Study on the effect of ketogenic diet combined with aerobic exercise on body posture, cardiopulmonary function and blood glucose of female college students

Jiacheng Feng[1,a],Qimeng Niu[1,b*]

[1]Physical Education Department, Tianjin University of Technology Tianjin, China

Abstract. Study jects: 30 ordinary female college students who had no professional sports training; Study method: subjects had a ketogenic diet for 30 days and completed a daily exercise program as required. Measurement indicators: measured before and after the experiment 1. Body weight, 2. subcutaneous fat and muscle thickness in the anterior and posterior segments of the upper arm, 3. muscle condition in the anterior and posterior femoral region, 4. Maximum oxygen intake, 5. maximum heart rate, 6. blood glucose and blood β ketone. The results showed that: 1. The aerobic training in the experimental and control groups decreased in the mean sebum thickness in each group.2 The mean maximum oxygen intake improved in both groups and one-sided T test showed significant differences in the experimental groups.3 Mean heart rate and weight decreased in the control group, while the mean heart rate increased more weight, with the one-sided T test for maximal heart rate significantly significantly in the experimental group significantly significantly.4. Through the design of aerobic training, the maximum oxygen content in the experimental group increased significantly.we can draw the following conclusions: 1. Certain intensity, time and regular aerobic training have certain effect on weight loss in non-experimental state and experimental state, which can effectively reduce the fat content of all parts of female college students and improve the quality of lean body; 2. certain intensity aerobic exercise based on ketogenic diet will make female college students have better slimming effect, and this mode will not cause adverse effects on the body within a certain range.

1. Introduction

Obesity in adolescents has become one of the important problems in today's society. If a person consumes more energy than the body consumes, then the excess energy may be stored in the form of fat, so over time, the person's weight may exceed the normal weight standard. A person over 10% of standard body weight is called overweight; 20% of standard body weight; moderate obesity over 30% of standard body weight; and 50% of standard body weight is called severe obesity[1].

If we analyze the weight loss process of exercise from the perspective of energy metabolism, then aerobic exercise is crucial. Aerobic exercise is the exercise in which the body metabolizes sugar and fat as energy supplies when the absorbed oxygen meets the body's oxygen needs[2].However, only through aerobic exercise to achieve the purpose of weight loss is relatively slow. In today's fast-paced life, we need to explore a diet that can be matched with aerobic exercise to complete rapid weight loss.

Therefore, in this paper, we studied the change of body composition and maximum oxygen intake and maximum heart rate of the experimental group composed of the ketogenic diet and the control group that had to synchronize the aerobic diet, and concluded whether the ketogenic diet and aerobic exercise can quickly lose weight.

2. Subjects and methods

2.1 Subjects

In this paper, 30 female college students with professional sports training were randomly divided into experimental group and control group by lottery. Subjects undergo moderate intensity aerobic training from 6:30 to Friday: 7:30. Each student was in good health, and before the experiment, subjects must sign a voluntary participation agreement and be informed about the purpose of the study, the methodology, and the experimental test procedure. During the whole study period, subjects in the control group participated in planned aerobic training to maintain daily physical activity patterns and daily eating habits; subjects in the experimental group participated in planned

[a] herbertfeng@163.com
[*b] Corresponding author: Qimengniu@163.com

aerobic training after 6:30 PM every day to maintain regular physical activity pattern and ketogenic diet (high fat, low carbohydrate and moderate protein diet)[3].

2.2 Measuring projects and methods

Measuring projects: weight; subcutaneous fat and muscle thickness of the anterior part and posterior part of the upper arm, the abdomen, regio femoral anterior and regio cruris posterior; the maximum oxygen absorbed and the maximum heart rate. Weight was measured using a weight meter. Subcutaneous fat and muscle thickness were determined using DW360B supersonic diagnostic set from Xuzhou Dawei (probe model: 7.5MHz), with exact accuracy of 1mm.

Subcutaneous fat was measured standing at anatomical position, measuring parts:

the thickest part of the biceps at the anterior part of forearm; the connecting center of LShoulder acromion and head of radius at the posterior part of forearm, namely triceps muscle belly; 1 cm next to the umbilical of the right abdomen; the connecting center of superior edge of patella and hip anterior superior iliac spine at regio femoral anterior, the thickest part of gastrocnemius at regio cruris posterior. Muscles of habitual hands were measured[4].

