RESEARCH ARTICLE

Effect of training load on the cardiac function of dancers based on blood lactic acid content

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During Latin dance training, when athletes bear exercise loads, a series of biochemical changes will occur in their bodies. There are significant differences in exercise load intensity among different training methods, and the same is true for their impact on physiological functions. This study aimed to investigate the effect of training load on the heart of dancers based on blood lactic acid content. 10 students (5 males and 5 females) majoring in sports dance and were active Latin dance competition players were included in this study. All participants won the top six results in the World Dance Sports Federation competition. A total of 6 tests were conducted once every other day, which included 9 different groups. The dance sequence of multi-dance groups was in accordance with the competition rules of the International Sports Federation (IDSF) with the five-dance group as Rumba, Samba, Cowboy, Cha-cha, and Bullfight, while the four-dance group as Rumba, Samba, Cowboy, and Cha-cha. The change of blood lactic acid concentration after Latin dance in the multi-dance group was obvious. The blood lactic acid value of the five-dance players after the exercise was 9.18 ± 2.54 mmol/L, which was very significant different from that before the exercise. The average value of blood lactate after four-dance exercises was 9.08 ± 2.52 mmol/L, which was very close to the value of five-dance group after exercise. Blood lactate is a sensitive indicator to assess the intensity of exercise load. The increase of blood lactate content indicated that the exercise intensity was large. After the Latin dance competition, the excitation of muscles and nerves increased, and the function of vestibular organs and the strength of lower limbs decreased. The results suggested that, in the training of Rumba and Cha-cha dance, it should strengthen the training of acid resistance of the players and prevent acidosis, while, in the training of Cowboy, Bullfighting, and Samba dances, it should strengthen the training of glycolysis and lactic acid elimination abilities of the players. The multi-dance group should strengthen aerobic and anaerobic metabolism ability. Players should pay attention to the control of music rhythm during training or competition and strengthen their balance and coordination ability. This study provided a solid theoretical basis for athletes to adjust their training load reasonably and prevent excessive fatigue and sports injuries. It also provided strong guidance for high-quality teaching and scientific training.

Keywords: heart rate monitoring; sports dance; exercise load; physical function.

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Introduction

Sports dance, also known as the international standard dance, is an ornamental and competitive dance popular in the world today [1]. It originated in Britain. When dancing, men and women form a pair and use technical skills to complete different difficult movements, showing different styles of sports dance. Sports dance is not only a single competitive dance or fitness exercise, but also to cultivate people's good mental state and create an elegant way of life and culture [2, 3]. Sports dance is divided into two categories including Latin dance and modern dance. Latin dance is a new sports competition, originating from the famous ethnic dances and folk dances in Latin America, which has a unique charm because of its standardized movements and graceful dancing [4]. Latin dance music and dance steps are warm, lively, unrestrained, and full of passion [5, 6]. It also has the effect of bodybuilding, cultivating good temperament, and cultivating sentiment. Therefore, it is welcomed by the dance industry and ordinary people. The factors that affect the competitive ability of high-level sports dancers mainly include dance partner, coach, external factors of the venue, self-factors, psychological quality, technical ability, competition status, physical quality, *etc*. Nowadays, strengthening the training of physical fitness has become the focus of players and coaches because only players with good physical fitness can successfully complete technical movements and more difficult movements [7-10].

Many experts and scholars have conducted in-depth research on the impact of training on the cardiovascular function of athletes. Qi *et al*. analyzed the hypoxic adaptation and exercise cardiopulmonary function indicators of plateau and plain athletes after 4 weeks of plateau training to understand their characteristic differences. Further, they analyzed the possible reasons for the impacts and provided guidance for comprehensively improving the scientific level of high-altitude training [11]. Liao *et al*. explored the impact of periodic high-intensity exercise training on the immune function of hockey players [12], while Zhang *et al*. studied and analyzed the effect of 10 weeks of high-intensity interval training on the cardiovascular function of wrestlers [13]. The results indicated that 10 weeks of high-intensity interval training for wrestlers could strengthen their cardiovascular function, reduce urea, and improve their athletic ability. Yang *et al*. observed the effect of a prolonged endurance training on the right ventricular systolic function of adolescent long-distance runners [14]. The results showed that younger athletes had a higher degree of decline in right ventricular systolic function. Qiang *et al*. and other researchers found that high-altitude training had a significant improvement effect on the performance of athletes, mainly affecting their exercise system, respiratory system, vascular system, cardiovascular system, and regulatory nervous system functions [15-17].

