Study on the Effects of Different Exercise Training Methods on HRV of Obese Male College Students

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Abstract: This study examines the effects of different exercise training methods on heart rate variability (HRV) in obese male college students. Forty obese male college students with a BMI of 28 or higher were selected and divided into an experimental group and a control group. Both groups underwent an eight-week training intervention, with the experimental group engaging in high-intensity interval training (HIIT) and the control group in moderate-intensity continuous training (MICT). The SPCS biofeedback system was used to monitor HRV-related indicators after each weekly training session. The results showed that HIIT training increased the time-domain indicators in the experimental group, enhancing heart rate variability and vagal activity, with a more positive impact on HRV from the early stages of training. In contrast, MICT training led to an overall decrease in time-domain indicators in the control group, along with a decline in HRV and vagal activity. Both training methods resulted in a simultaneous decrease in sympathetic and parasympathetic nervous system activity in the frequency domain. The study suggests that HIIT is more effective than MICT in improving the autonomic nervous regulation function of obese college students. It is recommended to incorporate HIIT into weight management plans for obese individuals and to further optimize the training regimen.

Key words: Intermittent Training Method; Continuous Training Method; Obese Male College Students; Heart Rate Variability

1. Introduction

Heart rate variability (HRV), a physiological indicator reflecting the instantaneous fluctuations in the RR interval between consecutive heartbeats, is designed to quantify and characterize the dynamic balance of sympathetic-vagal nerve tension [1]. Recent studies have shown that HRV-related indicators, due to their non-invasive, stable, and highly sensitive nature, have become important electrophysiological monitoring tools in competitive sports and public health. Based on HRV's capabilities for real-time monitoring and quantitative assessment of the autonomic nervous system function, numerous empirical studies have highlighted the significant application value of this set of indicators in monitoring exercise load. Notably, HRV parameters in the time domain, frequency domain, and nonlinear aspects can effectively assess the cumulative degree of athletic fatigue, pre-competition stress, and psychological training adaptability in athletes, as well as serve as an objective basis for evaluating the cardiovascular autonomic nervous regulation function in the general exercise population. This provides a solid theoretical foundation and practical pathway for exploring the mechanisms of cardiac autonomic nervous function remodeling under different exercise modes [2]. Existing research indicates that exercise interventions positively modulate HRV parameters in obese individuals across multiple dimensions. Different intensity exercise programs can enhance the cardiovascular system's functional adaptability by improving the balance of autonomic nervous tension and enhancing the dominance of the parasympathetic nervous system [3]. Based on this, this study introduces two exercise intervention models to systematically observe the dynamic response characteristics of HRV parameters in obese male college students under different load intensities. The aim is to uncover the intrinsic mechanisms linking exercise intensity, autonomic nervous function regulation, and health promotion effects.

2.Experimental Subjects and Methods

2.1 Research Object

In this study, 40 obese male college students (BMI≥28) [average age=(19.25±0.94) years old] were divided into experimental group and control group, with 20 people in each group.

2.2 Training Equipment

The Self-generate Physiological Coherence System (SPCS) is developed by Beijing Haofeng Digital Technology Co., LTD. with the technology provided by Heart Math Institute in the United States.

2.3 Test Design

Grouping: HIIT (high intensity interval training) was used in the experimental group and MICT (moderate intensity continuous training) was used in the control group.

Time: The intervention period was 8 weeks, three times a week, each time for 50~60min. After each training, the relevant indicators of heart rate variability were monitored by SPCS system.

Monitoring indicators: SDNN (NN refers to the sinus interval), a higher SDNN value indicates greater heart rate variability; RMS-SD (the state of change between adjacent RR intervals), a higher RMS-SD value indicates stronger vagal tone; PNN50 (reflects vagal activity), a lower PNN50 value indicates weaker vagal function; LF/HF (the ratio of energy in the LF and HF bands), this ratio reflects the balance of sympathetic and parasympathetic tension; LFnorm (normalized LF band energy); HFnorm (normalized HF band energy) [4]. The experimental training program is shown in **Table 1**.

