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RESEARCH

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Interventional effects of different track and field sports on human cardiovascular function indicators and physiological energy metabolism

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Abstract

Objective To analyze the effects of different track and field events on human cardiovascular function and physiological energy metabolism.

Method The research subjects were ordinary male students majoring in physical education at a certain university, aged between 18 and 25 years old. A total of 42 people were divided into four sub sample groups: sprint group (10 people), jump group (10 people), long-distance running group (10 people), and regular student group (12 people). The COSMED K5 portable gas metabolism analysis system was used to measure cardiopulmonary function, and key indicators such as Maximum Oxygen Uptake (VO_2max) were evaluated using a Stepwise Increasing Load Test (SILT). The two factor repeated measures ANOVA method was used to analyze the effects of different load levels and groups on cardiopulmonary function and energy metabolism.

Result The weight, systolic blood pressure, and diastolic blood pressure of different populations were not statistically significant in a quiet state ($p > 0.05$). The waist to hip ratios of the short-distance and long-distance running teams were 0.75 ± 0.03 and 0.76 ± 0.03, respectively, which showed significant differences compared to ordinary students ($p < 0.05$). There was also a significant difference in heart rate between different track and field teams and ordinary students in a quiet state ($p < 0.05$). The termination load of different track and field teams varied, with the long-distance running team having the highest load ($p < 0.01$), followed by the jumping team. Compared with ordinary students, there was a significant difference ($p < 0.05$) in the termination heart rate among the sprinting, long-distance, and jumping teams. However, there was $p > 0.05$ in the systolic blood pressure index among the four groups of subjects. There was a significant difference ($p < 0.05$) in diastolic blood pressure between sprinting and jumping teams and ordinary students. In a quiet state, the energy metabolism of long-distance running teams, sprinting teams, jumping teams, and ordinary students was 1.52 ± 0.64, 1.81 ± 0.91, 1.86 ± 0.87, and 2.87 ± 0.96, respectively.

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Conclusion In a quiet state, there are significant differences in body shape and function between different track and field training teams and the general population. In a quantitative load state, long-distance runners have the strongest adaptability to load.

Keywords Exercise intervention, Cardiovascular function, Energy metabolism assessment, Maximum oxygen uptake, Sports physiology

Introduction

The development of society has led to an increasing concern for health and quality of life, and sports as an important way to maintain physical and mental health have been widely valued. In higher education, physical education is no longer just a compulsory course; rather, it is increasingly regarded as a crucial element in the holistic development of students [1]. Track and Field (T-F) sports can be divided into aerobic and anaerobic metabolism dominant events based on the duration and intensity of the exercise. The analysis of energy system contribution indicates that endurance events such as Long-Distance Running (LDR) primarily rely on the aerobic metabolism system. The primary source of energy for these events is the aerobic oxidation metabolism of fat and glycogen, which facilitates enhanced fat utilization efficiency and an elevated overall metabolic level. Sprint and jumping events mainly rely on the phosphate system and anaerobic glycolysis system [2]. The characteristics of these events are high-intensity output in a short period, requiring high instantaneous explosive power and anaerobic endurance of muscles. However, the contribution ratio of different events to the energy system varies in specific training and competitions. For example, the 100 m sprint mainly relies on the phosphate system, while the 400 m sprint has a higher proportion of anaerobic glycolysis participation [3, 4]. LDR events mainly rely on aerobic metabolism, accounting for over 80%. T-F sports have a significant effect on improving cardiovascular function. Especially for LDR, it can significantly improve aerobic endurance and overall cardiovascular function. Sprinting, high jump, and other events place more emphasis on anaerobic endurance and explosive power, but can also improve cardiovascular function through high-intensity training [5]. The combination training of different T-F projects can comprehensively improve the human body's cardiovascular adaptability and endurance level. The impact of different T-F projects on physiological Energy Metabolism (EM) is mainly reflected in the different uses of energy supply systems and the adaptability of the body. LDR and race walking mainly rely on aerobic metabolism, which improves the efficiency of fat and glycogen utilization. Sprinting and high jump mainly rely on anaerobic metabolism, which enhances explosive power and short-term energy supply capacity. However, the impact on specific cardiovascular function indicators and metabolic items is not clear [6–8]. The study proposes the following hypothesis: Hypothesis 1: Compared with ordinary students, students who participate in sprinting, jumping, and LDR training have significant differences in cardiovascular function indicators at rest. Hypothesis 2: LDR training has the most significant improvement effect on cardiovascular function, followed by jumping training, while the improvement effect on cardiovascular function of ordinary students is the weakest. Hypothesis 3: In the incremental load test, the EM efficiency and load adaptation ability of the LDR team are better than those of the short running team and jumping team, while the load adaptation ability of ordinary students is the weakest. Therefore, this study selects ordinary male students majoring in physical education from a certain university as the research subjects and segmented them into four groups: sprinting team, jumping team, LDR team, and ordinary students. The experiment uses a Stepwise Increasing Load Test (SILT) to analyze Cardiopulmonary Function (CF) and Gas Metabolism (GM). The study selects key cardiovascular function indicators, including maximal oxygen uptake, heart rate, systolic blood pressure, diastolic blood pressure, respiratory rate, ventilation volume, etc. These indicators are commonly utilized to assess cardiovascular endurance, the adaptability of the circulatory system, and post-exercise recovery. They serve as crucial parameters for evaluating an individual's cardiovascular health status. For example, Maximum Oxygen Uptake (VO_2max), which is a core indicator of aerobic capacity, is closely related to an athlete's endurance and overall cardiovascular fitness. Research has shown that long-term aerobic endurance training can significantly increase VO_{2max} levels, while anaerobic training increases anaerobic threshold and muscle explosiveness more. The aim is to give a reliable basis for the intervention effects of different T-F exercises on human CF indicators and physiological EM. The innovation of the research lies in quantifying the impact of different exercises on GM to explore the intervention effects of different T-F exercises on human CF indexes and physiological EM. The study explores the effects of different T-F events on CF and EM, which has significant rationality. Firstly, different T-F events have different energy system requirements, and the differences in aerobic and anaerobic metabolism provide a clear theoretical basis for the research. Secondly, existing literature mostly focuses on a single event. This study systematically compares the differences in cardiorespiratory function among multiple T-F events, filling a research gap. Finally, the use of COSMED K5 analysis system and gradually increasing load testing ensures the scientific and reliable nature of the data. The contribution of the research lies in elucidating the differences in energy system and cardiorespiratory adaptability among different projects, providing empirical support for exercise physiology. This study provides a basis for optimizing training programs, which helps coaches develop personalized training plans and improve athletes' physical performance. The research results demonstrate the positive effects of aerobic exercise on cardiovascular health, providing scientific support for promoting exercise interventions, especially for college students.

