ORIGINAL RESEARCH

Using the Paired Sample *t* test to Analyze the Effect of Jogging on the Cardiovascular Function of College Students

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ABSTRACT

Background • In China, there have been instances of sudden cardiac death among university students, with a significant number of students being at risk of cardiovascular diseases. This risk is often attributed to sub-health conditions such as weight gain and obesity, which are triggered by sedentary lifestyles, irregular living habits, and unregulated diets. Therefore, it is crucial to enhance the guidance for participation in physical activities, encouraging students to actively reduce their risk of cardiovascular diseases (CVD). Jogging, characterized by its convenience, simplicity, and low-risk participation, has been widely accepted by university students. This study takes the impact of jogging on the cardiovascular function of university students as a starting point. It aims to explore the content of the changing process suitable for the development of cardiovascular function in university students. The ultimate goal is to promote the healthy development of the cardiovascular system function in university students and improve their adherence to physical activities.

Methods • The study recruited 60 university students with no exercise habits through on-campus poster advertisements. These 60 participants were randomly divided into two groups. The students in the experimental group were required to jog no less than three times a week, with each session lasting at least 30 minutes. The organizers of the experiment would remind the students daily in a WeChat group to complete their weekly exercise plan and persist in jogging, promoting the benefits of this activity. During jogging, the students used the Keep mobile application to record their jogging time and heart rate, which they then uploaded to the WeChat group. Follow-ups were conducted with students who did not complete their exercise plan, providing encouragement and guidance to continue participating in the experiment. The study employed a comparative research approach between the experimental group and the control group.

Results • According to the experimental protocol, after 12 weeks of jogging intervention, the cardiovascular health indicators of both male and female students in the experimental group showed positive changes. Measurements of cardiac function indicators in the experimental group of boys SPTI, DPTI, ED has decreased, SEVR has increased, the relevant indicators compared with the relevant indicators of the control group ($P < .05$) is significant; in the experimental group of girls, SPTI, DPTI, SEVR indicators decreased, ED increased, and compared with the relevant indicators of the control group ($P < .01$) has a very significant significance. Changes in vascular indicators in the experimental and control groups after the experiment, SBP, DBP, PP, CAP decreased in the experimental group, and DBP, CAP in the male and female groups were found to be ($P < .01$), with highly significant changes; while SBP, PP intergroup comparison ($P < .05$), with significant changes.

Conclusion • Jogging is a good aerobic exercise program characterized by convenient ways of carrying out simple methods and low risk of participation. The benefits of jogging are not only reflected physiologically but also psychologically; it can make participants enhance their self-confidence and make their moods more pleasant. It can also improve sleep quality and maintain a good mental state. Long-term jogging habits can effectively improve endothelial function and heart contraction function, reduce blood pressure effectively prevent atherosclerosis and prevent CVD by reducing the incidence of CVD risk factors. (*Altern Ther Health Med.* [E-pub ahead of print.])

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INTRODUCTION

Several studies pointed out cardiovascular disease is the disease with the highest fatality rate in the world.[1] Cardiovascular disease (CVD) is a major health threat to humanity, imposing a significant burden on medical and socio-economic resources. The cardiovascular system is responsible for delivering oxygen and nutrients to various parts of the body. By regulating vasoconstriction and vasodilation, it maintains normal blood pressure levels. The circulatory system removes waste and metabolic products from tissues and organs, transporting them to organs such as the lungs and kidneys for excretion. A healthy cardiovascular system is crucial for normal immune function, delivering immune cells and antibodies to areas where they are needed to fend off infections and disease invasions. Good cardiovascular health can enhance physical strength and endurance, enabling you to better cope with various physical activities. By maintaining the health of the cardiovascular system, the risk of cardiovascular diseases such as coronary heart disease, hypertension, and stroke can be prevented and reduced.so paying attention to cardiovascular health is very meaningful.