Excellent athletes need to possess excellent physiological qualities such as high speed, strong endurance, good static and dynamic strength, and balance ability. Among many Latin dance competition groups, endurance is particularly crucial, and biochemical indicators can objectively and standardly evaluate the physical condition of different athletes at the molecular level. During Latin dance training, when athletes bear exercise loads, a series of biochemical changes will occur in their bodies. There are significant differences in exercise load intensity among different training methods, and the same is true for their impact on physiological functions. This study evaluated the intensity of training load and grasped the changes in physiological functions of athletes by testing and analyzing biochemical indicators of different athletic groups. The results of this study would provide a solid theoretical basis for athletes to adjust their training load reasonably, improve competitive ability, strive to improve technical action level, prevent excessive fatigue and sports injuries. It would also provide strong guidance for high-quality teaching and scientific training.

Materials and methods

Recruitment of experimental candidates

Ten (10) sport dancers including 5 males and 5 females with the age of 15-19 years old from either college dance major or high school art candidates in Nanyang, Henan, China were involved in this study. All participants were active Latin dance competition players and won the top six results in the World DanceSport Federation (WDSF) competition in their age group. WDSF is one of the most authoritative international sports dance organizations headquartered in Lausanne, Switzerland with the commitment of promoting and regulating sports dance and providing a platform for global dance enthusiasts to communicate and compete. All participants signed an informed consent form before the experiment. All procedures of this study were approved by the Ethics Committee of Nanyang Vocational College of Agriculture, Nanyang, Henan, China.

Data and sample collection

The participants conducted a simulated Latin dance competition in the same specified dancing competition area (23 m long and 15 m wide) with the unified music. Each dance was 1.5 mins long, and the interval between two consecutive dances of multiple dance groups was 1 min. Before dancing, the fingertip blood sample, urine sample, and physiological indicators including heart rate (beats/minute), respiratory rate (times/minute), blood pressure (mmHg), blood oxygen saturation (%), pulse (times/minute), lung capacity (L), maximum expiratory pressure (mmHg), bradycardia (beats/minute), tachycardia (beats/minute), breathing depth (L), breath pause (seconds), difficulty breathing, blood gas analysis, myocardial oxygen consumption, electrocardiogram, neurological function, and body temperature (℃) were collected from each participant. During the exercise, the participants wore a Polar Grit X Pro high-end titanium heart rate meter (Polar Electro, Kempele, Finland) to record the start and end time of each dance, and the start and end time of each contestant's exercise. The fingertip blood samples were collected again immediately after exercise. Two tubes of 20 uL fingertip blood samples were collected before and after exercises by non-anticoagulant capillary blood collection tube for blood lactic acid and hemoglobin measurements, respectively. An additional 100 uL fingertip blood was also collected for blood urea and serum creatine kinase measurement. After exercise, the dance members were divided into two groups and the urine samples were collected separately after 15 minutes of quiet adaptation. The whole experiment consisted of 6 tests and was conducted once every other day. The dance sequence of multiple dance groups was in accordance with the competition rules of the WDSF.

Measurements of indicators

This study focused on the indicators that were of great significance for understanding the physiological changes of individuals during exercise. During the experiment, participants were required to complete a series of tests including assessment of subjective fatigue (RPE), recording of basic body information (age, height, weight, body fat), measurement of reaction time, grip strength, heart rate (HR), and stability by standing on one foot with closed eyes. In addition, the biochemical analysis of participants' blood and urine samples were performed at Zhang Zhongjing Traditional Chinese Medicine Hospital (Nanyang, Henan, China), which included blood lactate (Bla), blood glucose (GLU), serum creatine kinase (CK), blood urea (BU), and urinalysis.