Materials and methods

Research object

Ordinary male students majoring in physical education from a certain university were selected as the research subjects. This study used the Physical Activity Readiness Questionnaire (PAR-Q) to screen participants. The final screening population was determined to be 42 people: 10 for the sprint team, 10 for the long jump team, 10 for the LDR team, and 12 for ordinary students. The inclusion criteria: (i) Age between 18 and 25 years old; (ii) Students majoring in sports on campus; (iii) No serious chronic diseases like Cardiovascular Disease (CD), Respiratory System Disease (RSD), musculoskeletal system disease, etc.; (iv) No history of sports injury or surgery, able to perform normal sports training; (v) Not using drugs that affect physical function during exercise. The exclusion criteria: (i) Age ≤ 18 years old or ≥ 25 years old; (ii) Having cognitive and expression barriers, unable to communicate; (iii) Poor cognitive function, lacking certain oral and written expression abilities; (iv) Refuse to sign informed consent. (v) Severe CD, lung, or metabolic disorders. The participants of the sprint team received specialized training in sprinting, mainly for short-distance events such as 100 m and 200 m. The participants of the jumping team received specialized training in jumping such as high jump and long jump, emphasizing the cultivation of explosive power and technical ability. Participants in the LDR team received specialized training for LDR of 5,000 m or more, with a focus on aerobic endurance training. The participants in the ordinary student group did not receive specialized T-F training, but had basic physical exercise habits, serving as the control group.

Research method

The literature review method was used to provide necessary theoretical support for this study by reviewing monographs, published literature, journal articles, academic papers, etc. on CF and EM. PAR-Q was used to understand the physical health and physical activity of the subjects. The Rating of Perceived Exercise (RPE) was utilized to evaluate the status of participants during the trial process. Subjects with severe cardiovascular, pulmonary, or metabolic diseases were excluded to ensure safety during fitness and experimentation.

The study used the COSMED K5 portable GM analysis system (COSMED, Italy) for measuring CF, which has good validity and reliability, and is widely used in sports physiology research [9]. It is considered the gold standard equipment for measuring VO_{2max} and gas exchange indicators. The system is capable of real-time recording and analysis of important indicators such as oxygen consumption, carbon dioxide emissions, ventilation volume, and respiratory entropy. Validity and reliability studies have shown that the COSMED K5 system has high repeatability and consistency in measurement results under different exercise load conditions [10]. The load test was conducted in a certain laboratory. In the step-by-step load test, the subjects first wore respiratory masks and heart rate detectors, and sat quietly on a power bicycle for a 5-minute preparation period. During this period, the gas metabolism of the test subjects was measured in a quiet state, mainly using gas analysis instruments to record the subjects' oxygen intake, carbon dioxide emissions, and respiratory quotient. Next, the subjects began a step-by-step load test using power bicycles for testing. At the beginning of the test, the initial power of the subjects was set to 20 W, the speed was 60 r/min, and the load of each level was gradually increased in increments of 20 W. The test lasted for 2 min for each level. There is no rest time between each level, and a three-axis physical activity monitor is used to monitor the energy metabolism of the subjects in real time throughout the entire experiment. Simultaneously record the heart rate, blood pressure, and RPE of the subjects during the test. The experiment is conducted in the laboratory to ensure a suitable ambient temperature, accurate equipment, and good calibration. The main criteria for terminating the test are: (1) VO_2 reaches the plateau period with an increment of less than 150 ml/min; (2) Heart rate reaches the predicted maximum heart rate. Secondary criteria include: respiratory exchange ratio ≥ 1.10, self-perceived exercise intensity ≥ 18, or the occurrence of discomfort symptoms such as extreme fatigue. During the testing process, indicators such as oxygen absorption, carbon dioxide emissions, and ventilation volume were recorded. After the test was completed, sat quietly for 5 min to record the recovery period data. The test indicators mainly included metabolic equivalent, VO_{2max}, oxygen consumption, oxygen pulse, carbon dioxide consumption, ventilation per minute, tidal volume, and respiratory entropy.

Termination criteria: (i) The subject experiences symptoms such as difficulty breathing, dizziness, tinnitus, nausea, extreme fatigue, and pale complexion; (ii) The diastolic BP of the subjects is ≥ 100 mmHg, and the systolic BP is ≥ 200 mmHg; (iii) The subject's heart rate reaches the maximum expected heart rate; (iv) Abnormal S-T segment decrease and arrhythmia in the subject's electrocardiogram; (v) The RPE value of the subject is ≥ 18; (vi) Subject requests to stop testing; (vii) Unable to maintain the required conditions for normal testing for 10 s. When selecting one of the termination criteria mentioned above, the experiment should be immediately stopped.

