Analysis of the Correlation between Cardiorespiratory Fitness and Sports in the Youth Population

Hui Guo*, Zhuoran Li, and Meng Zhao

Abstract—The level of cardiopulmonary function of young people is generally in a downward trend. In order to scientifically and reasonably improve the level of cardiopulmonary function of young people through physical exercise, the effect of daily physical exercise habits on cardiopulmonary function of young people aged 18-39 years old was studied. The maximum oxygen uptake and other cardiopulmonary function indexes of 120 college students and young teachers were measured through cardiopulmonary exercise test. The correlation analysis of each index was performed using SPSS 19.0, and their daily exercise habits were investigated using questionnaires. The influencing factors included whether they had exercise habits, the number of days of moderate intensity exercise in a week, the most frequent exercise items, and whether they had strength training or flexibility training. Single factor analysis of variance was used to study the influence of daily exercise habits on the level of cardiopulmonary function. The indexes of aerobic metabolism of the subjects with exercise habits were significantly better than those without daily exercise habits (P<0.01), and the maximum oxygen uptake of the subjects who exercised more than three times a week with moderate intensity was significantly higher than that of the subjects who exercised less than three times a week (P<0.01). By analyzing the influence of different daily physical exercise habits on cardiopulmonary function, we can guide young people to carry out scientific, effective and reasonable physical exercise and improve cardiopulmonary function.

Index Terms—Cardiopulmonary exercise test, cardiopulmonary fitness, physical exercise, maximum oxygen uptake

I. INTRODUCTION

With the rise of national fitness, the decline in physical health level is gradually attracting attention. Cardiorespiratory fitness is an important component of physical health, and good cardiopulmonary fitness is the basis for the development of various functions and qualities of the human body, and cardiopulmonary endurance is also the most effective predictor of mortality and morbidity [1]. Physical activity, cardiopulmonary endurance, risk of cardiovascular death, and risk of total death were strongly, negatively, and independently correlated [2]. Therefore, to effectively prevent cardiovascular and other chronic diseases, the level of cardiopulmonary fitness should be improved.

Nowadays, with the improvement of living standards, the convenience of transportation and the lack of exercise, the aerobic capacity of young people has decreased, the tolerance to long-term exercise has decreased, the cardiopulmonary function has decreased, and the risk of cardiovascular disease has increased [3]. Daily physical activity has a great impact on cardiopulmonary function, moderate and individualized exercise can effectively improve the level of cardiopulmonary function and play a role in the prevention and control of the growing number of cardiovascular and cerebrovascular diseases [4]. Therefore, young people need to be able to plan their physical activity scientifically and rationally to improve their cardiopulmonary fitness.

The level of cardiopulmonary fitness can be directly reflected by a cardiopulmonary exercise test to measure aerobic metabolic indices. Treadmills and power bikes are the most commonly used methods to measure an individual's maximum oxygen uptake [5]. The power car step-by-step incremental load test (graded exercise test, GXT) is a laboratory use of power car for direct testing of maximum oxygen uptake [6]. The maximum oxygen uptake [7] and the oxygen pulse [8] measured in the experiment both reflect well the human cardiopulmonary function.

The main objective of this study is to evaluate the effect of daily physical activity habits on the level of cardiopulmonary fitness in young people aged 18-39 years, including school students and teachers, to analyze the correlation between physical activity habits and the level of cardiopulmonary fitness, to draw attention to physical health problems and the prevention of chronic diseases such as cardiovascular diseases, to arrange physical activity scientifically and rationally, to improve physical health.

II. MATERIALS AND METHODS

A. Human Participants

The test subjects were 120 university students and young teachers aged 18 to 39 years, of whom 62 were male (age 27.92±6.16) and 58 were female (age 27.91±6.66).

B. Equipment

Special instruments for the fifth national physical fitness monitoring are using to measure height, body mass, body fat percentage, lean body mass, and lung capacity, and the German Ergoline power cart is using for step-by-step incremental load experiments, and the German CortexMetaMax 3B exercise cardiopulmonary fitness tester is using to measure maximum oxygen uptake, oxygen pulse, and other aerobic metabolic indexes.
C. Experimental Process

Subjects were tested on basic physical and health indicators, including their height, body mass, vital capacity, percentage of body fat, vital capacity, etc. The subjects were required to carry out the stepwise load test of power car. The load scheme is that the initial load is 25w, each step is increased by 25w, the duration of each step is 2min, and the whole speed is kept at 60r/s [9]. The criteria for termination of the progressive load test were 1) heart rate at or above maximum heart rate (maximum heart rate is 220-age), 2) plateau in oxygen uptake, 3) respiratory quotient exceeding 1.15 [10], and 4) subject exhaustion with subjective fatigue feeling of 18 and inability to persist despite repeated encouragement [11].