Table 1. Design of Training Program for Experimental Group and Control Group

The experiment was dry Pre-time	experimental group	control group
Monday	5min warm-up (jump jacks, jogging, jogging) 5min stretch (shoulder, hip, knee, ankle) Combination 1: Jump jacks (40 / 60) + crunches (20 / 30) + squats (15 / 25) + Kneeling push-ups (10 / 15) Combination 2: high knee lift (40/60) + supine hip thrust (15/25) + plank hold (45s) + jumping jacks (40/60) Combination 3: mountain climbing step (25/35) + inclined plate (45s) + inclined plate (45s) + burpee (10/17) 10 minutes to relax	5min warm-up (jump jacks, jogging, jogging) 35 minutes of aerobic endurance running Heart rate (140-160) 10 minutes to relax
Wednesday	5min warm-up (jump jacks, jogging, jogging) 5min stretch (shoulder, hip, knee, ankle) Combination 1: lunge jump (16/24) + Russian turn (40/60) + jumping jacks (40/60) + back stretch (15/26) Combination 2: high knee lift (40/50) + supine cross legs (10/15) + supine hip thrust (15/25) + burpee (10/15) Combination 3: running with back kicks (40/60) + supine wheel (20/30) + kneeling push-ups (10/15) + jumping (40/60 10 minutes to relax	5min warm-up (jump jacks, jogging, jogging) 35 minutes of aerobic endurance running Heart rate (140-160) 10 minutes to relax
Friday	5min warm-up (jump jacks, jogging, jogging) 5min stretch (shoulder, hip, knee, ankle) Combination 1: Jump jacks (40 / 60) + crunches (20 / 30) + squats (15 / 20) + leg raises (20 / 30) Combination 2: high knee lift (40/50) + back stretch (15/26) + plank (45s) + mountain step (20/30) Combination 3: burpee (10/15) + incline planks (45s) + incline planks (45s) + freestyle leg kick (40/60) 10min relaxation (neck, shoulders, waist, legs)	5min warm-up (jump jacks, jogging, jogging) 35 minutes of aerobic endurance running Heart rate (140-160) 10 minutes to relax

3.Results and Analysis

3.1 The Changing Trend of HRV Indexes During the Training Period of the Experimental Group

As can be seen from Table 2, the values of time domain indexes all increased, the heart rate variability and vagus nerve activity were enhanced in the experimental group; in the frequency domain indexes, the LF/HF value fluctuated; the LFnorm and HFnorm values decreased, and the sympathetic and parasympathetic nerve activity were reduced together in the experimental group.

Table 2. Test Results of the Experimental Group in 8 Weeks (M±SD)

Testing time	SDNN	RMS-SD	PNN50	LF/HF	LFnorm	HFnorm
week 1	91.79±34.09	75.92±50.07	32.51±18.91	11.34±9.92	76.28±21.85	22.48±21.99
week 2	93.65±34.14	78.54±50.38	34.84±18.88	11.37±10.16	75.55±20.70	21.93±20.98
week 3	96.31±34.97	81.76±50.75	37.28±18.81	11.39±10.31	74.72±20.33	21.39±20.21
week 4	98.54±35.32	84.98±50.93	39.70±18.92	11.45±11.14	74.02±19.37	20.78±19.57
week 5	101.02±36.12	87.72±51.27	42.27±18.91	11.40±11.58	73.21±19.12	20.51±19.31
week 6	103.54±36.79	91.05±51.22	44.41±18.46	11.59±12.40	72.61±19.02	18.84±17.68
week 7	106.21±36.75	94.12±51.31	47.03±18.42	11.37±13.10	72.25±18.98	19.35±18.71
week 8	109.44±37.35	97.43±51.76	49.49±18.24	11.27±13.91	71.17±19.34	18.35±18.87

3.2 Changes in HRV Indexes During Training in the Control Group

Table 3. Test Results of the Control Group in 8 Weeks (M±SD)

testing time	SDNN	RMS-SD	PNN50	LF/HF	LFnorm	HFnorm
week 1	142.43±49.83	133.64±43.39	69.57±27.61	13.15±13.54	90.80±33.15	19.04±20.42
week 2	133.94±46.57	117.21±40.57	58.21±24.96	9.84±10.96	77.67±29.02	12.83±13.83
week 3	133.22±47.86	120.29±41.45	63.07±26.80	11.41±12.72	80.94±33.23	14.61±15.44
week 4	132.74±47.01	113.60±42.04	57.27±24.95	9.19±11.88	75.10±33.09	12.38±12.80
week 5	131.72±46.30	121.74±41.66	61.54±25.94	10.55±13.18	82.49±35.45	14.36±16.16
week 6	133.20±46.21	125.76±42.36	62.94±26.20	11.66±14.73	85.62±39.72	16.15±19.83
week 7	131.44±45.38	120.37±41.19	59.62±26.71	10.90±13.34	81.91±39.13	13.32±16.90
week 8	131.31±46.99	121.82±43.30	58.09±24.38	10.80±12.91	82.65±38.64	15.58±17.53

As can be seen from Table 3, the time-domain index values decreased overall, but there were fluctuations in the values. The heart rate variability and vagus nerve activity of the control group decreased; in the frequency domain index, the LF/HF value fluctuated; the LFnorm and HFnorm values decreased, and the sympathetic and parasympathetic nerve activity of the experimental group decreased together.