At the same time, the 30 students participating in the experiment were also conducted two blood tests, using OMRON's HEA-216NC and blood glucose and blood beta-ketone tester. The first blood test was conducted the day before the experiment, and the second blood test was conducted 14 hours after fasting in the experimental group. Blood routine, blood glucose and blood ketone of the adopted blood were tested and compared, analyzing whether there were abnormal situations for students participating in the experiment after fasting.

2.3 Methods

2.3.1Maximum oxygen absorbed and maximum heart rate tests

Maximum oxygen absorbed and maximum heart rate tests were fulfilled through WHO test procedure using Swedish MONARK Ergomedic 839E power bike and telemetry chest to monitor the heart rate.

In the test, in order to verify that the subjects have reached their maximum oxygen absorbed, they should meet the following two reference standards:

1) Heart rate per minute was greater than or equal to 180 times;

2) The subject could not maintain the predetermined exercise load intensity even she had tried her best.

2.3.2 Sports training

Before aerobic training two groups of subjects wore POLAR heart rate monitor and its monitoring watch, monitored to reach the heart rate of 70% of the average maximum heart rate. To warm up, subjects engaged in high-intensity jogging for 20 minutes, carried on online video teaching aerobic fighting exercises for half an hour, in the last ten minutes they jogged to relax, monitored heart rate of 130 times per minute in the process.

3. Results

3.1 Results of blood test

Table 1 shows the comparison of the blood test results of the 15 students in the experimental group before and after the experiment, and Table 2 shows the comparison of the blood test data in the control group. By comparison, we can see that the results of the blood test in the control group were not significantly different from before, and the values were within the normal range, and the blood ketone test was in the normal range; after 14 hours of the experiment, the white blood cell count, the neutrophil ratio, the red blood cell count, the hemoglobin and the platelet count of the experimental group decreased significantly, but all the results were within the normal range, indicating that the body function was not greatly affected, and the aerobic exercise was safe and reliable.

Table1. Comparison of the mean blood tests before and after 14 hours in the experimental group

	Unit	Number（n）	Experimental group (previously)	Experimental group (after)	Normal value
white blood cell count（WBC）	10-9/L	15	5.78±1.04	5.95±1.16	3.5-9.5
Neutrophil ratio （NEU%）	%	15	50.83±1.04	52.16±0.91	40-75
Red blood cell （RBC）	10-12/L	15	4.21±0.27	4.26±0.18	3.8-5.1
Hemoglobin （HGB）	g/L	15	127.47±6.06	130.34±9.09	115-150
Platelet（PLT）	10-9/L	15	264.27± 59.22	242.34±56.06	125-350
Blood glucose （GLU）	Mmol/L	15	5.58±0.53	4.73±0.46	3.9-7.0
Blood ketone bodies	μ mol/L	15	31.1±3.14	58.7±21.55.	26-122

Table2. Comparison of the mean blood test in the control group

	Unit	Number（n）	Experimental group (previously)	Experimental group (after)	Normal value
white blood cell count（WBC）	10-9/L	15	5.64±1.78	5.58±1.69	3.5-9.5
Neutrophil ratio （NEU%）	%	15	48.85±1.12	42.34±1.01	40-75
Red blood cell （RBC）	10-12/L	15	3.54±0.24	4.35±0.27	3.8-5.1
Hemoglobin（HGB）	g/L	15	121.31±7.47	131.03±8.91	115-150
Platelet（PLT）	10-9/L	15	248.67±59.81	273.24±59.96	125-350
Blood glucose （GLU）	Mmol/L	15	5.86±0.68	5.44±0.86	3.9-7.0
Blood ketone bodies	μ mol/L	15	33.34±5.34	36.17±4.17	26-122

3.2 Physiological outcome analysis

As can be seen from Table 3, the average thickness of biceps sebum in both the control and experimental group decreased, and the average thickness of non-experiment decreased from 6.60mm to 4.60mm after the test by 2mm; from 5.50mm to 4.50mm after the experiment. However, the main table of the paired sample T-test showed no significant difference between the control and experimental groups before and after the experiment.