Research tool

PAR-Q is a commonly used health assessment tool used to assess whether an individual is suitable to start physical activity or exercise. The purpose of this scale is to help participants understand their health status and consider potential risk factors before starting the experiment. If the subject encounters any potential health issues while answering PAR-Q questions, it is necessary to comprehensively consider whether the subject is eligible to participate in the study [11, 12].

The RPE scale is a tool used to evaluate the level of effort or fatigue felt by participants during physical activity or exercise. RPE is usually used to measure the intensity of exercise to help participants control the intensity of exercise during the training process, ensuring that they exercise within an appropriate range. Otherwise, the study used a rating scale of 6–20, and at 6–10, it shows mild activity and felt relaxed. At 11–13, the performance is moderate activity and feels moderate. At 14–17, it shows moderate to high-intensity activity and feels difficult. At 18–20, it exhibits high-intensity activity and feels very difficult [13, 14].

Statistical method

The experiment used SPSS 26.0 statistical software to establish a database, and the survey data were entered by two individuals separately, and then checked by a third person. When there was inconsistent data, it was necessary to verify it. After verifying that there were no errors, statistical analysis of the data was performed. Count data were expressed in "%". The mean plus error value represented the measurement data and *T*-test was used. $p < 0.05$ indicated a statistically significant difference. Due to two main factors involved in experimental design, the load of different groups gradually increased. Therefore, a two factor repeated measures ANOVA was chosen for statistical analysis. This method can simultaneously examine the main and interactive effects of group and load on cardiovascular and pulmonary function indicators (such as VO_2max, heart rate, ventilation volume, etc.).

Quality control

Before the formal trial began, all participants underwent ethical review and informed consent, and received unified training to understand the purpose and methods of this study. During the investigation process, a unified guiding language was used to clarify the inclusion and exclusion criteria, and the personal privacy of the research subjects was kept confidential. The questionnaire was collected immediately after the survey was completed, and the completeness of the collected data was verified item by item [15]. When organizing and analyzing data, the coding and input of data needed to be repeatedly checked and logically checked, and questionnaires with obvious logical errors or missing items ≥ 25% should be excluded.

Ethical review

This study has passed the ethical review of the research institution. Before the investigation begins, the research subjects will be fully informed of the purpose and methods of this study. If the subjects agree to join this study, they will sign an informed consent form. The subjects have the right to withdraw from this study at any time without the need for special explanations, and it will not have any impact on their academic performance or physical health. All research subject information will be kept confidential, and patient information will not be disclosed throughout the entire research process and publication of results [16].

Results

Comparison of general information in a quiet state

This study included a total of 42 participants, including 10 from the sprinting team, 10 from the jumping team, 10 from the LDR team, and 12 from ordinary students. The basic information of subjects in each group under quiet state was compared, and the results are shown in Table 1. The weight, systolic BP, and diastolic BP of different populations were not statistically significant in a quiet state ($p > 0.05$). The waist to hip ratios of the sprint team and the LDR team were 0.75 ± 0.03 and 0.76 ± 0.03, respectively ($p < 0.05$), and there were significant differences in heart rate between different T-F teams and ordinary students in quiet ($p < 0.05$). The height and lung capacity of the jumping team were (182.3 ± 3.2) cm and (5213.1 ± 411.5) ml, respectively, with significant differences. The Body Mass Index (BMI) of LDR team was lower than that of ordinary students and has statistical significance.

Comparison of maximum oxygen uptake at different stages

The VO_{2max} of different subjects at different stages was compared, and the results are shown in Fig. 1. VO_{2max}

Table 1 Comparison of general information of subjects

Index	Sprint team	LDR team	Jumping team	Ordinary students
Height (cm)	176.1 ± 5.1	174.9 ± 6.2	182.3 ± 3.2**	174.8 ± 6.1
Weight (kg)	71.2 ± 6.1	68.7 ± 5.9	76.3 ± 7.3	73.8 ± 13.8
BMI (kg/m^2)	22.7 ± 1.8	21.6 ± 1.4*	23.8 ± 2.0	28.4 ± 4.1
WHR	0.75 ± 0.03*	0.76 ± 0.03*	0.79 ± 0.02	0.83 ± 0.06
Vital capacity (ml)	4589.6 ± 598.4	4765.1 ± 781.2	5213.1 ± 411.5*	4536.2 ± 521.3
Heart rate (times/min)	74.3 ± 8.4*	71.8 ± 4.9*	72.7 ± 7.6*	85.1 ± 11.1
Systolic pressure (mmHg)	121.8 ± 8.1	121.9 ± 12.7	124.2 ± 8.2	132.1 ± 6.7
Diastolic pressure (mmHg)	66.4 ± 11.1	74.2 ± 11.2	68.2 ± 11.9	78.6 ± 12.2

Note: Compared with ordinary students, * indicates $p < 0.05$, ** represents $p < 0.01$