3.3 Comparison of Heart Rate Variability Index Between Experimental Group and Control Group in the First 4 Weeks

Table 4. Comparison of Heart Rate Variability Index Between Experimental Group and Control Group in the First 4 Weeks

metric	t price	p price
SDNN	-35.08	0
RMS-SD	-22.46	0
PNN50	-20.42	0
LF/HF	0.54	0.59
LFnorm	-0.32	0.75
HFnorm	10.04	0

As shown in Table 3, at the initial stage of the intervention, there were highly significant differences between the experimental group and the control group in SDNN, RMS-SD, PNN50, and HFnorm. Notably, SDNN, RMS-SD, and PNN50 showed a significant improvement. This suggests that both high-intensity interval training and moderate-intensity continuous training had a more positive impact on heart rate variability in obese male college students during the early stages of training. The significant difference in SDNN may indicate that the regulatory effects of these two training methods on the autonomic nervous system began to diverge early on.

3.4 Comparison of Heart Rate Variability Index Between Experimental Group and Control Group After 4 Weeks

Table 5. Comparison of Heart Rate Variability Index Between Experimental Group and Control Group After 4 Weeks

metric	t price	p price
SDNN	-23.52	0
RMS-SD	-10.76	0
PNN50	-12.83	0
LF/HF	1.9	0.07
LFnorm	-10.16	0
HFnorm	9.47	0

In the final four weeks of the comparative analysis, except for LF/HF, all other heart rate variability indicators showed highly significant differences, with SDNN, RMS-SD, and PNN50 showing significant improvements. This further confirms that different training intensities have a lasting and varying impact on the heart rate variability of obese male college students. As training duration increases, these differences may either worsen or stabilize at a certain level.

3.5 Comparison of Heart Rate Variability Index in the First Four Weeks and the Last Four Weeks of the Experimental Group

By comparing the heart rate variability indicators of the experimental group over four weeks before and after the intervention, it was found that there were significant differences in SDNN, RMS-SD, PNN50, LFnorm, and HFnorm. Specifically, SDNN, RMS-SD, and PNN50 showed significant improvements, while LFnorm and HFnorm showed significant decreases. This indicates that during the 8-week experimental period, high-intensity interval training had a significant positive impact on time-domain indicators, leading to a notable increase in participants' heart rate variability. Therefore, it can be inferred that under the stimulation of high-intensity interval training, the autonomic nervous system regulation ability of obese male college students was significantly enhanced[5].

Table 6. Comparison of Heart Rate Variability Index in the First Four Weeks and the Last Four Weeks of the Experimental Group

metric	t price	p price
SDNN	-8.14	0
RMS-SD	-8.01	0
PNN50	-8.2	0
LF/HF	0.74	0.47
LFnorm	7.93	0
HFnorm	6.92	0

3.6 Comparison of Heart Rate Variability Index in the First and Last Four Weeks of The Control Group

Table 7. Comparison of Heart Rate Variability Index in the First Four Weeks and the Last Four Weeks of the Control Group

metric	t price	p price
SDNN	3.2	0
RMS-SD	-0.71	0.48
PNN50	1.55	0.14
LF/HF	0.52	0.61
LFnorm	-0.95	0.35
HFnorm	0.89	0.38

According to the data in the table, only the SDNN showed a significant decrease in the control group, while the other indicators did not show statistical significance. This suggests that during the 8-week experiment, moderate-intensity continuous training had no significant impact on these indicators. This may be due to the mild nature of the moderate-intensity continuous training, which led to a slower adaptation process for the body, or the low sensitivity of these indicators to such training.

4. Conclusions and Suggestions

4.1 Conclusion

Eight weeks of HIIT training positively influenced the heart rate variability and vagal activity in obese male college students. Compared to MICT training, HIIT was more effective in improving autonomic nervous regulation and provided better feedback early in exercise. Additionally, both HIIT and MICT showed a simultaneous decrease in sympathetic and parasympathetic nerve activity in frequency domain indicators, which may be due to individual adaptive adjustments resulting from long-term training. Future research should further refine analyses by examining different training durations and frequencies to identify the most suitable training regimen for obese individuals, thereby achieving optimal health outcomes.

4.2 Recommendations

Given the significant benefits of HIIT in improving heart rate variability (HRV) among obese male college students, it is recommended to incorporate this training into weight management and health promotion programs for obese individuals. Considering individual differences, a comprehensive health assessment should be conducted before starting HIIT to ensure the safety and effectiveness of the training. Additionally, future research could explore how different training durations and frequencies affect HRV in obese individuals, aiming to optimize training programs and enhance their effectiveness.

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