Table 3. Paired sample T test of biceps muscle sebum thickness

	Paired difference mean	Paired difference standard deviation	t	Sig. (bilateral)
control group	2.000	2.121	2.108	.103
experimental group	1.000	1.224	1.826	.142

As can be seen from Table 4, the average thickness of biceps in the control and experimental groups increased, and the average thickness of non-experiments increased from 24.00mm before test to 25.20mm by 1.2mm; the average thickness of the experimental group increased from 25.50mm before experiment to 26.00mm by 0.5mm. However, the main table of the paired sample T-test showed no significant difference between the control and experimental groups before and after the experiment.

Table 4. Paired sample T test of biceps muscle thickness

	Paired difference mean	Paired difference standard deviation	t	Sig. (bilateral)
control group	-1.200	2.387	-1.124	.324
experimental group	-.500	2.692	-.415	.699

As can be seen from Table 5, the average thickness of triceps sebum decreased in both the control group and the experiment group, and the average thickness of non-experiment decreased from 15.40mm before the test to 10.40mm after the test by 5mm; the average thickness decreased 2.75mm from 12.75mm before the experiment to 10.00mm by 2.75 mm. Furthermore, the main table of the paired sample T-test showed significant differences between the control and experimental groups before and after the experiment.

Table 5. Paired sample T test of triceps muscle sebum thickness

	The mean difference in pairs	Paired difference standard deviation	t	Sig. (bilateral)
control group	5.000	1.871	5.976	.004
experimental group	2.750	.433	14.201	.000

From Table 6, we can find that the average thickness of triceps in the control group increased before and after the test, from the 18.00mm to the 18.20mm to increase by 0.2mm; however, the average thickness of the experimental group decreased from the 22.00mm to the 21.00mm by 1.0mm. However, the main table of the paired sample T-test showed no significant difference between the control and experimental groups before and after the experiment.

Table 6. Paired sample T test of triceps muscle thickness

	The mean difference in pairs	Paired difference standard deviation	t	Sig. (bilateral)
control group	-.200	2.588	-.173	.871

It can be concluded from Table 7 that the average thickness of abdominal sebum in both the control group and the experimental group decreased before and after testing, and the average thickness of non-experiments decreased from 32.60mm before testing to 30.40mm by 2.20mm; the experimental group decreased by 1.50mm from 29.50mm before testing to 28.0mm. However, the main table of the paired sample T-test showed no significant difference between the control and experimental groups before and after the experiment.

Table 7. Paired sample T test of abdominal sebum thickness

	The mean difference in pairs	Paired difference standard deviation	t	Sig. (bilateral)
control group	2.200	6.221	.791	.473
experimental group	1.500	3.500	.958	.392

As can be seen in Table 8, the average thickness of the control group and the experiment group increased and the average thickness of non-experiment increased from 10.20mm before the trial to 10.60mm by 0.40mm; the average thickness increased by 0.25mm from 10.00mm before the experiment to 10.25mm by 0.25 mm. However, the main table of the paired sample T-test showed no significant difference between the control and experimental groups before and after the experiment.

Table 8 .Paired sample T test of abdominal muscle thickness

	The mean difference in pairs	Paired difference standard deviation	t	Sig. (bilateral)
control group	-.400	2.074	-.431	.688
experimental group	-.250	1.090	-.513	.635

Table 9 shows that the mean thickness of femfat in both the control and experimental groups decreased before and after the non-experiment decreased from pre-14.80mm to 13.20mm by 1.60mm; the experimental group decreased by 0.50mm from pre-10.50mm to post-10.00mm. However, the mean thickness in the control group was significantly different before and after the experiment.

Table 9. Paired sample T test of femoral sebum thickness

	The mean difference in pairs	Paired difference standard deviation	t	Sig. (bilateral)
control group	1.600	.894	4.000	.016
experimental group	.500	1.118	1.000	.374

In Table 10, we can find that the mean femoral thickness in both the control and experimental groups increased; the mean non-experimental thickness increased from 52.20mm before to 57.00mm by 4.80mm; the mean thickness increased by 3.75mm from 59.00mm before to 62.75mm. However, the control and experimental groups varied significantly before and after the experiment.