Previous studies have confirmed that aerobic exercise can improve cardiovascular health, including aerobic capacity, cardiac function, and vascular endothelial function.[2-4] Jogging is a good aerobic exercise program, which has the characteristics of a convenient way, simple method, and low participation risk; the benefits of jogging are not only the physically, but also psychological.[5,6] When the human body jogs under conditions of sufficient oxygen supply, the circulatory system can increase blood flow by enhancing the degree of microvascular opening and improving vasodilation capacity, thereby improving the function of tissues, organs, and vascular endothelium. Jogging can improve cardiovascular function by promoting cellular glucose metabolism, inhibiting oxidative stress, and reducing myocardial ischemia/reperfusion-induced myocardial cell apoptosis, thereby decreasing the degree of myocardial ischemia/reperfusion injury. During jogging, the body releases endorphins, which are natural stress-relievers that can improve mood and alleviate anxiety and stress. Jogging can trigger the release of dopamine and serotonin in the body, chemicals that can elevate mood, making the jogger feel joyful and happy. Each jogging session serves as a validation and breakthrough of one's capabilities, gradually cultivating resilience, self-confidence, and belief in one's ability to overcome difficulties and achieve success. Jogging is not only a physical exercise but also a dialogue with oneself. It can alleviate stress, improve mood, and enhance self-confidence and self-esteem and it can enhance self-confidence of the participants and make the mood more Pleasure, can also improve the quality of sleep, maintain a good mental situation and so on.[7]

The rapid changes in today's society have significantly altered people's lifestyles and accelerated the pace of life, leading to a severe lack of physical exercise. This has resulted in a substantial decline in physical fitness and an annual increase in the number of people with chronic diseases such as obesity and cardiovascular diseases. From 1990 to 2019, the total incidence of global CVD has grown from 271 million cases to 523 million cases, nearly doubling in 30 years. The number of deaths from CVD has steadily increased from 12.1 million to 18.6 million (over 9.6 million men and more than 8.9 million women), accounting for about one-third of the total global deaths.[8] University students, as the future of the nation and society, are the fresh blood for national development. Their health should receive widespread attention at all levels. Good health is the most basic condition for maintaining a healthy life. The health of university students is the material basis for national construction and social development, and it is a valuable wealth of the nation. If a country wants to stand out in future world competition, it must improve the physical health of university students as a whole. This study takes the impact of jogging on the cardiovascular function of university students as a starting point. It aims to explore the content of the changing process suitable for the development of cardiovascular function in university students. The ultimate goal is to promote the healthy development of the cardiovascular system function in university students and improve their adherence to physical activities, providing a reference for research on the cardiovascular system.

Table 1. Experimental grouping

Group	Number of people	Exercise	Frequency/duration
experimental group	30 (Male 15 Female 15)	jogging	≥3; 30mins
control group	30 (Male 15 Female 15)	none	none

Table 2. Test the indicators

Indicators	Measurement content			
Heart function	SPTI	MPI	SEVR	ED
Vascular status	SBP	DBP	PP	CAP

Note: Left Heart Load Index (SPTI), Myocardial.

METHODS

Participants

Through poster advertisements within Chizhou university, 60 university students with no exercise habits (no jogging experience or other sports experience) were recruited, including 30 males and 30 females. Participants were interviewed to determine those who met the inclusion criteria for the experiment. The recruitment criteria were as follows: physical activity frequency of less than three times per week, each physical activity session lasting less than 30 minutes, and each physical activity session being less than 3 METs. The experimental subjects were randomly divided into an experimental group of 30 (15 males, 15 females) and a control group of 30 (15 males, 15 females).

Experiment procedures

The experiment was conducted from March 2022 to June 2022 at Chi Zhou University outdoor field. Recruit suitable subjects, then pull the selected experimental personnel into a group, and publish the experimental process during the entire experimental process; the experimental instruments involved in this study are a standard height and weight measuring instrument, cardiovascular function detector (model BX-CFTI-100), all participants in the experiment to collect various index data, cardiovascular function detector measurement site for the wrist radial artery, for the insurance of the accuracy of the test results, all subjects are required not to have strenuous exercise behavior before the test, requiring lying still for a few minutes to rest and maintain even breathing. The detection indicators are shown in Table 2.