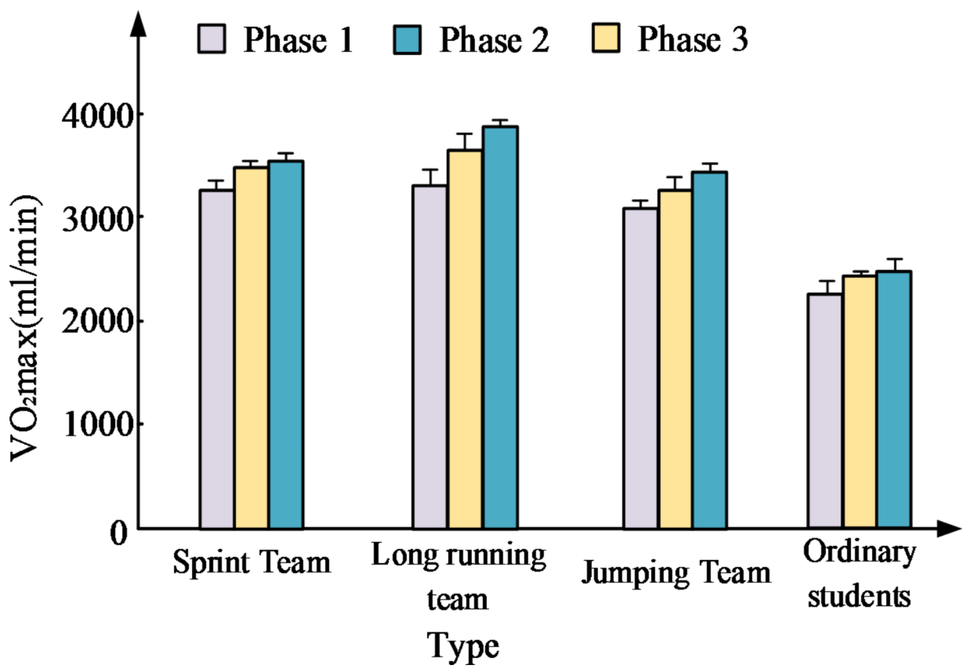

Fig. 1 VO_{2max} analysis of different populations

represents maximum oxygen uptake. The VO_{2max} exhibited by different T-F teams varies, with the LDR team having the highest oxygen uptake, followed by the sprint team, then the jumping team, and finally the ordinary students. This is because LDR belongs to endurance projects, while sprinting and jumping are both explosive projects, and ordinary students have a smaller amount of exercise. The research results show that regularly participating in sports training can help improve CF.

Analysis of various indicators at the termination of exercise in different subjects

The analysis of various indicators at the end of exercise for different participants is shown in Fig. 2. The termination load varied among different T-F teams, with the LDR team having the highest load ($p < 0.01$), followed by the jumping team. Due to the correlation between exercise time and termination load, there was a significant difference ($p < 0.01$) in the termination time between the LDR team and ordinary students. In terms of terminating heart rate, compared with ordinary students, the sprint team, LDR team, and jumping team all showed significant differences ($p < 0.05$). In terms of systolic BP indicators, there was no significant difference among the four groups of subjects ($p > 0.05$). There was a significant difference ($p < 0.05$) in diastolic BP between sprinting and jumping teams and ordinary students.

Tidal volume analysis of different T-F training teams under quantitative load conditions

Figure 3 presents the results of analyzing the tidal volume of T-F training teams under different load conditions. In a quiet state, the tidal volume of LDR team, sprint team, jumping team, and ordinary students was 0.71 ± 0.29, 0.95 ± 0.22, 0.83 ± 0.21, and 0.87 ± 0.41, respectively. As the load gradually increased, the tidal volume of the LDR team increased with the increase of load. At 140 W, the tidal volume of the LDR team was 2.35 ± 0.37, while the