Table 10. Paired sample T test of femoral muscle thickness

	The mean difference in pairs	Paired difference standard deviation	t	Sig. (bilateral)
control group	-4.800	4.147	-2.588	.061
experimental group	-3.750	3.112	-2.694	.054

Table Table 11 shows that the average calf sebum thickness in both the control and experimental groups decreased before and after the trial, and the non-experimental average thickness decreased from the pre-trial 12.40mm to 10. At 60mm, the amplitude decreased by 1.80mm; the average thickness decreased from 8.75mm before to 5.50mm, or 3.25mm. Furthermore, the main table of the paired sample T-test showed no significant differences between the control groups before and after the experiment, but not between the experimental groups.

Table 11 . Paired sample T test of crural sebum thickness

	The mean difference in pairs	Paired difference standard deviation	t	Sig. (bilateral)
control group	1.800	4.438	.907	.416
experimental group	3.250	1.299	5.594	.005

As can be seen from Table 12, the average thickness of calf muscle in the control group increased before and after the test, from 62.60mm before the test to 63.60mm after the test by 1.00mm; no significant change in the average thickness in the fasting group. Furthermore, the main table of the paired sample T-test showed no significant difference between the control and experimental groups before and after the experiment.

Table 12 . Paired sample T test of crural muscle thickness

	The mean difference in pairs	Paired difference standard deviation	t	Sig. (bilateral)
control group	-1.000	8.246	-.271	.800
experimental group	.000	6.745	.000	1.000

The mean weight of the control group decreased before and after the test, from 59.80kg before the test to 59.46kg by 0.34kg; the mean weight decreased by 0.83kg from 59.73kg to 58.90kg after the experiment. The mean maximum heart rate in the control group decreased before and after the test, from 192.60 beats / min before the trial to 189.40 beats / min by 3.2 beats / min; the mean maximum heart rate in the experimental group increased from 182 beats / min before the experiment to 184 beats / min, or 2 beats / min. The main table of the paired sample T-test showed no significant difference between the control and experimental groups before and after the experiment, but the one-sided test showed that the mean maximum heart rate was significantly different before and after the experiment. The mean maximum oxygen intake in both the control and experimental groups increased before and after the test, and the mean maximum oxygen intake increased from 49.88ml/kg min-1 to 50.88ml/kg min-2 to 1.00 ml/kg min-1; it increased from 44.56ml/kg min-1 to 53.52ml/kg min-1 by 8.96 ml/kg min. The main table of the paired sample T-test showed no significant difference between the control and experimental groups before and after the experiment, but the one-sided test showed that the mean maximum oxygen absorption varied significantly before and after the experiment.

4. Analysis and discussion

Aerobic exercise is a physical exercise performed with adequate oxygen supply. Aerobic exercise takes more than 30 minutes per physical exercise and is a continuous physical exercise, with your heart rate remaining at 60% - 80% of your maximum heart rate. Calformula of aerobic exercise: Heart rate of aerobic exercise = (heart rate =220-age) (60% -80%).

When people do exercise, various changes occur in the human body system. These changes arise as an adaptive response where the functional system initiates due to elevated levels of basal metabolism stimulated by body movement. Among these changes, the change in the circulatory system is particularly obvious, as it provides a guarantee for the operation of other functional systems. In this respect, to shape our bodies, we first have to shape our heart [5]. Aerobic exercise is a kind of physical exercise that enhances cardiopulmonary function. The rhythmic exercise can last for longer times. It can enhance cardiopulmonary function and enable the cardiovascular system to quickly and efficiently transmit oxygen to all parts of the body[6].

In a long time of exercise, when the body metabolism into a stable state, the total energy consumption level is basically stable, but with the increase of exercise time, the metabolic substrate will change, gradually reducing the energy supply of sugar oxidation, fat oxidation energy supply and its proportion gradually increase, however, how long to change the metabolic substrate, the change of substrate mobilization and exercise intensity, substrate reserve, age, gender and metabolic ability is the relationship between what, is worth studying[7].

When the body is hungry, with insufficient sugar supply and is on a ketogenic diet, the body's organ metabolism changes harmoniously: 1. Reduced glycogen synthesis and glycogen decomposition increases; 2. Gluconeogenesis begins to increase; 3. Promote fat mobilization, produce a large amount of fatty acids to the liver and muscle, making them replace glucose oxidation, thus indirectly increasing blood glucose.4. The body cannot use sugar, but uses fatty acids to provide energy; 5. Kone body replaces glucose and provides energy for brain tissue and muscle, thus saving the oxidation and utilization of glucose[8].