D. Indicators

The questionnaire was administered to the subjects through the "Adult Cardiorespiratory Endurance Comparison Test Card", which included whether they had an exercise habit, the number of moderate intensity exercises performed in a week, the most frequent sports, whether they performed strength training and whether they performed flexibility training.

The routine indicators of national physique monitoring include body mass, height, BMI (BMI=body mass/kg ÷ (height/m)^2), body fat percentage, lean body mass (defatted body mass), vital capacity, etc.

The indicators of cardiodiaphragmatic function evaluation measured in the step-by-step incremental load experiment include maximum relative oxygen uptake, absolute oxygen uptake, absolute carbon dioxide excretion, oxygen pulse, and tidal volume.

E. Statistical Analysis

SPSS 19.0 software was used for analysis, and the descriptive statistics of the measured data were expressed as mean ± standard deviation. The test subjects were divided into two groups according to whether they exercised or not, into two groups for different exercise frequencies (divided into the group of 3 times per week and above and the group of fewer than 3 times per week), into four groups for different training items performed most frequently, and into two groups each for strength training and flexibility training. The Z-score of each cardiorespiratory endurance evaluation index was derived, and the Z-score of each index was summed for each individual to obtain the fitness index [12], which indicates the health status of cardiorespiratory function. The fitness indices were classified as "healthy cardiorespiratory function" and "sub-healthy cardiorespiratory function" according to the fitness indices greater than or equal to 0 and less than 0, respectively [13]. The Pearson χ² test was used to compare exercise habits with the physical fitness index [14]. The influence of exercise habits on various indexes of cardiodiaphragmatic function was analyzed by multivariate logistic regression model, and the difference was statistically significant with P<0.05.

As can be seen in Table I, the BMI and lean body mass of the subjects were lower in females than in males, the percentage of body fat was higher than in males, and the aerobic metabolic indexes including lung capacity, relative oxygen uptake, and oxygen pulse were lower than in males. The study found that there was no significant difference in the maximum oxygen uptake between men and women before puberty, and the difference in the maximum oxygen uptake began to become obvious after the age of 12-13 years [15]. The differences between sexes in maximal oxygen uptake and all other aerobic metabolic indexes were statistically significant(P<0.05).

B. The Relationship between Exercise Habits and Cardiorespiratory Fitness

1) Pearson χ² test

The Pearson χ² test was used to compare each exercise habit with the physical fitness index obtained from the Z score, and the results are shown in Table II.

III. RESULTS

A. Descriptive Statistic

The measured height, body mass, body fat percentage, spirometry, maximal oxygen uptake, and oxygen pulse were subjected to descriptive statistics, as shown in Table I.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Cardiorespiratory subfitness</th>
<th>Cardiorespiratory subfitness</th>
<th>χ²</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Percent age (%)</td>
<td>Frequency</td>
<td>Percent age (%)</td>
<td></td>
</tr>
<tr>
<td>Whether exercise</td>
<td>Yes</td>
<td>23</td>
<td>44.2</td>
<td>46</td>
</tr>
<tr>
<td>Not</td>
<td>29</td>
<td>55.8</td>
<td>7</td>
<td>13.2</td>
</tr>
<tr>
<td>Exercise frequency</td>
<td>≥3 times one week</td>
<td>45</td>
<td>81.8</td>
<td>32</td>
</tr>
<tr>
<td>&lt;3 times one week</td>
<td>10</td>
<td>18.2</td>
<td>25</td>
<td>43.9</td>
</tr>
<tr>
<td>Most frequent sport</td>
<td>Walking</td>
<td>26</td>
<td>83.9</td>
<td>17</td>
</tr>
<tr>
<td>Running</td>
<td>3</td>
<td>9.7</td>
<td>8</td>
<td>17.4</td>
</tr>
<tr>
<td>Ping, Pong, Badminton, Tennis</td>
<td>1</td>
<td>3.2</td>
<td>6</td>
<td>13.0</td>
</tr>
<tr>
<td>Soccer, basketball, volleyball</td>
<td>1</td>
<td>3.2</td>
<td>15</td>
<td>32.6</td>
</tr>
</tbody>
</table>

