Influence of 12 weeks of basketball training on college students’ heart function

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Abstract. – OBJECTIVE: This study aims to investigate the influence of 12 weeks of basketball training on college students’ heart function. SUBJECTS AND METHODS: The subjects were 30 college male basketball players. Carry out 8-week interval training, monitor the training load and interval time of athletes, and strictly control the heart rate during the interval. Before and after training, we used safe and effective experimental instruments – without any damage to the athletes – to detect the relevant indicators of the athletes’ physiological functions; hence we compared and analyzed the various indicators before and after training.

RESULTS: The time domain indexes Root Mean Square of Successive Differences (RMSSD), Statistically Determined Spatial Drift (SDSD), percentage of NNN50 in the total number of NN intervals (PNN50), and Standard Deviation of all NN intervals for all 5-min segment (SDNN) after training were significantly higher than those before training, and the differences were statistically significant (p<0.05). Average (Avag) and Statistically Determined Allocation Weights (SDAW) after training were significantly higher than those before training, the difference was statistically significant (p<0.05). Asymmetry (Asym) and Tension index (TI) were significantly lower than those before training, the difference was statistically significant (p<0.05). Application Information Index (ApInf) had no significant difference (p>0.05). There was no significant difference in shooting hit rate (p>0.05). The speed of the 8-character dribble in the whole field after training was significantly lower than that before training, and the differences were statistically significant (p<0.05). There was no significant difference in average jump height, maximum jump height, average time in the air, and best jump time in the air after training (p>0.05). For the test of athletes’ explosive power, five vertical jumps in situ were selected for testing, and the jump height and time in the air of each vertical jump were counted to calculate the maximum and average values of five vertical jumps. The results showed that there was no significant change in the explosive force of the athletes’ lower limbs after training. The reason may be that strength training needs to follow the principles of heavy load, specialization, exercise sequence and reasonable interval. The intermittent training method used during training is not specialized in strength training, and the reasonable interval of strength training was not considered in the training process.

CONCLUSIONS: Intermittent training can increase the tension of the cardiac vagus nerve of college basketball players, increase the cardiac reserve function and the load that the heart can bear, so that the cardiac function can be improved well. It can improve the cardiopulmonary function and aerobic work ability of college basketball players. It can improve the adjustment ability of the heart, lungs, liver, and other organs of college basketball players. It also can increase the load intensity that the central nerve can bear and improve the function of the central nerve and autonomic nerve. The anti-fatigue ability of athletes can be improved. It can improve the speed quality of college basketball players.

Key Words: College student, Basketball, Interval training, Physiological function index.

Introduction

With the development of basketball, the action’s rhythm in basketball matches is accelerating, and the confrontation degree is also constantly strengthening, which has a higher requirement for the physical quality of athletes. Basketball is a combination of aerobic and anaerobic sports. Therefore, it is particularly important to improve the physiological function level and competitive ability of basketball players by deeply understanding their metabolic characteristics and physiological function status. This research aims to improve the physical function level of college basketball players in an all-around way. During the winter vacation, the college basketball players were trained for 8 weeks by using the intermittent
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Subjects and Methods

Research Object
The subjects were 30 male college basketball players. Basic information on the subjects is shown in Table I.

Experimental Methods
Eight weeks of interval training are required, and athletes’ training load and interval time are monitored. During intervals, it is necessary to strictly control the heart rate. Before and after training, we used safe and effective experimental instruments – without any damage to the athletes – to detect the relevant indicators of the athletes’ physiological functions and afterward, we compared and analyzed the various indicators before and after training.

Training Methods
Interval training method was adopted. During the training process, the heart rate during the interval was strictly controlled to ensure that each interval could make the athlete’s heart rate recover to 120-130 times/min, and the next group of training was carried out. During the interval, the enthusiasm recovery method is adopted. The training content was divided into two parts, the first part included a basic training and a resistance training, the second part included physical quality, technical and tactical cooperation. During training, the athlete’s heart rate was monitored according to the heart rate value displayed on the polar table. Rest when the heart rate of basic training and technical and tactical cooperation training reaches 160-170 times/min, and rest when the heart rate of resistance training and physical fitness training reaches 180-190 times/min.

