

Research on the Maximum Oxygen Uptake in Long-Distance Running among Non-Sports Major College Students

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Abstract: The decline in cardiopulmonary function of college students has attracted much attention. Cardiorespiratory function is crucial for physical fitness, and maximal oxygen uptake (VO_{2max}) is a key indicator of cardiopulmonary endurance. Although long-distance running can improve cardiopulmonary function, non-sports major college students often experience shortness of breath and chest tightness due to low ventilation efficiency and insufficient VO_{2max} . This study focused on 60 non-sports major college students, including 30 males and 30 females. Through literature analysis, questionnaire surveys, experiments, and mathematical statistics, the study explored their VO_{2max} during long-distance running. The study found that males had better VO_{2max} than females, and height, weight, and BMI were significantly correlated with VO_{2max} . Maintaining a high level of physical activity helps to improve VO_{2max} , enhance cardiopulmonary endurance, and promote health, while low activity levels may lead to a decrease in VO_{2max} .

Keywords: long-distance running, maximal oxygen uptake, non-sports major students, gender differences

1. Study Subjects

This study recruited healthy young adult college students aged 20-25 years old, with no history of vascular disease or exercise dysfunction, normal physical and cardiopulmonary function, no regular exercise habits, no diseases that are contraindicated for participating in physical activities, and who voluntarily signed an informed consent form. A total of 60 undergraduate students from a certain university were recruited, including 30 males and 30 females, with an average age of 20.40 ± 3.17 years old. The average height and weight of male students were 176.60 ± 7.41 cm and 78.50 ± 10.81 kg, respectively, with an average BMI of 24.65 ± 3.33 ; the average height and weight of female students were 159.49 ± 5.43 cm and 50.78 ± 12.41 kg, respectively, with an average BMI of 21.68 ± 5.27 . The subjects met the experimental requirements, providing a reliable sample base for subsequent VO_{2max} testing and related research.

2. Research Methods

2.1 Experimental Instrumentation

Xiaomi Mi Band 8, which supports professional sports algorithms, currently provides four types of sports assessments and recommendations: maximal oxygen uptake, training load, recovery time, and training effects.

2.2 Literature Review and Comparison Method

By consulting relevant books, journals, and magazines on the methods, criteria, influencing factors of maximal oxygen uptake testing, as well as body activity measurement, evaluation, and influencing factors, and searching authoritative literature in Chinese databases such as CNKI, Wanfang, and foreign databases such as Web of Science, we obtained a large number of research results on maximal oxygen uptake. Using "maximal oxygen uptake" as the keyword, we retrieved 536 core documents; using

"non-sports major college students" as the keyword, we retrieved 62 core documents, totaling 598 core Chinese journal articles. After excluding literature with low relevance and effectiveness, 20 articles were selected that met the requirements of this study. These articles provide different testing methods for maximal oxygen uptake, and based on this, a summary was made as shown in the table 1 below. ^[1]

Table 1: Comparison table of different test methods for the maximum oxygen uptake

| Test method | Scope of application | Advantage | Disadvantage |
|---|---|---|--|
| PWC170 ^[2] | Physical fitness test for college students | The test process is simple and easy to perform, Low cost of funds | The load during the test is difficult to control |
| Astrand Hierogram method ^[3] | A test with smaller numbers | The calculation is simple | The error is relatively large |
| FOX method ^[4] | The elderly and the people with poor physique | Load is fixed, and the error is small | The cost is higher |
| 12min run ^[5] | Physical fitness test for students | The testing process is simple and easily controlled | The test process is too monotonous |
| Chen Wenyu method ^[1] | sportsman | High accuracy, easy to promote and apply | The cost is higher |
| 20min Turn back to run ^[6] | Student Physical fitness test, athlete | Subjects were prone to achieve the maximum oxygen uptake | Strong rhythm |

After comparing different methods ^[7] and considering the school's existing resources and the actual environment, this study adopted the "12-minute run method" to conduct experiments and study the maximal oxygen uptake during the long-distance running process of non-sports major college students.

2.3 Social Survey Method

A preliminary online questionnaire was conducted to investigate freshmen and sophomores who participated in campus running. The results were analyzed to understand the types, frequencies, and durations of exercise among the subjects. Based on the questionnaire results and the physical exercise standards ^[8], it was determined whether the subjects exercised regularly: at least 3 times a week, with each session lasting more than 30 minutes, and involving moderate to high-intensity aerobic exercise.^[2]

2.4 Testing Method

2.4.1 Testing Procedure

Sixty students, half male and half female, who met the criteria in the questionnaire survey were randomly selected to ensure their physical health and compliance with the experimental standards. Before testing, the participants were informed in detail about the experimental procedures and precautions, and the process was supervised by a professional medical team to ensure safety. The testing period was from September to October 2023, during which height and weight were measured, BMI was calculated, and professional teachers were invited to supervise and guide the experiment to ensure its safety and accuracy. Multiple pre-experiments were conducted to optimize the grouping and lay a solid foundation for data collection, as shown in Figure 2:

$$BMI = \frac{weight \ (kg)}{(height)^2 \ (m^2)} \quad (1)$$

Using the 12-minute run activity, each group leader monitored different groups, and the testers wore sports bracelets, ensuring correct calibration before testing. Groups of 5 individuals each participated in the 12-minute run, recording the average heart rate and maximal oxygen uptake data from the bracelet. Any outliers were discarded, and the data were organized into tables for subsequent analysis.^[3]

2.4.2 Mathematical and statistical method

The exercise bracelet was collected to monitor the heartbeat rate and maximum oxygen uptake of runners, and the T-test and multiple regression analysis were used to study the relationship between

physical exercise and maximum oxygen uptake of college students. In addition, the maximum oxygen uptake of different gender groups was also studied, and the final conclusions were reached through data analysis.

