pulse stagnation, blood pressure increase and other symptoms will appear.

3.2.1.1 Standard
The hygienic standard of C0₂ in indoor air (GB/T17094-1997) stipulates that the daily average maximum allowable concentration is less than 0.10%.

The Health Standards for Public Places (GB9668-1996) stipulates that the concentration of C0 shall not exceed 0.07%-0.15%.

Table 6. CO₂ measurement of spinning room, aerobic room and running room

| place | Spinning room | Aerobic gym | running room |
|-------|---------------|-------------|--------------|
|       | Before using  | After using | Before using | After using | Before using | After using |
| A1    | 0.082         | 0.315       | 0.113        | 0.133       | 0.11         | 0.145       |
| A2    | 0.073         | 0.3025      | 0.189        | 0.1023      | 0.097        | 0.136       |
| A3    | 0.078         | 0.3235      | 0.124        | 0.137       | 0.095        | 0.138       |
| A4    | 0.081         | 0.335       | 0.123        | 0.123       | 0.094        | 0.125       |
| A5    | 0.083         | 0.315       | 0.103        | 0.143       | 0.071        | 0.124       |

Through the investigation: 5 gyms, spinning, aerobic gym, running room three Spaces, after the use of increased, spinning room before the use of the lowest CO₂ concentration, but after the use of the highest. The concentration of carbon dioxide in the spinning room after use is more than 3 times before use, the aerobic gym is about 1.2 times before use, and the running room is about 1.35 times before use.

3.2.2. Formaldehyde. Formaldehyde, also known as antaldehyde, is a colorless gas with strong irritant, is a volatile organic compound, right Human health effects are manifested in irritation of the eyes and respiratory tract, resulting in abnormal immune function of the lungs and liver. In 1995, formaldehyde was identified as a suspected carcinogen by the International Agency for Research on Cancer (IARC). Indoor formaldehyde mainly comes from plywood, woodworking board, laminate wood floor and other panels used for decoration, as well as furniture, paint and coatings made of these panels [5]. Benzene system owner to come from the use of all kinds of paint, coating, adhesives and other dilution solvent decoration. Ammonia mainly comes from expansion agent in building decoration material concrete, antifreeze agent in coating and adhesive used in wooden boards, which releases gaseous ammonia at room temperature, causing indoor ammonia pollution [6]. It was found that formaldehyde and toluene constituted the main pollution sources of indoor benzene series.

The background concentration of formaldehyde outdoors is generally 0.1*10⁻⁶. Studies have shown that formaldehyde has negative effects on human health Ring. When the indoor air formaldehyde content reaches 0. LMG /m³, there will be a sense of peculiar smell and discomfort. Long-term exposure to low dose formaldehyde (0.017–0.068mg/m³) can cause chronic respiratory diseases, menstrual disorders, pregnancy syndrome, neonatal physical decline and so on. High concentration of formaldehyde is toxic to the nervous system, immune system, liver, and so on on Teratogenesis and carcinogenesis. The International Institute for Research on Cancer has recommended that it be treated as a suspected carcinogen. In high temperature, high humidity, negative pressure and high load conditions will intensify the intensity of formaldehyde emission. Under certain conditions, the concentration of formaldehyde in indoor air can be aggregated. To the level that the standard allows. Japan Yokohama National University research shows that indoor formaldehyde release period is generally 3-15 years.

3.2.2.1 Standard
Indoor air quality standard (GB/T1883-2002) stipulates that the daily average maximum allowable concentration of formaldehyde is less than 0.1mg/m³.
The Hygiene Standard for Public Places (GB5.68-1996) stipulates that the concentration of formaldehyde in stadiums should not exceed 0.12mg/m³.

3.2.2.2. Test results

According to industry research, indoor formaldehyde concentration is gradually released to a low value as time goes by.

**Table 7. Test results of formaldehyde content in gyms**

| point | Opening date | Opening time | Maximum formaldehyde concentration | Lowest formaldehyde concentration |
|-------|--------------|--------------|-------------------------------------|----------------------------------|
| A1    | 2013         | 8            | 0.0085%                             | 0.0054%                          |
| A2    | 2016         | 6            | 0.0095%                             | 0.0067%                          |
| A3    | 2017         | 5            | 0.0125%                             | 0.0104%                          |
| A4    | 2018         | 4            | 0.0345%                             | 0.0184%                          |
| A5    | 2019         | 3            | 0.0441%                             | 0.0233%                          |

The investigation learned that A1 Gym opened in 2013, A2 Gym in 2016, A3 Gym in 2017, A4 Gym in 2018 and A5 Gym in 2019. According to this monitoring, the gyms with a short opening time will be opened in 2019. The shortest opening time of these five gyms is 3 years, and the longest one has a history of nearly 8 years. The gym with the shortest renovation period is 3 years, and the most is 10 years. The highest value of formaldehyde concentration was 0.0441% and the lowest value of formaldehyde concentration was 0.0233%. Because detect the limitation of fund, after soliciting the expert's opinion, the use material that decorate according to and start business fixed number of year, formaldehyde index releases to national standard basically. Therefore, there is no sense in continuing to detect formaldehyde content and discontinue.