A one-week test was conducted before the training, including relevant indicators of Omega Wave physiological function test system, cardiopulmonary function test system and basketball specific ability. After the test, the training lasted for 12 weeks. After the training, the relevant indexes of Omega Wave physiological function test system, cardiopulmonary function test system and basketball specific physical fitness were tested repeatedly.

Statistical Analysis
Excel software shall be used to input and sort out the data, and the data shall be processed and analyzed through SPSS 25.0 (IBM Corp., Armonk, NY, USA). The paired sample t-test was conducted for the test data before and after the experiment, and the significance level was set as p<0.05. The Chi-square test was conducted for the number (%) of the central nervous system and other indicators at different levels. All data are expressed as mean ± standard deviation.

Results

Heart Rate Variability
The analysis of heart rate variability (HRV) can be divided into time-domain analysis and frequency-domain analysis. The frequency-domain

<table>
<thead>
<tr>
<th>Sample size (person)</th>
<th>Age</th>
<th>Weight (kg)</th>
<th>Height (cm)</th>
<th>Athlete Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>20.55±1.55</td>
<td>83.52±12.06</td>
<td>187.82±7.63</td>
<td>Second-grade Athlete</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Index</th>
<th>Before training</th>
<th>After training</th>
<th>t-value</th>
<th>p-value</th>
<th>Effect amount d</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDNN (ms)</td>
<td>62.23±25.06</td>
<td>71.04±20.45</td>
<td>-2.247</td>
<td>0.040</td>
<td>0.39</td>
</tr>
<tr>
<td>RMSSD (ms)</td>
<td>58.42±27.28</td>
<td>75.49±24.81</td>
<td>-4.125</td>
<td>0.000</td>
<td>0.66</td>
</tr>
<tr>
<td>SDS (ms)</td>
<td>75.15±25.13</td>
<td>98.53±30.47</td>
<td>-4.273</td>
<td>0.000</td>
<td>0.80</td>
</tr>
<tr>
<td>PNN50 (ms)</td>
<td>17.55±9.76</td>
<td>24.45±7.40</td>
<td>-4.187</td>
<td>0.000</td>
<td>0.81</td>
</tr>
</tbody>
</table>

Standard Deviation NN intervals for all 5-min segment (SDNN); Root Mean Square of Successive Differences (RMSSD) reflects the regulatory capacity level of vagus nerve; Statistically Determined Spatial Drift (SDS); NN50 in the total number of NN intervals (PNN50).
analysis can make up for the deficiency of time-domain analysis. Based on the time-domain analysis, further analysis of HRV is carried out. In the time domain indicators, Standard Deviation of all NN intervals for all 5-min segment (SDNN) reflects the overall activity level of sympathetic nerve and vagus nerve, which is used to evaluate the overall regulatory capacity of the cardiac autonomic nervous system. Root Mean Square of Successive Differences (RMSSD) reflects the regulatory capacity level of vagus nerve, as well as the Statistically Determined Spatial Drift (SDSD). The percentage of NN50 in the total number of NN intervals (PNN50) also measures the regulatory capacity of vagus nerve on cardiac rate variability.

According to the results in Table II, the time domain indexes RMSSD, SDSD, PNN50, SDNN after training were significantly higher than those before training, and the differences were statistically significant ($p<0.05$). It shows that the vagus nerve regulation ability of basketball players is enhanced after training. SDNN represents the overall regulatory capacity of sympathetic nerve and vagus nerve; RMSSD, SDSD and PNN50 all reflect the vagus nerve tension. The increase of SDNN does not fully represent the enhancement of sympathetic nerve regulation ability of athletes, so it needs to be further discussed with frequency domain indicators. The effect of RMSSD is 0.66, showing a medium effect; the effect amount of SDSD=0.80, showing a medium effect; the effect of PNN50 is 0.81, showing a high effect. It can be considered that the above indicators are greatly affected by the independent variable interval training method.