In this study, the experimental group and the control group were compared before and after testing. The cardiovascular function of the experimental group and the control group was measured at T1 before the experiment and at T2 after 12 weeks.

The study was conducted with university students who were recruited from Chizhou university and had no exercise habits. They participated voluntarily and signed informed consent forms. The participants in the experimental group were required to jog at least three times a week, with each session lasting more than 30 minutes. The control group consisted of 30 university students, 15 males and 15 females, who maintained their normal lifestyle patterns without regular exercise that could interfere with cardiovascular function. Before the experiment (September 4, 2022 - September 25, 2022): Suitable participants were recruited from Chizhou university from

September 4 to September 10. A total of 71 suitable participants were recruited, and 60 participants who met the inclusion criteria were added to a WeChat group. The entire experimental process was published in the group, and the 60 participants were divided into two groups: the experimental group and the control group. From September 11 to September 17, pre-experiment data measurements of the cardiovascular function of the university students were conducted, serving as the initial data (T1) for the experiment. During the experiment (September 18, 2022 - December 10, 2022): The experimental period lasted twelve weeks. Cardiovascular function tests and data recording were conducted for both groups one week before the start of the experiment and after twelve weeks. The university students in the experimental group were required to jog at least three times a week, each time for no less than 30 minutes. The organizers would remind the students daily in the WeChat group to complete their weekly exercise plan. The students recorded their jogging time and heart rate using the Keep mobile app during jogging and uploaded it to the WeChat group for recording. Follow-ups were conducted with students who did not complete their exercise plan, encouraging them to continue participating in the experiment. No jogging records were kept for the control group. For participants with low compliance who might drop out of the experiment, the organizers would conduct follow-up visits and provide verbal encouragement to enhance self-efficacy among the participants. After the experiment (December 11, 2022 - December 17, 2022): Within one week after the end of the experiment, data collection on cardiovascular function was completed for both the experimental group and control group.

Cardiovascular-related index data of the experimental group and the control group were collected at two time points before and after the experiment. They included myocardial perfusion index (DPTI), left cardiac load index (SPTI), subendocardial myocardial activity rate (SEVR), ejection time (ED), and vascular status: systolic blood pressure (SBP), diastolic blood pressure (DBP), pulse pressure difference (PP), and central arterial pressure (CAP). There is no subjective or self-report, and all data is derived from the "cardiovascular function test". In addition, the measurement of carpal radial artery is convenient and non-invasive, and the evaluation of cardiovascular function is simple and rapid. The carpal and radial pulse wave is the trajectory of the arterial vessel fluctuation accompanied by the periodic contraction of the heart, which integrates the pumping activity of the heart and the information carried by the pressure wave along the artery tree. Arterial elastic function was evaluated by recording the pulse wave shape and extracting its characteristic information, such as shape, period, amplitude and velocity.

RESULTS

The comparison of statistics between the experimental group and the control group before the experiment

From Table 3 and Table 4, it can be seen that the basic conditions of subjects in the experimental group and the control group, age, height, weight, and heart rate index comparison $P > .05$, there is no significant difference, indicating that the basic conditions of the experimental participants are roughly the same.