3.2.3. Absorbable particulate matter.

Particulate matter is the main part of the air pollution, the representative of air pollutants in solid phase, with its form, more porous and adsorbability, become the carrier of all kinds of pollutants, so the particles is a kind of complex ingredients, can be a long period of time a wide range (a few miles to a few tens of kilometers) suspended in a exist in aerosol state of the pollutants in the air, it become PingJiaShi particle size is smaller, the deeper the sedimentation of the respiratory tract, the greater the damage, and most of the pollutants and microbial bacteria in the < 10 um size particles, so the index of hygiene significance as well. The concentration of inhalable particulate matter at 0.1546mg/m³ is the maximum daily allowable concentration of air in residential areas, that is, the body will not be affected in the long-term under this concentration. When > was 0.2mg/m3, the immune capacity of the body began to change after a long time or concentrated exposure to this concentration.

3.2.3.1 Standard

The average daily maximum allowable concentration of inhalable particulate matter in indoor air (GB/T17095-1997) is 0.15mg/m³. The Health Standard for Public Places (GB9668-1996) stipulates that the concentration of inhalable particulate matter should not exceed 0.25%.

The result shows, 5 gymnasium indoor solid particulate matter concentration does not have before student jump hold, accord with national health standard, but after jump hold begins, the concentration of particulate matter increases as the extension of movement time, the appreciation rate rises 75.06-97.86 for every hour. There was no significant change in the index of inhalable particulate matter before and after the use of the running room, but the index of inhalable particulate matter in the spinning room was 2.5 times that before the use of the running room, with a significant increase.
Fig. 1 Inhalable particulate matter index at different time in spinning room; (mg/m³)

Fig. 2 Inhalable particulate matter index at different time in aerobic gym

Fig. 3 Indexes of inhalable particulate matter at different times in the running room

4. Conclusion
For lum five gym main indicator of indoor air quality (carbon dioxide, formaldehyde, particulate matter, etc.) of the test results show that the carbon dioxide concentrations with increased with the extension of
the gym business hours, 5 gym, spinning, three oxygen gym, running room space, after use has increased, spinning room before using CO2 concentration, the lowest after use has risen to the highest. The carbon dioxide concentration of spinning room after use is more than 3 times before use, aerobic gym is about 1.2 times before use, running room is about 1.35 times before use. At the same time, the survey shows that the indoor CO2 of gyms is related to the per capita area and per capita capacity of gyms. Gyms with smaller per capita volume are more likely to exceed the standard of CO2 concentration. Other indicators of indoor air quality of the 5 gyms tested -- formaldehyde, inhalable particulate matter and other indicators meet the national standards. Among them, the highest value of formaldehyde concentration was 0.0441%, and the lowest value was 0.0233%. With the extension of the decoration years, the formaldehyde index was gradually released to the lowest value. The five gyms investigated had opened for 3 years at the shortest time. If the gym is opened after decoration, it is estimated that the formaldehyde index will exceed the standard; the concentration of particulate matter increased with the extension of exercise time, and the value added rate increased from 75.06 to 97.86 per hour. There was no significant change in the index of inhalable particulate matter before and after the use of the running room, but in the spinning room Inhalable particulate matter after use is 2.5 times of before use, there is a significant increase; This paper puts forward the monitoring countermeasures of indoor air quality in the gym: 1. Increase the fresh air supply in the gym to purify the air. 2. Strengthen the publicity of the public's environmental health knowledge and the correct and scientific use of air conditioners, especially the publicity of indoor air pollution in public places which is closely related to it. 3. Draw lessons from the new air supply of foreign museums to purify the air. 2. Strengthen the publicity of the public's environmental health knowledge and the correct and scientific use of air conditioners, especially the publicity of indoor air pollution in public places which is closely related to it. Due to a lack of research on issues related to materials at home and abroad, based on the analysis of problems related to the lack of contrast material: in addition, due to the time and budgetary constraints, this study of gym indoor air pollution and the implementation of the monitoring, surveillance industry is still a good many problems such as lack of depth, this will be my complement and perfection in the future research work.

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