As can be seen in Table I, the BMI and lean body mass of the subjects were lower in females than in males, the percentage of body fat was higher than in males, and the aerobic metabolic indexes including lung capacity, relative oxygen uptake, and oxygen pulse were lower than in males. The study found that there was no significant difference in the maximum oxygen uptake between men and women before puberty, and the difference in the maximum oxygen uptake began to become obvious after the age of 12-13 years [15]. The differences between sexes in maximal oxygen uptake and all other aerobic metabolic indexes were statistically significant(P<0.05).
As can be seen from Table II, in terms of whether or not they have exercise habits, the youth population had the highest health fitness detection rate (86.8%) for “exercise habits” with a $\chi^2$ value of 21.10 and a lower cardiorespiratory fitness detection rate (13.2%) for “no exercise habits”. The difference was statistically highly significant (P<0.001). Regarding the frequency of exercise in a week, the detection rate of cardiorespiratory fitness (56.1%) was higher for “moderate intensity exercise more than or equal to 3 days a week,” with a $\chi^2$ value of 8.59, and the difference was statistically significant (P<0.01). Regarding the most frequently played sports, the detection rate of cardiorespiratory fitness (3.2%) was the lowest in “soccer, basketball and volleyball,” with a $\chi^2$ value of 17.73, a statistically significant difference (P<0.01).

2) Effect of the presence or absence of exercise habits on cardiorespiratory fitness

A one-way ANOVA was performed on all cardiorespiratory endurance indices for both groups of subjects with and without exercise and exercise habits, and the results are shown in Table III.

### TABLE III: COMPARISON OF AEROBIC METABOLIC CAPACITY OF PEOPLE WITH DIFFERENT EXERCISE HABITS

<table>
<thead>
<tr>
<th>Whether exercise</th>
<th>Number of people</th>
<th>Statistical value</th>
<th>Spirometry (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>72</td>
<td>375.4±721</td>
<td></td>
</tr>
<tr>
<td>Not</td>
<td>37</td>
<td>289.8±659</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>109</td>
<td>346.1±808</td>
<td></td>
</tr>
</tbody>
</table>

Table IV: Effect of the training program on cardiorespiratory fitness

The questionnaire survey and statistics were conducted on the most frequently performed training programs of 70 of the 120 people with exercise habits, and a one-way ANOVA was conducted on the maximum oxygen uptake and oxygen pulse corresponding to the four most frequently performed training programs. The results are shown in Table V.

### TABLE IV: FREQUENCY OF MODERATE INTENSITY EXERCISE IN RELATION TO MAXIMUM RELATIVE OXYGEN UPTAKE

<table>
<thead>
<tr>
<th>Exercise frequency</th>
<th>Number of people</th>
<th>Statistical value</th>
<th>Maximum oxygen uptake (ml/min/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥3 times/week</td>
<td>35</td>
<td>30.2±5.7</td>
<td></td>
</tr>
<tr>
<td>&lt;3 times/week</td>
<td>35</td>
<td>25.8±6.1</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>28.0±6.3</td>
<td></td>
</tr>
</tbody>
</table>

4) The effect of the training program on cardiorespiratory fitness

It can be seen from Table V that the fourth group of people with training items of football, basketball and volleyball are the best in aerobic metabolism, the third group of Ping Pong, badminton, tennis category of maximum oxygen uptake second, the second group of running again, the first group of walking, walking maximum oxygen uptake is the lowest, the difference between the groups is statistically significant (P<0.01).
419

< 0.01).

5) Effects of strength training and flexibility training on cardiorespiratory fitness

A one-way ANOVA was performed on the maximum relative oxygen uptake of those who performed strength exercises versus those who did not, and the results are shown in Table VI.