Statistical analysis

SPSS software (IBM, Armonk, New York, USA) was employed for statistical analysis of this study. All experimental data were expressed as mean ± standard deviation (SD). One-way ANOVA was applied to detect the differences among the variables with the *P* value less than 0.05 as significant difference and *P* value less than 0.01 as very significant difference. Regression analysis was applied to reveal the causal relationship between the research variables.

Results and discussion

Changes of indexes in Latin dance simulation competition of individual groups

Table 1. The heart rate (beats/minute) of individual group before and after simulated competition.

	Cha-cha	Rumba	Cowboy	Samba	Bullfight
Before	110.60 ± 4.45	108.40 ± 7.12	115.10 ± 3.90	111.80 ± 4.69	117.20 ± 2.74
After	174.20 ± 4.32**	165.80 ± 13.78**	184.60 ± 6.95**	180.50 ± 7.79**	182.60 ± 8.95**

Note: ** indicated that there was a very significant difference before and after exercise (*P* < 0.01).

Table 2. The *P* values of one-way ANOVA tests of heart rate after exercise among individual groups.

	Rumba	Cowboy	Samba	Bullfight
Cha-cha	0.401	0.014	0.222	0.113
Rumba	-	0.008	0.068	0.037
Cowboy	-	-	0.728	0.979
Samba	-	-		0.979

The heart rate changed before and after the exercise of all style of dances were very significant (*P* < 0.01) (Table 1). There was a significant heart rate difference between the Cha-cha dance and Cowboy dance after the exercise (*P* < 0.05), and a very significant difference between Rumba dance and Cowboy dance (*P* < 0.01). In addition, there was a significant heart rate difference between the Rumba dance and Bullfighting dance after the exercise (*P* < 0.05). However, no significant heart rates difference was observed between the other dance types (*P* > 0.05) (Table 2). During the exercise, the maximum heart rate of Cha-cha dancer reached 201 beats/min. The maximum heart rate levels of Cowboy dancer and Bullfighting dancer were basically about the same and showed the significant differences compared with Rumba dancer (*P* < 0.01).

The dancers' heart rate curves of the five style dances all showed an upward trend with a large rise in the first minute and a gentle rise in the next 30 seconds. The heart rate curves of Rumba dance and Cha-cha dance were close, while the heart rate curves of Samba dance and Bullfighting dance were close. However, the trend of the heart rate curve of Bullfighting dance was steeper with the largest rising range, while that of Rumba dance was the smallest one and the heart rate decreased in the second half. The change of heart rate of Cha-cha dance was very similar to that of Rumba dance in the first 30 seconds, and the rising range of heart rate of Cha-cha dancer was greater than that of Rumba dancer in the last 1 minute.

The heart rate distribution of different dances was different. The center rate of Cowboy dancer was concentrated between 181 - 200 beats/min, accounting for 44.2% of the whole exercise heart rate, while Bullfighting dancer and Samba dancer took the second place, accounting for 35.5% and 33.7%, respectively. The heart rate of Cha-cha dancer was mostly between 161 - 180 beats/min, accounting for 54.1% of the heart rate of the whole dance. Samba dancer took the second place, accounting for 43.5%, while the heart rate of Rumba dancer was mainly between 141 - 160 beats/min.

Changes of indexes in Latin dance simulation competition of multi dance groups

The heart rate changes of multi dance groups after and before the exercise were very significant (*P* < 0.01) (Table 3). The heart rate after completing two dances was significantly different from that after completing three, four, and five dances (*P* < 0.01). However, the heart rate changes among other groups were not significant (*P* > 0.05) (Table 4). The changes of blood lactic acid before and after 2, 3, 4, and 5 dances exercise groups demonstrated significant differences (Table 5). The blood lactic acid concentration after five consecutive dances was the highest one, reaching 9.18 ± 2.54 mmol/L,

Table 3. Changes of heart rate in multi dance groups before and after exercise.

	Two dances	Three dances	Four dances	Five dances
Before	108.40 ± 12.10	108.40 ± 12.10	118.24 ± 14.25	115.32 ± 14.80
After	165.80 ± 13.78	184.60 ± 6.95	180.50 ± 7.79	182.70 ± 9.71

Table 4. The *P* values of one-way ANOVA analysis of heart rate after exercise in multi dance groups.