Table 3. Statistics of the basic situation (male)

Group	Subjects	Age	Height (cm)	Weight (kg)	Resting heart rate (beats/ min)	*P* value
test group	15	21.5±1.5	170.6±5.2	59.8±7.5	67.9±6.7	>.05
control group	15	21.5±1.6	169.7±5.2	58.8±7.2	68.7±6.8	>.05

Table 4. Statistics of the basic situation (female)

Group	Subjects	Age	Height (cm)	Weight (kg)	Resting heart rate (beats/min)	*P* value
test group	15	21.1±1.7	163.7±4.2	50.2±7.2	76.2±7.1	>.05
control group	15	21.2±1.6	164.5±4.6	51.1±5.9	75.3±6.7	>.05

Table 5. Comparison of cardiac function in two groups before the experimental procedure

Index	Jogging group male	Jogging group female	Control group male	Control group female
SPTI	2589.8±444.9	2597.3±398.9	2633.2±419.9	2604.9±454.2
MPI	3048.5±319.9	3131.2±465.6	2867.5±353.9	2840.2±344.3
SEVR	1.21±0.207	1.23±0.231	1.11±0.173	1.16±0.147
ED	0.4±0.043	0.40±0.041	0.42±0.029	0.431±0.031

Table 6. Comparison of the vascular status between the control group and the experimental group before the experimental procedure

Index	Jogging group male	Jogging group female	Control group male	Control group female
SBP	124.47±11.673	121.75±12.578	122.77±9.444	122.53±15.670
DBP	74.95±8.462	72.90±9.290	78.31±8.380	77.87±9.970
PP	49.53±9.094	48.85±8.299	4.46±7.446	44.67±9.302
CAP	111.00±15.944	16.90±15.124	112.31±8.004	111.67±19.981

Comparison of various indexes between the control group and the experimental group before the experimental procedure

In order to ensure the preciseness, reliability, and authenticity of the results of the exercise intervention experiment, all the experimental participants in the 2 groups were tested for various indicators of cardiac function and vascular status before the experiment. According to the analysis results from Table 5 and Table 6, we can observe that there is no obvious difference between the indicators of the two groups ($P > .05$), which meets the experimental requirements. The comparison of various indexes before the experiment aims to provide a comparative benchmark for the post-test at the end of the experiment to explain the effect of the change after the experiment.

Comparison of cardiac function indicators of the control group and the experimental group after the experimental procedure

We can observe from Table 7 and Table 8 that the measurement indicators of cardiac function in the experimental group are compared to those in the control group, and the four indicators of cardiac function in the jogging exercise intervention group carried out in the experimental group have changed, while the control group has changed but not significant. Among the four indicators in the experimental group, the SPTI, MPI, and ED of the boys in the experimental group decreased, and the SEVR increased. Compared with the related indicators of the

Table 7. Comparison of cardiac function among male university students in experimental group and control group

Measurement standard	Jogging group male	Control group male	*P* value
Before SPTI experiment	2589.79±444.872	2633.2±419.9	<.05
After SPTI experiment	2339.11±228.745	2756.3±420.5	
Before DRTI experiment	3048.47±319.878	2855.8±359.4	<.05
After MPI experiment	3013.21±355.693	2867.5±353.9	
Before SEVR experiment	1.21±0.207	1.12±0.175	<.05
After SEVR experiment	1.31±0.179	1.11±0.173	
Before EP experiment	0.40±0.043	0.42±0.028	<.05
After EP experiment	0.39±0.031	0.42±0.029	

Table 8. Comparison of cardiac function of female university students in experimental group and control group

Measurement standard	Jogging group female	Control group female	*P* value
Before SPTI experiment	2597.30±398.985	2604.9±454.2	<.01
After SPTI experiment	2553.95±414.386	2607.5±456.1	
Before DRTI experiment	3131.20±465.611	2841.1±345.5	<.01
After MPI experiment	2870.85±407.636	2840.2±344.3	
Before SEVR experiment	1.23±0.231	1.16±0.147	<.01
After SEVR experiment	1.15±0.207	1.15±0.154	
Before EP experiment	0.040±0.041	0.431±0.031	<.01
After EP experiment	0.41±0.039	0.440±0.032	

Table 9. Comparison of the vascular status of female university students in the experimental group and the control group