<table>
<thead>
<tr>
<th>Whether to train for strength</th>
<th>Number of people</th>
<th>Statistical value</th>
<th>Maximum oxygen uptake (ml/min/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>25</td>
<td>30.1±6.7</td>
<td></td>
</tr>
<tr>
<td>Not</td>
<td>45</td>
<td>26.9±5.8</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td></td>
<td>28.0±6.3</td>
</tr>
<tr>
<td>F-value</td>
<td>4.46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-value</td>
<td>0.04</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As shown in Table VI, the maximum oxygen uptake of subjects undergoing strength training (26.9 ± 5.8 ml/min/kg) was significantly higher than that of subjects without strength training (30.1 ± 6.7 ml/min/kg) (P<0.05). During strength training, lactic acid is metabolized into glucose or glycogen, and the demand for O2 will increase [19]. Therefore, the ability of muscles to consume or use oxygen determines the level of oxygen uptake. Compared with the testers without strength training, proper strength training can greatly improve the maximum oxygen uptake of the testers [20].

Compared with strength training, there is a small difference in the maximum oxygen uptake between the two groups of flexibility training or not, and there is no obvious effect of strength training on the maximum oxygen uptake.

IV. DISCUSSION

With the development of society, people's living standards are improving with each passing day. Many sub-health, obesity, and other problems caused by not paying attention to physical exercise are also gradually highlighted. The higher the degree of obesity, the worse the aerobic exercise capacity due to low-fat energy supply capacity [21]. And excessive obesity can also lead to a decrease in human pulmonary ventilation function [22]. The decrease in the level of cardiopulmonary function can cause many cardiovascular diseases and other chronic diseases. In this study, we measured the aerobic metabolic indexes under the incremental load test in young people aged 18-39 years old, including university students and teachers, to show more intuitively the effects of exercise habits and different exercise programs and exercise frequencies on the level of cardiorespiratory fitness.

Those with daily exercise habits performed better in all basic physical indicators and all aerobic metabolic indicators. The exercise group had greater lung capacity than the non-exercise group (P<0.01), and has less body fat percentage than the non-exercise group (P<0.01). Those with daily exercise habits had higher maximal oxygen uptake (28.0±6.3 ml/min/kg) and oxygen pulse than the non-exercise group's. Hawkins [23] found that maximum oxygen uptake in adults decreases at a rate of 0.4-0.5 ml/kg/min per year (9%-10%/10 years) at 25-30 years of age in those without exercise habits, while in contrast, men who perform intense regular physical exercise (Excluding the elderly), the rate of decline is less. Thus, maintaining an exercise habit is essential to improve cardiorespiratory fitness. Therefore, persisting in sports can improve the heart and lung function, and achieve the effect of physical fitness and disease prevention.

In the population with exercise habits, the maximal oxygen uptake was higher (p<0.01) in testers who exercised more than three days a week at moderate intensity (30.2±5.7 ml/min/kg) compared to those who exercised less than three days at moderate intensity (25.8±6.1 ml/min/kg), while using high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) The improvement in maximal oxygen uptake was the same for both training modes, the only difference being the duration of the exercise [24]. Therefore, in terms of exercise efficiency and the intensity of exercise that the body can withstand, for young people who want to effectively improve their level of cardiorespiratory fitness through physical exercise, more than three times a week of moderate-intensity exercise can be performed to maintain physical vitality and improve physical health. According to the Guidelines and Recommended Standards on Physical Activity for Adults, physical activity of moderate or vigorous intensity not less than 30 min per day no less than five times a week is necessary to improve cardiorespiratory fitness and exercise levels and maintain physical health [25], therefore, 3-5 times a week of moderate-intensity exercise is a reasonable and effective exercise arrangement when physical conditions allow.

Among the four most common training activities obtained from the questionnaire, the relative oxygen uptake was significantly higher in those who performed soccer, basketball, and volleyball-type activities (32.7±5.7 ml/min/kg), followed by table tennis, badminton, and tennis-type (31.3±4.9 ml/min/kg), and the maximum oxygen uptake in the running population (27.1±5.2 ml/min/kg) was higher compared to The maximum oxygen uptake of the walking population (25.0±5.3 ml/min/kg) was higher, but lower compared to ball sports. The same results were obtained for the comparison between spirometry and oxygen pulse groups, and the differences between the groups were statistically significant by one-way ANOVA test (P<0.01).

He Chengbin [26] found that skeletal muscle content was higher in students with special training in volleyball and basketball compared to students with other specialties, and skeletal muscle has a tremendous ability to increase blood flow and VO2 [27], so the relative oxygen uptake was significantly higher in people with soccer, basketball, and volleyball-type activities. Ball games have the characteristics of being short and fast, and due to the variety of movements and the need for strength confrontation, they will mobilize more muscles during exercise, and to a certain extent, they can raise the maximum oxygen uptake and improve cardiorespiratory fitness faster and more effectively than running and walking. Therefore, under the condition that physical fitness allows, more kinds of exercise programs can also make the body not adapt to a kind of exercise, maintain the body's vitality, and more effectively improve cardiorespiratory function.