2.5 Study route (as shown in Figure 1)

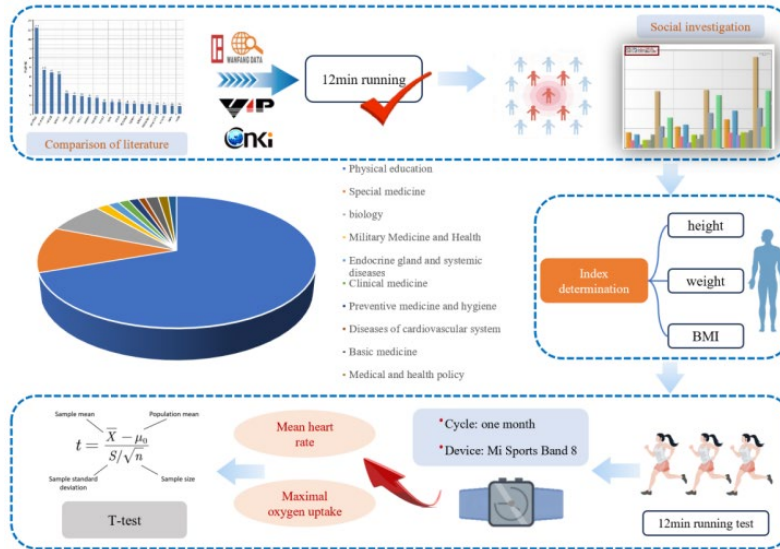


Figure 1: Study route

3. Results of the study

3.1 Questionnaire survey results

Questionnaire statistics show that 6% of people seldom do exercise, the most exercise 1-2 times a week, and the exercise time is mostly 30-60min. It reflects the low frequency and short time of non-sports majors, due to heavy schoolwork, high academic pressure, or lack of understanding and awareness of sports.^[4-5]

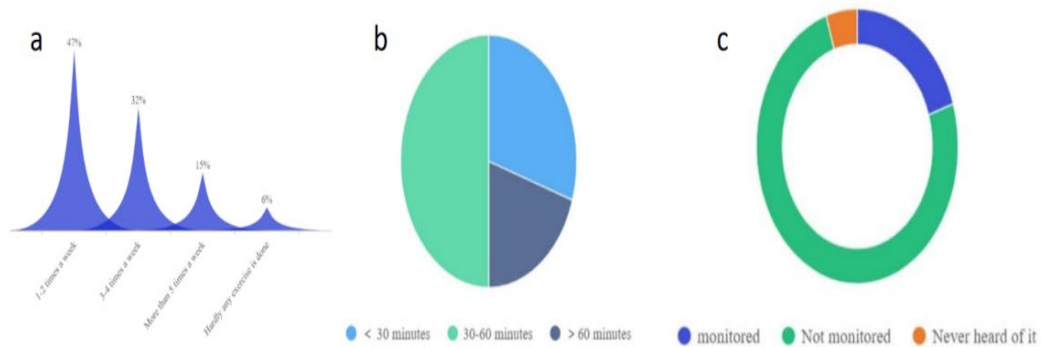


Figure 2: Results of questionnaire survey (a: results of exercise frequency; b: results of exercise time; c: statistics of monitoring VO2 habits)

According to the results of the questionnaire, most of the college students in the sample did not monitor the maximum oxygen consumption, and a few did not even heard of this index, reflecting the lack of knowledge or lack of attention. Ignoring this index cannot accurately assess exercise intensity, because VO2max monitoring is helpful to evaluate exercise intensity, and no monitoring may lead to improper intensity and affect the effect.^[6]

3.2 Statistics of maximum oxygen uptake

The separate statistical analysis of the maximum oxygen uptake for each sex gives Table 2. The

relative value of maximum oxygen uptake averaged 50.76ml/min/kg for male college students and 38.97ml/min/kg for girls.