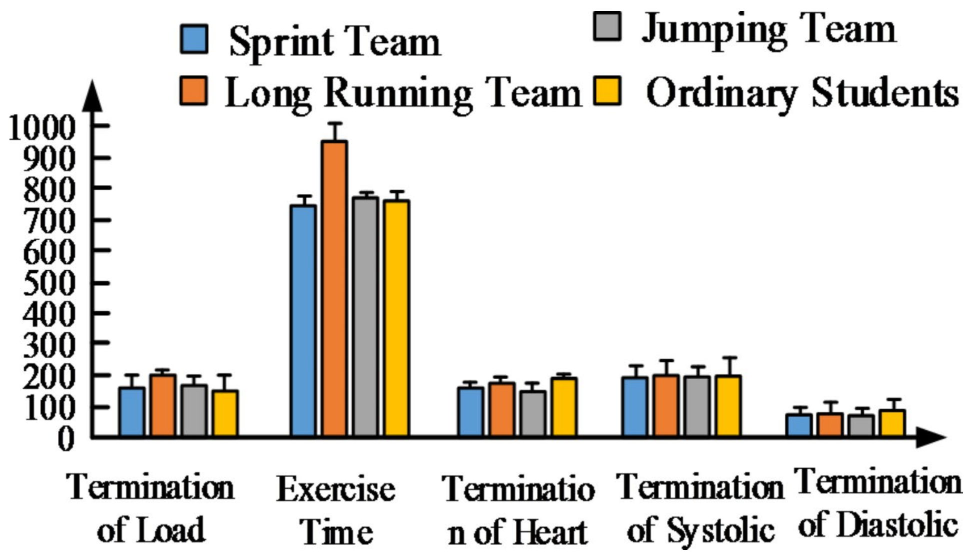

Fig. 2 Analysis of various indicators at the end of exercise

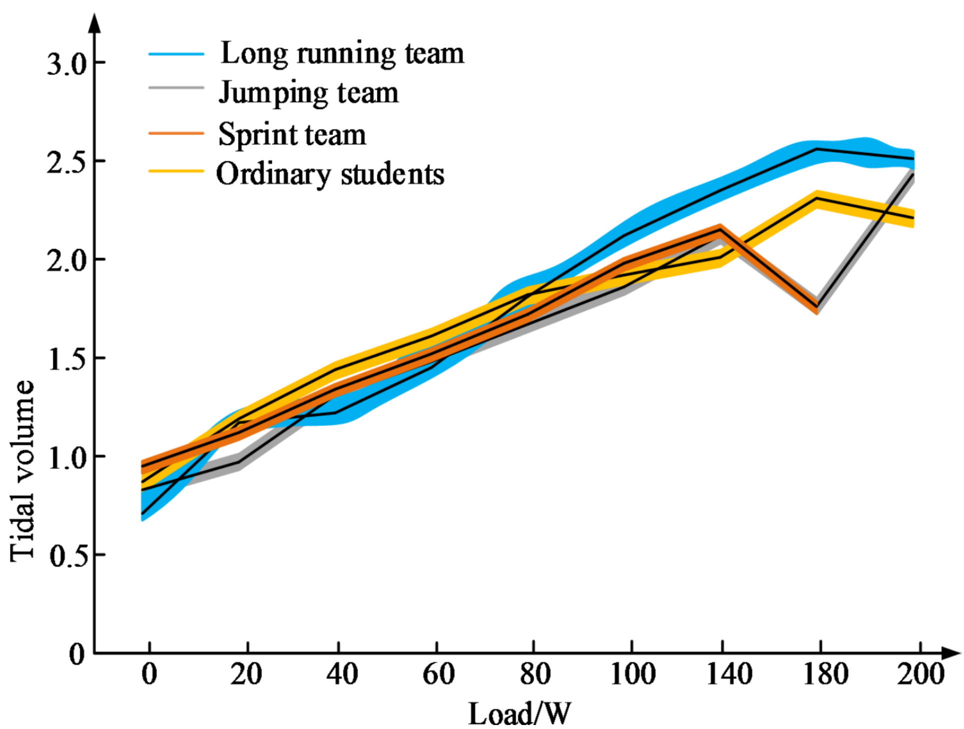

Fig. 3 Tidal volume analysis of different T-F training teams

tidal volume of the sprint team decreased significantly at 180 W, reaching 1.76 ± 0.18, both of which showed significant differences compared to the tidal volume of ordinary students ($p < 0.05$). The tidal volume of the jumping team gradually increased during the load movement process. When the exercise load was 185 W, its tidal volume significantly decreased to 1.76 ± 0.43. When the load was 60 W, its tidal volume was 1.48 ± 0.16, which was significantly different from that of ordinary students ($p < 0.05$).

Respiratory frequency analysis of different T-F training teams under quantitative load conditions

Table 2 analyzes the respiratory rate of T-F training teams under different load conditions. In a quiet state, the respiratory rates of LDR, sprint, jumping, and ordinary students were 17.2 ± 4.7, 19.6 ± 3.9, 17.6 ± 5.9, and 19.9 ± 5.5, respectively. During the process of increasing load exercise, both the LDR team and ordinary students showed an increasing trend in respiratory rate. After increasing the load to 80 W, there was a significant

Table 2 Respiratory frequency analysis of different T-F training teams

Load capacity	Long running team	Sprint team	Jumping team	Ordinary students
Rest	17.2 ± 4.7	19.6 ± 3.9	17.6 ± 5.9	19.9 ± 5.5
20 W	20.6 ± 4.7	22.1 ± 4.4	21.3 ± 2.8	23.1 ± 4.4
40 W	21.7 ± 5.3	21.6 ± 3.7	20.2 ± 4.9	22.6 ± 5.4
60 W	21.7 ± 3.9	23.5 ± 3.1	21.8 ± 2.7	23.8 ± 4.1
80 W	22.1 ± 3.6**	25.6 ± 4.7	26.0 ± 2.3*	29.9 ± 5.6
100 W	25.8 ± 3.6**	29.7 ± 5.6	25.9 ± 3.9**	32.9 ± 4.7
140 W	27.8 ± 3.6**	33.9 ± 6.1	26.7 ± 4.2**	39.1 ± 6.4
180 W	32.6 ± 4.8**	51.5 ± 7.4	35.7 ± 10.5	47.2 ± 9.3
200 W	33.4 ± 9.7	/	28.6 ± 0.0	56.3 ± 0.0

Table 3 Analysis of relative oxygen uptake of different T-F training teams

Load capacity	Long running team	Sprint team	Jumping team	Ordinary students
Rest	6.7 ± 3.6	9.6 ± 3.1**	6.1 ± 2.9	5.6 ± 2.7
20 W	10.1 ± 4.5	11.3 ± 2.4**	9.9 ± 3.6	9.1 ± 1.2
40 W	14.6 ± 6.8	16.7 ± 3.6**	14.6 ± 4.8	12.4 ± 2.8
60 W	17.4 ± 6.9	20.2 ± 2.6**	17.8 ± 4.4	15.2 ± 3.4
80 W	22.1 ± 7.1*	25.89 ± 3.6**	20.3 ± 4.9*	16.7 ± 3.7
100 W	25.6 ± 9.7*	33.7 ± 2.5**	21.1 ± 8.6	18.8 ± 4.8
80 W	31.8 ± 12.6*	34.7 ± 5.8**	27.6 ± 8.7*	17.1 ± 4.3
180 W	34.9 ± 11.5*	38.6 ± 5.8**	32.7 ± 9.4*	16.8 ± 6.9
200 W	32.3 ± 12.5		44.1 ± 0.0	23.4 ± 0.0

difference ($p < 0.01$) in the respiratory rate between the LDR team and ordinary students.