By analyzing the effect of strength training and flexibility
training on maximal oxygen uptake, we can see that strength training can increase maximal oxygen uptake more significantly. This is because strength training activates more muscle groups in the body, increasing muscle content and the number and activity of mitochondria in muscle cells, which are the main site of aerobic respiration, and the more muscle content, the greater the aerobic metabolic capacity [28]. For those who want to improve their cardiorespiratory fitness level, strength training should be appropriately arranged in daily exercise to improve aerobic capacity. Although flexibility training has a relatively small effect on maximal oxygen uptake, flexibility is an important component of physical fitness, reflecting the range of motion of the body’s joints and the ability to stretch muscles, tendons, and other soft tissues. The lack of flexibility may lead to hamstring strain or other functional losses during exercise [29], therefore, proper arrangement of flexibility training in daily life can increase the range of motion and prevent sports injuries while maintaining good body form.

In conclusion, with the rise of national sports, maintaining good scientific sports habits is crucial for the physical health of young people. Young people should find the most suitable exercise program and frequency within their ability according to their actual situation, carry out physical exercise scientifically and reasonably, improve their cardiorespiratory function, improve physical fitness, maintain good exercise habits, and reduce the risk of diseases.

In the follow-up study, we will try to carry out a long-term comparative experiment to compare the changes of cardio-pulmonary function indicators such as oxygen intake of people who adhere to a certain exercise habit before and after a certain period of time, and more clearly compare the impact of different exercise habits on the improvement of cardio-pulmonary function, and increase the questionnaire items, such as smoking, diet, stress, occupation, etc. Compare the effects of various living habits and sports habits on cardiopulmonary function horizontally to increase the reference of research results and guide young people to improve their physical health.

V. CONCLUSION

The exercise group had a higher lung capacity than the non-exercise group (P<0.01) and a significantly lower body fat percentage than the non-exercise group (P<0.01), while the maximum oxygen uptake (28.0±6.3 ml/min/kg) and oxygen pulse rate of those with daily exercise habits were higher than those of the non-exercise group. The maximum oxygen uptake (24.1±6.3ml/min/kg) and oxygen pulse rate of the group with daily exercise habits were higher than those of the non-exercise group. It can be seen that adherence to physical activity can effectively improve the body’s cardiorespiratory function and achieve the effect of strengthening the body and preventing diseases.

Among the people with exercise habits, the maximum oxygen uptake was higher in the test subjects who exercised more than three days a week at moderate intensity (30.2±4.57 ml/min/kg) compared with those who exercised less than three days at moderate intensity (25.8±6.1 ml/min/kg) (p<0.01). For young people who want to improve their cardiorespiratory fitness through physical exercise, 3-5 times a week of moderate intensity exercise is a reasonable and effective exercise schedule if physical conditions allow.

Among the four most common training activities obtained from the questionnaire, the relative oxygen uptake was significantly higher in soccer, basketball, and volleyball (32.7±5.7 ml/min/kg), followed by table tennis, badminton, and tennis (31.3±4.9 ml/min/kg), and the maximum oxygen uptake in running (27.1±5.2 ml/min/kg) compared to The maximum oxygen uptake of the walking population (25.0±5.3 ml/min/kg) was higher, but lower compared to ball sports. The same results were obtained for the intergroup comparison of spirometry and oxygen pulse, and the differences between the groups were statistically significant by one-way ANOVA test (p<0.01).

The results of the analysis of the effect of whether or not strength training and flexibility training on maximal oxygen uptake showed that strength training could more significantly increase maximal oxygen uptake. For those who want to improve the level of cardiorespiratory fitness, strength training should be appropriately arranged in daily exercise to improve aerobic capacity.

CONFLICT OF INTEREST

The authors declare no conflict of interest

AUTHOR CONTRIBUTIONS

Hui Guo, Zhuoran Li, and Meng Zhao conducted the research; Zhuoran Li analyzed the data; Meng Zhao collate test data and screen valid data: Zhuoran Li wrote the paper; all authors had approved the final version.

REFERENCES


Copyright © 2023 by the authors. This is an open access article distributed under the Creative Commons Attribution License which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited (CC BY 4.0).