Table 2: Statistics of maximum oxygen uptake for college students

| Sex | Index | Sample capacity | Minimum value | Maximal value | Average value | Standard deviation | Median |
|-------|--|-----------------|---------------|---------------|---------------|--------------------|--------|
| Man | Relative value of the maximum oxygen uptake(ml/min/kg) | 30 | 46.20 | 56.70 | 50.76 | 2.77 | 50.82 |
| | Maximum oxygen uptake in absolute value (ml/min) | 30 | 2.76 | 4.76 | 4.03 | 0.36 | 4.06 |
| Woman | Relative value of the maximum oxygen uptake(ml/min/kg) | 30 | 33.67 | 43.28 | 38.97 | 2.05 | 39.21 |
| | Maximum oxygen uptake(ml/min) | 30 | 1.66 | 2.84 | 2.17 | 0.28 | 2.21 |

3.3 t-test analysis of sex and maximum oxygen intake

Table 3: Analysis of t-test for sex and max oxygen intake

| | Gender (mean value \pm SD) | | t | p |
|-----------------------|------------------------------|------------------|---------|--------|
| | Woman(n=30) | Man(n=29) | | |
| Maximal oxygen intake | 38.97 \pm 2.05 | 50.76 \pm 2.77 | -18.547 | 0.0001 |

As can be seen in Table 3, all different gender samples are significant for the maximum oxygen uptake ($p < 0.05$), which means that different gender samples are different for the maximum oxygen uptake.

The sex factor reached a significance of 0.01 level in the difference in maximum oxygen intake ($t = -18.547$, $p = 0.0001$). According to comparative analysis, it was observed that the average of maximum oxygen intake in girls (38.97) was significantly less than the average of maximum oxygen intake in boys (50.76).

3.4 Analysis of Reasons for Differences in Maximal Oxygen Uptake Among Samples

3.4.1 Analysis of Differences in Maximal Oxygen Uptake Between Male and Female College Students

From the experimental data, it can be observed that the maximal oxygen uptake of males is generally higher than that of females. Through literature review and analysis, the following reasons may account for this difference:

Pulmonary Function: Under the same age and height, differences in lung structure and morphology between females and males include lung capacity, maximal respiratory flow rate, airway diameter, and diffusion surface. These differences may affect overall respiratory response, respiratory muscle function, and gas exchange in the lungs during exercise.

(1) **Muscle Mass:** Generally, males have more muscle mass than females. Muscles are the main consumers of oxygen, so more muscle mass implies a higher resting metabolic rate and higher maximal oxygen uptake capacity.

(2) **Hemoglobin Level:** Males usually have higher hemoglobin levels than females, which contributes to the amount of oxygen-carrying hemoglobin. Hemoglobin is crucial for transporting oxygen from the lungs to body tissues, so a higher hemoglobin level helps improve oxygen uptake capacity. [7]

(3) **Hormone Levels:** Male hormones such as testosterone have positive effects on muscle mass, hemoglobin levels, and metabolism. In contrast, female hormones may impose certain limitations on oxygen uptake capacity.

3.4.2 Analysis of the difference of the maximum oxygen intake level of college students with different physical indicators

The physical fitness and maximum oxygen uptake of boys were studied according to the data in Table 4. According to the data analysis of the maximum oxygen uptake in male samples, in general, the lower the body fat rate in the normal range, the higher the maximum oxygen intake level, and the better

the endurance level.

(1) Basic situation of male VO₂max: VO₂max is a key index to measure aerobic metabolism, respiration, circulation and muscle function, reflecting the highest ability of individual oxygen acquisition and utilization, and is often used to evaluate aerobic exercise performance. This test showed that most male VO₂max in this undergraduate university reached the medium level.^[8]

(2) The relationship between VO₂max and physical constitution: Studies show that low body fat rate means large VO₂max and good mobility. The male VO₂max medium group body fat rate was lower than the general group, indicating that high fat affects aerobic capacity. VO₂max It is related to lung ventilation, cardiac output, red blood cell number, and oxygen utilization. Elevated body fat rate leads to lipoprotein changes, increased blood stagnation, blocked oxygen transport and utilization, fat accumulation increases the cardiovascular burden, and reduces aerobic endurance and activity ability. The male middle group confirmed that VO₂max was associated with endurance exercise.^[9-10]

Table 4: The relationship between different VO₂max levels and physical fitness in boys

| Observational indicators | VO ₂ max medium group (n=19) | VO ₂ max general group (n=11) | t | p |
|--------------------------|---|--|------|-------|
| Body fat rate(%) | 15.62±3.65 | 18.13±3.27 | 3.21 | <0.01 |
| BMI(kg/m ²) | 20.65±2.04 | 21.35±2.66 | 1.37 | >0.05 |
| Vital capacity(ml) | 4129.68±702.1 | 4005.35±706.98 | 0.79 | >0.05 |
| 12min run(m) | 1600.78±11.21 | 1653.04±20.15 | 4.08 | <0.01 |

4. Conclusion

When testing the maximum oxygen uptake for college students without training experience, a 12-min run measurement can be used under limited conditions. The experiment found that the maximum oxygen uptake in men is higher than that in women, which is related to lung respiration, muscle mass and hemoglobin level, which deserves further exploration. At the same time, the maximum oxygen uptake was positively correlated with the BMI value, reflecting the importance of height and weight ratio for efficient exercise. With the progress of The Times, the breathing skills in the middle and long-distance running sports have also undergone innovation. Runners should insist on practice, choose the appropriate breathing method according to their personal situation, and keep the breathing and pace in harmony to achieve the best exercise effect.

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