Analysis of ventilation per minute for different T-F training teams under quantitative load conditions

Figure 4 shows the analysis of ventilation per minute for T-F training teams under different load conditions. In a quiet state, the ventilation rates per minute for LDR, sprint, jump, and ordinary students were 13.1 ± 5.7, 20.6 ± 5.7, 16.7 ± 3.9, and 13.7 ± 4.9, respectively. There was a significant difference ($p < 0.05$) in the ventilation volume per minute between the sprint team and ordinary students. As the exercise load increased, there was a significant difference in ventilation per minute between the LDR team and regular students at a load of 20 W. In the sprint team, when the load reached 180 W, the ventilation rate per minute was 75.2 ± 8.6, showing a significant difference ($p < 0.01$) compared to ordinary students. In the jumping team, there was a significant difference ($p < 0.05$) between the jumping team and ordinary students during the fifth and seventh level of load exercise.

Analysis of relative oxygen uptake of different T-F training teams under quantitative load conditions

Table 3 analyzes the relative oxygen uptake of T-F training teams under different load conditions. In a quiet state, the relative oxygen uptake of LDR team, sprint team, jumping team, and ordinary students was 6.7 ± 3.6, 9.6 ± 3.1, 6.1 ± 2.9, and 5.6 ± 2.7, respectively. There was a very significant difference ($p < 0.01$) between the sprint team and ordinary students from a stationary state to a load of 180 W. When the load reached 80 W, the LDR team began to show significant differences in relative oxygen uptake compared to ordinary students ($p < 0.05$). There was a significant difference ($p < 0.05$) in the relative oxygen uptake between jumping teams and ordinary students when the load was 80 W, 140 W, and 180 W.

Oxygen pulse analysis of different T-F training teams under quantitative load conditions

Table 4 shows the analysis of oxygen pulse of T-F training teams under different load states. In a quiet state, the oxygen pulse of LDR team, sprint team, jumping team, and ordinary students was 5.1 ± 2.7, 8.6 ± 2.1, 6.8 ± 2.7, 4.0 ± 1.1, respectively. There was a significant difference

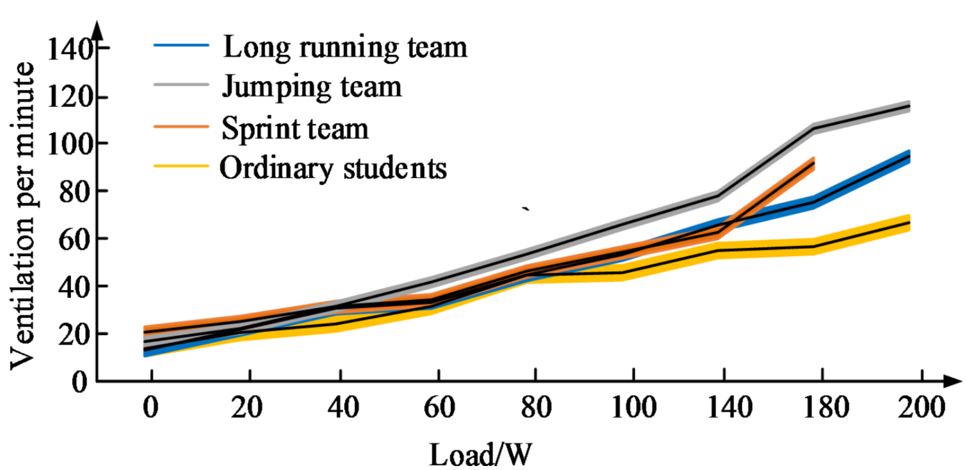

Fig. 4 Analysis of ventilation per minute for different T-F training teams

Table 4 Relative oxygen pulse analysis of different T-F training teams

Load capacity	Long running team	Sprint team	Jumping team	Ordinary students
Rest	5.1 ± 2.7	8.6 ± 2.1**	6.8 ± 2.7*	4.0 ± 1.1
20 W	9.1 ± 2.4*	9.9 ± 1.7**	7.1 ± 2.6	5.7 ± 0.8
40 W	11.7 ± 4.3*	13.1 ± 1.9**	11.7 ± 2.9*	7.0 ± 0.9
60 W	11.9 ± 4.2	13.7 ± 1.9**	12.8 ± 2.1**	7.7 ± 1.3
80 W	12.7 ± 3.1**	13.8 ± 1.9**	11.9 ± 3.9*	7.9 ± 1.8
100 W	13.8 ± 4.3**	15.6 ± 1.8**	12.1 ± 4.1*	7.6 ± 1.3
140 W	14.6 ± 4.1**	14.9 ± 2.9**	13.9 ± 4.7*	6.9 ± 1.4
180 W	14.9 ± 5.4*	14.5 ± 1.7**	10.6 ± 1.9*	6.1 ± 2.0
200 W	14.7 ± 5.1	/	11.7 ± 0.0	6.6 ± 0.0

Table 5 Respiratory entropy analysis of different T-F training teams

Load capacity	Long running team	Sprint team	Jumping team	Ordinary students
Rest	0.88 ± 0.09	0.75 ± 0.11**	0.79 ± 0.11*	0.96 ± 0.12
20 W	0.81 ± 0.13	0.76 ± 0.08**	0.79 ± 0.14*	0.94 ± 0.16
40 W	0.81 ± 0.19**	0.78 ± 0.14**	0.75 ± 0.12**	1.14 ± 0.18
60 W	0.83 ± 0.23*	0.71 ± 0.17**	0.88 ± 0.26	1.11 ± 0.16
80 W	0.83 ± 0.19**	0.78 ± 0.08**	0.92 ± 0.14	1.29 ± 0.11
100 W	1.01 ± 0.11**	0.81 ± 0.25**	0.93 ± 0.18**	1.38 ± 0.14
140 W	1.05 ± 0.11**	0.87 ± 0.14**	0.92 ± 0.13**	1.65 ± 0.32
180 W	1.24 ± 0.23*	1.12 ± 0.14*	0.86 ± 0.15*	2.18 ± 0.76
200 W	1.37 ± 0.26	/	0.76 ± 0.0	2.14 ± 0.0

($p < 0.05$) between the jumping team and the sprinting team and ordinary students. There is a significant difference ($p < 0.01$) between the oxygen pulse of the sprint team from a stationary state to a load of 180 W and ordinary students. In the LDR team, the difference between quiet state and 60 W load was not significant compared to ordinary students. In the jumping team, under a load of 20 W, the difference with ordinary students was not significant, while under other loads, significant differences were observed with statistical significance ($p < 0.05$).