Measurement standard	Jogging group female	Control group female	*P* value
Before SBP experiment	121.75±12.578	121.77±9.454	<.05
After SBP experiment	116.80±10.436	122.65±9.175	
Before DBP experiment	72.90 ±9.290	73.11±8.380	>.01
After DBP experiment	72.65±9.290	73.26±8.752	
Before PP experiment	48.85±8.299	48.96±7.446	<.05
After PP experiment	44.15±5.887	48.541±7.346	
Before CAP experiment	116.90±15.124	115.31±8.004	<.01
After CAP experiment	109.00±13.055	115.14±7.829	

control group ($P < .05$), the related indicators had significant significance. The indexes all increased or decreased obviously, among which SPTI, MPI, SEVR decreased, and ED increased, which was very significant compared with the related indexes of the control group ($P < .01$).

Comparison of two sets of vascular status indexes after the experiment

From Table 9, it can be seen that the changes in vascular indexes in the experimental group and the control group after the 12-week experiment, the SBP, DBP, PP, and CAP of the experimental group all decreased. There are very significant changes; while the comparison between SBP and PP groups ($P < .05$), there are significant changes.

DISCUSSION

The effect of jogging intervention on the exercise heart function of university students

Jogging establishes a connection with the heart because it promotes positive adaptations in the morphology, function, and regulatory capacity of the human cardiovascular system. Regular jogging can stimulate blood circulation and accelerate metabolism, thereby reducing cardiac load. Jogging can enhance the contractility of the heart, promote the contraction and relaxation of the myocardium, improve the pumping ability of the heart, and enhance the blood circulation function of the heart. Jogging can also promote an increase in cardiac blood supply, accelerate blood circulation speed, improve the quality and efficiency of cardiac blood supply, thereby reducing the risk of cardiac ischemia.

After the increase in exercise, the cardiac load was reduced, the myocardial contractility of university students was improved, and the blood circulation in the cardiovascular system was effectively promoted. After the jogging intervention experiment, the experiment The group's indicators excels more than those of the control group. The subjects in the experiment were mainly university students, and the myocardial contractility decreased with the deterioration of physical function. Studies have shown that exercise intervention has great benefits on the heart and coronary vascular system, as myocardial oxygen demand, endothelial function, coronary collateral vessels, etc.[9-11]; regular physical activity of university students can lead to the reduction of the risk of cardiovascular diseases. It can effectively improve endothelial function; physical exercise can improve cardiac indicators such as myocardial contractility and heart rate. It also helps reduce myocardial oxygen consumption and boosts oxygen, blood circulation, reserve heart rate, and heart pumping capacity in the body. The research results show that jogging exercise intervention can reduce SPTI, MPI, ED indicators, improve SFVR indicators, and improve university students' cardiac pumping ability. The experimental group is mainly based on aerobic jogging, which can improve heart rate variability, promote autonomic regulation of the heart and reduce resting heart rate; the increase in exercise after jogging exercise intervention can improve the ED of university students so that the heart can pump sufficient blood; experimental subjects According to the recommended exercise plan, the increase in the amount of exercise will reduce the resistance of the left ventricle during systole, thereby increasing the resistance of the other side of the heart ventricular systole, reducing the left heart load index and increasing the myocardial perfusion index. It can be seen that the female experimental group has a very significant difference in ED, SPTI, SEVE, and MPI compared with the female control group after the increased exercise, and the health benefits are outstanding. The comparison of various indicators of cardiac function in the control group before and after the experiment was not statistically important, which was related to the lifestyle and exercise of the control group. Aerobic jogging can effectively reduce HR, control BP, enhance heart pumping volume and heart rate reserve function, etc.[12-14]; Previous studies have pointed out that aerobic exercise can reduce HR, DBP, SBP indicators, improve Indicators of ED and MPI.[15] Therefore, jogging intervention has good health benefits on increasing the amount of exercise and ing university students' cardiovascular indicators. The control and experimental groups had different lifestyles during the trial period but produced high short-term health gains.From the comparison before and after the experiment, it can be seen that self-efficacy should be improved to improve cardiovascular function, and good exercise habits should be developed.