**Changes in Cardiac Function**

According to the results shown in Table III, the average and standard deviation after training were significantly higher than those before training and the difference was statistically significant ($p<0.05$). Asym and TI were significantly lower than those before training, and the difference was statistically significant ($p<0.05$), ApInf had no significant difference ($p>0.05$). It shows that after training, the regulation degree of central nervous system on heart activity decreases and the training effect is significantly strengthened. It can also be seen that the fatigue degree is significantly reduced, and the stress response has no significant change. The cardiac function reserve is significantly increased, and the vagus nerve influence factor is enhanced. The sympathetic nerve influence factor is weakened, and the athletes’ cardiac function regulation ability is significantly improved after training. The effect amount of SDNN is 0.55, which shows a medium effect. The effect amount of Statistically Determined Allocation Weights (SDAW) is 0.48, close to the medium effect. It can be considered that the above indicators are greatly affected by the independent variable interval training method.

**Table III.** Changes of cardiac function indexes before and after training.

<table>
<thead>
<tr>
<th>Index influence factor</th>
<th>Before training</th>
<th>After training</th>
<th>t-value</th>
<th>p-value</th>
<th>Effect amount d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avag</td>
<td>0.16±0.08</td>
<td>0.21±0.08</td>
<td>-2.853</td>
<td>0.005</td>
<td>0.55</td>
</tr>
<tr>
<td>Asym</td>
<td>35.35±11.23</td>
<td>30.52±7.48</td>
<td>2.795</td>
<td>0.011</td>
<td>0.53</td>
</tr>
<tr>
<td>TI</td>
<td>86.20±62.21</td>
<td>57.78±34.62</td>
<td>2.817</td>
<td>0.011</td>
<td>0.54</td>
</tr>
<tr>
<td>ApInf</td>
<td>1.60±0.27</td>
<td>1.52±0.16</td>
<td>1.03</td>
<td>0.255</td>
<td>0.24</td>
</tr>
<tr>
<td>SDAW</td>
<td>0.015±0.011</td>
<td>0.020±0.007</td>
<td>-2.970</td>
<td>0.004</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Average (Avag); Asymmetry (Asym); Tension Index (TI); Application Information Index (ApInf); Statistically Determined Allocation Weights (SDAW).
rate variability caused by faster heart rate due to inspiration and slower heart rate due to expiration. Avag and Asym indicators mainly reflect the training effect and fatigue level of athletes.

Intermittent training can effectively improve the vagus nerve tension of athletes. The increase of vagus nerve can effectively inhibit the excitability of the heart, reduce the number of heart beats, and reduce the heart rate. The acceleration of heart rate will lead to insufficient ventricular filling, which will affect the blood pumping function of the heart. At the same time, it will increase the energy consumption of the heart muscle, which can easily lead to myocardial fatigue. Therefore, the increase of vagus nerve excitability after training can better inhibit the beating of the heart, reduce the occurrence of myocardial fatigue, reduce the fatigue index and tension index, and play a good role in the functional reserve of the heart.

**Discussion**

According to the results in Table IV, there is no significant difference in shooting hit rate ($p>0.05$). The speed of the 8-character dribble in the whole field after training is significantly lower than that before training, and the differences are statistically significant ($p<0.05$). It shows that the movement speed of basketball players has been significantly improved after training, and the shooting percentage has not changed significantly. And the effect amount of the whole field eight-character dribble d=0.64, showing a medium effect. It can be considered that the above indicators are greatly affected by the independent variable interval training. The change in shooting hit rate is related to multiple factors.

It is a long-term accumulation process, which requires targeted training. The intermittent training method adopted during this training mainly aims at improving the athletes’ physical fitness and the stable use of skills and tactics. The shooting hit rate has not been significantly improved, but its stable play is maintained. The change of movement speed is consistent with several research results. Interval training can enhance the movement speed of athletes.

Speed quality is very important in basketball. It is essential in the fast break, forward court promotion, offensive and defensive conversion, rebounding, and dribbling. The intermittent training method adopts active rest during intervals. The respiratory system and central nervous system are still in an excited state, which is of great significance for the improvement of athletes’ speed quality.

According to the results in Table V, there is no significant difference in average jump height, maximum jump height, average time in the air, and best jump time in the air after training ($p>0.05$). For the test of athletes’ explosive power, five vertical jumps in situ were selected for testing, and the jump height and time in the air of each vertical jump were counted to calculate the maximum and average values of five vertical jumps. After each vertical jump, there is enough time to rest, which can ensure that each jump has sufficient preparation and power accumulation time and ensure that each vertical jump athlete can exert maximum strength.