Respiratory entropy analysis of different T-F training teams under quantitative load conditions

The respiratory entropy of T-F training teams under different load states was analyzed, as shown in Table 5. In a quiet state, the respiratory entropy of LDR team, sprint team, jumping team, and ordinary students was 0.88 ± 0.09, 0.75 ± 0.11, 0.79 ± 0.11, 0.96 ± 0.12, respectively. There was a significant difference ($p < 0.01$) in the respiratory entropy of the sprint team from a stationary state to a 180 W load compared to ordinary students. In the LDR team, when the load reached 40 W, there was a significant difference ($p < 0.05$) in respiratory entropy between the students and the general students. In the jumping team, when the load was 60–80 W, the difference in respiratory entropy between them and ordinary students was not significant.

Table 6 EM analysis of different T-F training teams

Load capacity	Long running team	Sprint team	Jumping team	Ordinary students
Rest	1.52 ± 0.64**	1.81 ± 0.91	1.86 ± 0.87	2.87 ± 0.96
20 W	2.76 ± 0.53**	3.32 ± 1.41	2.98 ± 0.91	3.74 ± 0.68
40 W	3.43 ± 0.74**	4.43 ± 1.96	4.26 ± 1.24	5.11 ± 0.46
60 W	4.42 ± 0.93**	4.96 ± 1.98	4.95 ± 1.23	6.23 ± 0.74
80 W	4.71 ± 0.62**	6.27 ± 1.64*	6.32 ± 1.62*	7.66 ± 0.73
100 W	5.31 ± 1.24**	7.59 ± 2.33	7.11 ± 2.27	9.23 ± 0.68
140 W	4.96 ± 0.98**	8.86 ± 3.15*	8.41 ± 2.32**	10.12 ± 1.36
180 W	4.74 ± 1.91**	9.32 ± 3.66*	9.36 ± 2.90	10.67 ± 0.55
200 W	6.1 ± 2.1	9.42 ± 4.40	13.16 ± 0.0	/

EM analysis of different T-F training teams under quantitative load conditions

Table 6 shows the analysis results of EM of T-F training teams under different load states. In a quiet state, the EM of LDR team, sprint team, jumping team, and ordinary students were 1.52 ± 0.64, 1.81 ± 0.91, 1.86 ± 0.87, and 2.87 ± 0.96, respectively. There was a significant difference in EM between the LDR team and ordinary students from a stationary state to a load of 180 W ($p < 0.01$). In the sprint team, there was a significant difference in EM between the students under loads of 80 W, 140 W, and 180 W, and there was statistical significance ($p < 0.05$). In the jumping team, there was a significant difference in EM between students with a load of 80 W and 140 W, and there was statistical significance ($p < 0.05$).

Discussion and conclusion

With the improvement of people's health awareness and living standards, physical exercise has become an indispensable part of their daily lives. In higher education institutions, physical exercise is not only an important way for students to maintain physical health, but also an effective means to cultivate their physical and mental qualities and enhance their teamwork spirit [17–20]. However, there may be differences in physical exercise plans for sports majors compared to ordinary students, as different projects have different requirements for physical fitness, which also poses different challenges to their CF and EM. CF refers to the coordination performance of the heart and lungs during exercise and rest, as well as the ability to provide oxygen and nutrients to body tissues. A healthy cardiovascular system can maintain normal bodily function and adapt to various physiological and environmental challenges. The intensity of EM can reflect a person's level of activity, and higher EM intensity means higher athletic ability and endurance [21, 22].