	Three dances	Four dances	Five dances
Two dances	0.002	0.021	0.006
Three dances	-	0.836	0.78
Four dances	-	-	0.969

Table 5. Changes of blood lactic acid (mmol/L) before and after multi dance exercise.

	Two dances	Three dances	Four dances	Five dances
Before	1.93 ± 0.36	1.93 ± 0.36	1.90 ± 0.31	1.87 ± 0.29
After	7.61 ± 2.28	8.19 ± 2.20	9.08 ± 2.12	9.18 ± 2.54

which was very close to that after four consecutive dances that was 9.08 ± 2.12 mmol/L. There was no significant difference of blood lactic acid among the four groups after exercises.

Physiological requirements for different style dances

The results showed that Latin dance was a sports event with high load intensity, and sports dance players needed to have good physical function and high requirements for physical fitness. However, different kinds of dances have different physical requirements for players. In Samba, Bullfighting, and Cowboy dancing, anaerobic energy supply was mainly used, and most of the exercise time was in anaerobic intensity, which was necessary to strengthen the player's abilities of glycolysis and lactic acid elimination. In Rumba and Cha-cha dances, players needed to have high acid resistance. From the perspective of exercise time in multiple dances, with the increase of dance groups, the exercise time was prolonged, and the exercise intensity and amount were also changed. Energy was mainly supplied by both aerobic and anaerobic metabolisms. The five dances group including five styles of dances had the longest exercise time with the exercise time of each type of dance at 1.5 minutes and 1 minute interval between each dance. In high-intensity intermittent sports, the players needed to have good physical fitness and good lactic acid tolerance.

Assessment of the physical quality of the players

(1) Reaction time and grip strength

Reaction time is the focus of common concern of coaches and athletes in the field of sports. Reaction ability is the key for athletes to master and use sports technology, which is mainly reflected in the time when the body reacts when it is stimulated by the outside world. It includes the time required for sensory organs to be stimulated, the time required for brain processing, the time for nerve conduction, and the time for muscles to respond. The factors affecting the response time are mainly divided into two parts that are the objective factors including the time, intensity, and difficulty of stimulation and the subjective factors including age, gender, adaptation level, individual differences, and so on. The results of this study showed that the reaction time decreased, and the grip strength increased after continuous multi dance exercise, but there was no significant difference before and after exercise.

(2) Balance ability

Standing on one foot with eyes closed is a simple method to test the balance ability. It is to maintain the standing status (time) of the body with one foot without any visual reference, which only relies on the equilibrium receptors of the vestibular organs of the inner ears and brain, and the coordinated movement of the muscles of the whole body to reflect the strength of the balance ability. If the time is short, it indicates that the physical function is poor, and the exercise of the balance ability needs to be strengthened. The results demonstrated that the standing time of one foot with eyes closed was shortened after exercise and there was a significant difference among the female athletes. It was suggested that the vestibular organ balance ability of the subjects should be strengthened during the training, and the muscle strength and coordination ability should be assisted.

(3) Subjective fatigue (RPE)

The results showed that there were very significant differences in RPE values before and after the exercise, especially after the multi dance exercise, the players felt that it was more difficult. The average player's RPE value of the five dances group was 13.29 after the exercise, and the body was in a slightly tired state. Which suggested that the Latin dance competition of multiple dance groups had a significant impact on the physical function of the players. Although the Latin dance competition is short, the continuous dance of multiple dance groups requires sufficient muscle endurance, balance ability, and movement coordination ability of the players. Completing each movement will consume a lot of energy. The internal energy balance will be broken, and the players will feel tired. From the RPE test results, it was found that the player's RPE value after multiple dances was significantly higher than that of the single dance group. Among them, the RPE values of the five dances group and the four dances group were higher than the other groups, and the players felt very tired subjectively. However, the RPE values of the three dances group and the two dances group were low, and the players felt slightly tired subjectively, and the body could recover after a short period of quiet rest.