The results show that there is no significant change in the explosive force of the athletes’ lower limbs after training. The reason may be that strength training needs to follow the principles of heavy load, specialization, exercise sequence, and reasonable interval. The intermittent

<table>
<thead>
<tr>
<th>Index</th>
<th>Before training</th>
<th>After training</th>
<th>$t$-value</th>
<th>$p$-value</th>
<th>Effect amount $d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>One minute shooting hits (times)</td>
<td>9.22±3.34</td>
<td>10.29±4.18</td>
<td>-1.334</td>
<td>0.150</td>
<td>0.32</td>
</tr>
<tr>
<td>Eight-character dribble time (sec)</td>
<td>41.82±3.72</td>
<td>39.13±4.02</td>
<td>5.03</td>
<td>0.000</td>
<td>0.64</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Index</th>
<th>Before training</th>
<th>After training</th>
<th>$t$-value</th>
<th>$p$-value</th>
<th>Effect amount $d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average jumping height (cm)</td>
<td>42.06±6.68</td>
<td>42.01±4.04</td>
<td>0.060</td>
<td>0.833</td>
<td>0.01</td>
</tr>
<tr>
<td>Maximum jumping height (cm)</td>
<td>44.40±6.07</td>
<td>44.23±5.27</td>
<td>0.176</td>
<td>0.742</td>
<td>0.02</td>
</tr>
<tr>
<td>Average dead time (ms)</td>
<td>590.40±44.67</td>
<td>590.34±33.86</td>
<td>0.001</td>
<td>0.881</td>
<td>0.00</td>
</tr>
<tr>
<td>The best jump time (ms)</td>
<td>606.30±45.44</td>
<td>605.52±35.01</td>
<td>0.134</td>
<td>0.775</td>
<td>0.03</td>
</tr>
</tbody>
</table>
training method used during training is not specialized in strength training, and the reasonable interval of strength training is not considered in the training process.

The explosive power is mainly provided by anaerobic metabolism, which is composed of phosphate energy supply system and glycolysis energy supply system. It reflects the ability of human muscle to provide energy through anaerobic metabolism. The improvement of glycolysis energy supply system is mainly carried out through maximum lactic acid training and lactic acid tolerance training. The training is generally required to be more than 30 seconds, and 1-2 minutes is the most appropriate to maintain a certain functional state, stimulate the blood lactic acid level of the body, and improve the buffer capacity and the activity of lactate dehydrogenase in the muscle. The results of interval training show that it has a significant effect on the improvement of aerobic metabolism but has no significant effect on the improvement of anaerobic metabolism.

Conclusions

According to the experimental analysis, the following conclusions are drawn: (1) Intermittent training can improve the tension of the cardiac vagus nerve of college basketball players, increase the cardiac reserve function and the load that the heart can bear, and improve the cardiac function. (2) Intermittent training can improve the cardiopulmonary function and aerobic working ability of college basketball players. (3) Intermittent training can improve the adjustment ability of the heart, lungs, liver, and other organs of college basketball players, increase the load intensity that the central nerve can bear, improve the function of the central nerve and autonomic nerve, and improve the anti-fatigue ability of athletes. (4) Interval training can improve the speed quality of college basketball players.

At the same time, this paper also has some suggestions: (1) According to the physical quality of college basketball players, formulate corresponding scientific training programs, strictly monitor the training heart rate to better improve the aerobic sports ability of athletes, and reasonably arrange the number, time, and intensity of training. (2) Reinforce the strength quality and agility training of college basketball players. (3) Increase the richness of training content and strengthen the subjectivity of athletes’ training. (4) Intermittent training can be combined with other training methods to train athletes more comprehensively.

Conflict of Interest

The Authors declare that they have no conflict of interests.

Funding

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Informed Consent

Informed consent was obtained from all individual participants included in the study.

Availability of Date and Materials

The data generated in this study were all derived from experiments and shared by all authors of this paper.

Ethics Approval

This study was approved by Zhoukou Normal University (No. 4855214).

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