This study selected ordinary male students majoring in physical education from a certain university as the research subjects and used SILT for CF and GM analysis. It analyzed the metabolic equivalent, VO_2max, oxygen consumption, oxygen pulse, carbon dioxide consumption, minute ventilation, tidal volume, and respiratory entropy of the subjects through PAR-Q and RPE. Research has shown that a total of 42 participants were included, including 10 from the sprinting team, 10 from the jumping team, 10 from the LDR team, and 12 from ordinary students. The weight, systolic, and diastolic BP of different populations were not significant in a quiet state ($p > 0.05$). The waist to hip ratios of the sprint team and the LDR team were 0.75 ± 0.03 and 0.76 ± 0.03, respectively, which showed significant differences compared to ordinary students ($p < 0.05$), and there was also a significant difference in heart rate between different T-F teams and ordinary students in a quiet state ($p < 0.05$). The height and lung capacity of the jumping team were (182.3 ± 3.2) cm and (5213.1 ± 411.5) ml, respectively, with significant differences. The termination load of different T-F teams varied, with the LDR team having the highest load and a significant difference compared to ordinary students ($p < 0.01$), followed by the jumping team. Due to the correlation between exercise time and termination load, there was a significant difference ($p < 0.01$) in the termination time between the LDR team and ordinary students. In terms of terminating heart rate, compared with ordinary students, the sprint team, LDR team, and jumping team all showed significant differences ($p < 0.05$). In terms of systolic BP indicators, there was no significant difference among the four groups of subjects ($p > 0.05$). There was a significant difference ($p < 0.05$) in diastolic BP between sprinting and jumping teams and ordinary students. In a quiet state, the tidal volume of LDR team, sprint team, jumping team, and ordinary students was 0.71 ± 0.29, 0.95 ± 0.22, 0.83 ± 0.21, and 0.87 ± 0.41, respectively. As the load gradually increased, the tidal volume of the LDR team increased with the increase of load. At 140 W, the tidal volume of the LDR team was 2.35 ± 0.37, which was significantly different from that of ordinary students ($p < 0.05$). When the exercise load of the sprint team was 180 W, its tidal volume significantly decreased to 1.76 ± 0.18, and there was a significant difference in tidal volume compared to ordinary students ($p < 0.05$). The tidal volume of the jumping team gradually increased during the load movement process. When the exercise load was 185 W, its tidal volume significantly decreased to 1.76 ± 0.43. In a quiet state, the respiratory rates of LDR, sprint, jumping, and regular students were 17.2 ± 4.7, 19.6 ± 3.9, 17.6 ± 5.9, and 19.9 ± 5.5, respectively. During the process of increasing load exercise, the respiratory rate of both the LDR team and ordinary students showed an increasing trend. After increasing the load to 80 W, there was a very significant difference in respiratory rate between the LDR team and ordinary students ($p < 0.01$). The ventilation rates per minute for LDR team, sprint team, jumping team, and regular students were 13.1 ± 5.7, 20.6 ± 5.7, 16.7 ± 3.9, and 13.7 ± 4.9, respectively. There was a significant difference ($p < 0.05$) in the ventilation volume per minute between the sprint team and ordinary students. As the exercise load increased, there was a significant difference in ventilation per minute between the LDR team and regular students at a load of 20 W. The oxygen pulse of LDR team, sprint team, jumping team, and ordinary students were 5.1 ± 2.7, 8.6 ± 2.1, 6.8 ± 2.7, and 4.0 ± 1.1, respectively. There was a significant difference ($p < 0.05$) between the jumping team and the sprinting team and ordinary students. There was a significant difference ($p < 0.01$) between the oxygen pulse of the sprint team from a stationary state to a load of 180 W and ordinary students. The respiratory entropy of LDR team, sprint team, jumping team, and ordinary students were 0.88 ± 0.09, 0.75 ± 0.11, 0.79 ± 0.11, and 0.96 ± 0.12, respectively. There was a significant difference *($p < 0.01$)* in the respiratory entropy of the sprint team from a stationary state to a 180 W load compared to ordinary students. The EM of LDR team, sprint team, jumping team, and ordinary students were 1.52 ± 0.64, 1.81 ± 0.91, 1.86 ± 0.87, and 2.87 ± 0.96, respectively. There was a significant difference in EM between the LDR team and ordinary students from a stationary state to a load of 180 W ($p < 0.01$). In the sprint team, there was a significant difference in EM between the students under loads of 80 W, 140 W, and 180 W, and there was statistical significance ($p < 0.05$). There were significant differences in CF and EM among different T-F events. At rest, the waist to hip ratio of sprinters and long-distance runners was significantly lower than that of ordinary students ($p < 0.05$), which is due to the reduction of fat percentage caused by high-intensity training. The VO_2max of the LDR team was the highest, reflecting their advantage in aerobic endurance. The high oxygen uptake of sprinting and jumping teams was lower because they mainly relied on the anaerobic metabolic system [4–23]. In the incremental load test, the termination load and heart rate of the LDR team were significantly higher than those of other groups, indicating strong cardiovascular adaptability. This is similar to the results in reference [24]. In terms of EM, LDR teams exhibited higher efficiency under high loads, mainly relying on aerobic metabolism, while sprinting and jumping teams relied on anaerobic metabolism. The change in respiratory rate showed that the LDR team increased oxygen intake by increasing respiratory rate, while the sprinting team tended to increase tidal volume. This is similar to the results in reference [25].

In summary, under quiet conditions, there are significant differences in body shape and function between different T-F training teams and the general population. In a quantitative load state, LDR team members have the strongest adaptability to the load, low response, and can achieve energy savings, followed by sprint teams, and then jump teams. Ordinary people have a greater impact on quantitative load. Although this research has revealed the effects of different types of exercise on physiological indicators, there are still limitations. Firstly, the sample size is relatively limited, and the groups are not perfectly balanced, which may limit the generalizability of the results. In the future, the sample size can be expanded and athletes of different ages and training years can be considered. In addition, the study mainly focuses on the immediate physiological response at the end of exercise, without analyzing the recovery period and long-term adaptive changes. In the future, indicators such as heart rate recovery time can be added. The research is limited to direct measurements and does not delve into the intricacies of molecular biology and neural regulatory mechanisms. The potential for further analysis methods to be combined in the future should be acknowledged.

Supplementary Information

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Supplementary Material 1

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R.J. contributed to Writing - Original Draft; Z.W. contributed to Investigation, Formal analysis; C.M. contributed to Methodology, Writing - Review & Editing.

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Data availability
The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was approved by the Ethics Committee of Dongshin University (No. DSU[2022-05-01]). We conclude that the project conforms to ethical guidelines and adequately protects the rights and privacy of participants. We certify that the study was performed in accordance with the 1964 Declaration of Helsinki and later amendments. The research's informed consent document clearly communicates the study's purpose, procedures, risks, benefits, and rights to participants. Participants are informed that data will remain confidential, and their participation is voluntary.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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