The effect of jogging intervention on the vascular function of university students

Jogging can lower blood pressure and improve vascular elasticity, promoting blood circulation, clearing blood vessels, and having a preventive and therapeutic effect on atherosclerosis. This helps to improve vascular function. Jogging can enhance the contractility and diastolic capacity of the heart, making the heart more flexible. It can lower blood pressure, central arterial pressure (CAP), and pulse pressure difference, preventing diseases such as arteriosclerosis. Jogging can increase the contractility and diastolic capacity of the myocardium, improving the ability to supply blood to the myocardium, thereby increasing blood circulation.[16-18] This study shows that the vascular indexes of the experimental subjects in the experimental group have been well improved, and the vascular function of university students has been improved. Jogging intervention can effectively increase the amount of exercise. Adhering to the exercise plan recommended by the experiment can improve the indicators of SBP, DBP, CAP, and PP, and reduce the risk of cardiovascular disease. The comparison statistics of the two groups before and after the experiment showed that DBP and CAP decreased, and there were very significant changes, while the comparison between the SBP and PP groups ($P < .05$) . The decrease of SBP is related to the heart pumping volume, heart rate, and other indicators. During the exercise, the muscle blood vessels extend outward, increasing the capillaries, promoting blood circulation and metabolic function, and reducing peripheral vascular resistance.[19] The improvement of SBP is the effect of the effect of increasing the amount of exercise on vascular endothelial remodeling, vasodilation, and the like. Protogerou et al pointed out that regular exercise can improve the pulse pressure difference.[20-23] CAP is a risk factor for cardiovascular disease. FERREIRA et al pointed out that regular aerobic exercise can improve peripheral blood pressure and CAP, and CAP reduces the load on the heart.

This study shows that regular weekly jogging interventions increase the amount of exercise for university students and effectively improve various vascular indicators. Among them, systolic blood pressure, diastolic blood pressure, central arterial pressure, and pulse pressure difference have all decreased. There are very significant differences in systolic blood pressure, diastolic blood pressure, and central arterial pressure before and after the experiment in the experimental group. The pulse pressure difference is significantly different. Therefore, long-term regular aerobic exercise can greatly improve vascular function and vascular elasticity. The 12-week regular jogging intervention enhances muscle metabolism, dichloroacetate activity, antioxidant capacity, and endothelial function of blood vessels to achieve the effect of reducing blood pressure and reducing cardiac load. The university student group has high compliance and plenty of free time. The entire process of the experiment is complete, and the results after the experiment are very ideal. Panzarino et al[24,25] pointed out that the indicators before and after the experiment showed that endothelial-independent vasodilation was improved through exercise intervention. It can be seen from this study that the vascular function of the experimental group has been significantly improved after the experimental intervention, and there is no significant difference in the indicators of vascular function in the control group.

CONCLUSION

A 12-week jogging regimen significantly improves vascular indicators, including systolic and diastolic blood pressure, and central arterial pressure. It enhances vascular function and elasticity, reduces cardiac load, and boosts myocardial contractility.

Cardiovascular disease (CVD) is a concern for many university students in China, particularly those with sedentary lifestyles and sub-health conditions like hypertension.Regular physical examinations and increased sports training can help mitigate these risks.

The study focused on university students without exercise habits.The results showed significant cardiovascular improvements, suggesting that long-term regular exercise can effectively prevent CVD.

Future interventions should aim to increase students'awareness of exercise and encourage active participation in jogging to prevent cardiovascular diseases.

CONFLICT OF INTERESTS

The authors announce that they're objective in the paper and that no competing financial interests or personal relationships could influence this thesis.

DATA AVAILABILITY STATEMENT

The statistics used to support the findings of this research are available from the corresponding author upon request.

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