(4) Heart rate

The results of this study showed that, in the process of continuous multi dance movement of Latin dance, the heart rate of each dance type had obvious changes after 1.5 minutes of continuous movement and 1 minute of the rest adjustment. The heart rate underwent a rapid rise period followed by a stable period, and then rapidly decline. When the next dance started, the heart rate continued to rise and then decline. However, each peak and the underestimated heart rate were different, and the initial heart rate of the multi dance group had an increasing trend. Different groups had different Latin dance sports time. The competition times of five dances, four dances, three dances, and two dances groups were about 11.5, 9, 6.5, and 4.5 minutes, respectively. With the increase of exercise time, the body bears more load. The experimental results showed that there were very significant differences between the three dances group, the four dances group, and the five dances group after two consecutive dances. There were also very significant differences between the three dances group and the five dances group, but there was no significant difference between three dances and four dances groups. There was also no significant difference in heart rate between the five dances and four dances groups after exercise. The results suggested that the load intensities of continuous five dances and four dances were the same, while the intensity of three dances was slightly smaller, and the load of two dances was the smallest one. In different groups of Latin dances, in addition to the differences in exercise time, there were also differences in dance types and dance sequences, resulting in different exercise load intensity.

Biochemical indicators

(1) Blood lactic acid concentration

The change of blood lactic acid concentration after Latin dance in the multi dance group was obvious. From the analysis of the rising range of blood lactic acid concentration after the exercise, the blood lactic acid value of the five dances players after the exercise was 9.18 ± 2.54 mmol/L, which was very significant different from that before the exercise ($P < 0.01$). The average value of blood lactate after four dances exercise was 9.08 ± 2.52 mmol/L, which was very close to the value of five dances group after exercise. Blood lactate is a sensitive indicator to assess the intensity of exercise load. The generation of lactate is mainly in skeletal muscle, and the elimination site is mainly in skeletal muscle, cardiac muscle, and liver. The increase of blood lactate content indicates that the exercise intensity is large. The exercise intensities of Latin five dances and four dances groups in multiple dance groups were significantly higher than that of two dances and three dances groups.

(2) Urine protein

In addition to blood lactic acid concentration, urine protein is a sensitive indicator for assessing the intensity of load. After intense competition or sports training, the protein in urine will increase. Especially, the increase of urine protein after competition is significantly higher than that during training, which may be because the stimulation of load intensity in competition is greater than that during training. The impact on the body is more intense, and the endocrine activity may be strengthened due to the highly concentrated and tense mental state during the competition. The results of this study showed that the positive rate of urinary protein in the urine after the five dances was the highest one, indicating that the body was in a state of maladjustment, which had great stimulation to the body. The positive rate of urine protein in the four dances group was lower than that of the five dances group. However, it was significantly higher than that in three dances and two dances groups, which indicated that, among the Latin dances of multiple dance groups, the intensity from the highest to lowest was following the sequence of five dances, four dances, three dances, and two dances.

Conclusion

In solo Latin dance, Cowboy dance had the highest exercise load intensity followed by Bullfighting dance and Samba dance. Chacha dance and Rumba dance had similar exercise load intensity, but Rumba dance had the smallest load intensity. The exercise load intensities of the five dances and four dances groups were similar, but were significantly higher than that of the three dances and two dances groups. The solo group mainly relied on anaerobic metabolism, while the continuous Latin dance mainly relied on both aerobic and anaerobic metabolisms. After the Latin dance competition, the excitability of muscles and nerves increased, while the function of vestibular organs and lower limb strength decreased. The results suggested that, in the training of Cha-cha and Rumba dances, it was necessary to strengthen the training of athletes' acid resistance to prevent acidosis, while, in the training of Cowboy, Bullfighting, and Samba dances, it should strengthen the training of athletes' glycolytic and lactate clearance abilities. For the multi dance combinations, the training should enhance the aerobic and anaerobic metabolic abilities of athletes. Athletes should pay attention to controlling the rhythm of music and enhancing their balance and coordination abilities during training or competition. The recommended five dances sequence for Latin dance competitions was Rumba, Samba, Cowboy, Cha-cha, and Bullfighting, while the recommended order for the four dances was Rumba, Samba, Cowboy, and Cha-cha.

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