This study shows that, in order to reduce the body's sugar reserves, three hours a week of aerobic training no significant change in the experimental group, indicating that in low intensity aerobic training and timely energy after training will not adversely affect body function, but the experimental group low intensity training maximum oxygen and maximum heart rate unilateral T test significant difference, indicating that aerobic training in the experimental state is more beneficial than the non-experimental state.

Maximum oxygen intake refers to the amount of oxygen consumed per unit of time, the cardiac pump function of the oxygen delivery system and the oxygen consumption capacity of the muscle when required for exhausting a large number of muscle groups[9].It can directly reflect the maximum aerobic capacity of an individual, marking the strength of a person's oxygen delivery system function. Maximum oxygen intake (or maximum oxygen intake) is related to cardiopulmonary function, muscle size and activity status, blood carrying capacity and oxygen carrying capacity, as well as the ability of tissues to absorb and use oxygen, and can be used to comprehensively determine the physical condition. The increase in maximum oxygen uptake indicates that the body function is greatly improved.

Maximum heart rate refers to the highest level of heart rate that can be reached under the maximum load intensity of exercise, reaching the limit of oxygen consumption and heart rate. For example, during exercise, with the increase of exercise load, oxygen consumption and heart rate will also increase[10].

There have been different conclusions about whether the maximum heart rate changes after exercise training. A total of 12 experimental studies, including Karvonen and Costill, concluded that exercise training significantly reduced the maximum heart rate, while 10 experiments showed that the maximum heart rate change was not obvious after aerobic training; one experimental study showed that the maximum heart rate increased significantly after exercise training. Therefore, the results of maximal heart rate improvement have some accuracy.

5. Conclusions

Through the above experiments and analysis, we can draw the following conclusions: 1. Certain intensity, time and regular aerobic training have certain effect on weight loss in non-experimental state and experimental state, which can effectively reduce the fat content of all parts of female college students and improve the quality of lean body; 2. certain intensity aerobic exercise based on ketogenic diet will make female college students have better slimming effect, and this mode will not cause adverse effects on the body within a certain range.

References

1 Torben Rokkedal-Lausch, Jesper Franch, Mathias K. Poulsen et al. Chronic high-dose beetroot juice supplementation improves time trial performance of well-trained cyclists in normoxia and hypoxia[J] Nitric Oxide, 2019, 85

2 Akram Falahati, Hamid Arazi Association of ACE gene polymorphism with cardiovascular determinants of trained and untrained Iranian men[J] Genes and Environment, 2019, 41(1)

3 Zubac Damir, Goswami Nandu, Ivančev Vladimir et al. Independent influence of age on heart rate recovery after flywheel exercise in trained men and women[J] Scientific Reports, 2021, 11(1)

4 Piyapong Prasertsri, Thapanee Roengrit, Yupaporn Kanpetta et al. Cashew apple juice supplementation enhances leukocyte count by reducing oxidative stress after high-intensity exercise in trained and untrained men[J] Journal of the International Society of Sports Nutrition, 2019, 16(1)

5 Youngju Choi, Takeshi Otsuki, Asako Miyaki et al. Oxidative stress and arterial stiffness in strength- and endurance-trained athletes[J] Artery Research, 2009, 3(3)

6 Youngju Choi, Seiji Maeda, Takeshi Otsuki et al. Oxidative stress and arterial stiffness in strength- and endurance-trained athletes[J] Artery Research, 2010, 4(2)

7Brett W. Fling, Anita Christie, Gary Kamen Motor unit synchronization in FDI and biceps brachii muscles of strength-trained males[J] Journal of Electromyography and Kinesiology, 2008, 19(5)

8 Paulo Gentil, James Fisher, James Steele et al. Effects of equal-volume resistance training with different training frequencies in muscle size and strength in trained men[J] PeerJ, 2018, 6

9 Michael J. Falvo, Brian K. Schilling, Richard J. Bloomer et al. Repeated bout effect is absent in resistance trained men: An electromyographic analysis[J] Journal of Electromyography and Kinesiology, 2008, 19(6)

10 Jesus Isley, Michel Flutot Pauline, Deramaudt Therese B. et al. Effects of aerobic exercise training on muscle plasticity in a mouse model of cervical spinal cord injury[J] Scientific Reports, 2021, 11(1)