Effects of L v Jian sports drink on selected physiological parameters in athletes

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Abstract: Objective: To investigate the effects of L v Jian sports drink on certain physiological indicators in boxing and taekwondo athletes under high-intensity training conditions, and to explore whether it has the function of improving physical performance and anti-fatigue. Methods: Boxing and taekwondo athletes were randomly and equally divided into an experimental group and a control group. The experimental group and the control group were supplemented with L v Jian sports drink and control drink daily, respectively. Blood biochemical indicators of the subjects were tested before the experiment, and at 2 and 4 weeks. Results: Compared with the control group, the experimental group showed significantly increased serum testosterone levels ($P<0.05$), significantly decreased creatine kinase ($P<0.05$), and relatively stable hemoglobin content. Conclusion: Supplementation with L v Jian sports drink is beneficial for improving physical function and promoting fatigue recovery in boxing and taekwondo athletes during high-intensity training.

Keywords: L v Jian sports drink, Cistanche deserticola, Lycium barbarum, anti-fatigue, athletes

1. Introduction

During high-intensity training, sufficient training stimuli cause microstructural damage to muscles, and muscle cells produce supercompensation during the repair process of this microstructural damage. Timely, scientific, and reasonable nutritional supplementation after training can enable the metabolic state of muscle cells to rapidly shift from catabolism-dominant during exercise to anabolism-dominant, achieving rapid fatigue elimination, enhanced muscle strength, and maintenance or improvement of athletes' physical performance. This not only concerns athletes' physical health but also directly affects training outcomes. Therefore, we developed L v Jian sports drink and conducted a study on its effects on physiological indicators in boxing and taekwondo athletes. The results are reported as follows.

2. Materials and Methods

2.1. Formulation characteristics of L v Jian sports drink

The main ingredients of L v Jian sports drink contain effective components of Cistanche deserticola and Lycium barbarum, supplemented with various vitamins and minerals.

2.2. Basic information of experimental subjects

The experimental subjects were second-line athletes from the Third Sports Team of Inner Mongolia, including 30 male boxing athletes and 20 female taekwondo athletes.

2.3. Experimental grouping and intervention protocol

Experimental Design: Boxers and taekwondo athletes were randomly divided into an experimental group and a control group. Each group consisted of 15 boxers and 10 taekwondo athletes, totaling 25 participants. No statistically significant differences were found in the general baseline characteristics between the two groups ($P>0.05$), indicating comparability (see Table 1). The experimental group and control group were

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supplemented daily with 2,000 ml of L v Jian sports drink and a control beverage (lacking the active ingredients of the L v Jian drink but with similar appearance and taste), respectively, for 4 consecutive weeks. Training was conducted 6 days per week; Sundays were designated as rest days with no supplement administration. Both groups maintained consistent training and dietary standards throughout the experimental period.

Table 1 General Baseline Characteristics of the Subjects ($\bar{x} \pm s$)

Group	Subjects	n	Gender	Age (years)	Height (cm)	Weight (kg)
Control	Boxers	15	Male	18.5±0.8	179.5±3.7	75.6±4.9
	Taekwondo athletes	10	Female	18.0±1.3	166.0±2.4	65.2±4.5
Experimental	Boxers	15	Male	18.3±1.1	177.1±2.6	74.2±4.0
	Taekwondo athletes	10	Female	17.8±1.9	165.2±3.1	64.8±5.7

2.4. Measured indices

2.4.1. Protein metabolism indices

Serum testosterone (T), cortisol (Cor), and blood urea nitrogen (BUN). Testosterone was measured using a radioimmunoassay kit from MP Biomedicals (USA-China), cortisol using a radioimmunoassay kit from Beijing North Institute of Biological Technology, and urea using a product from Bio Sino Bio-Technology & Science Inc.

2.4.2. Oxygen-carrying capacity related indices

Red blood cells (RBC), hemoglobin (Hb), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and ferritin. Ferritin was measured using a radioimmunoassay kit from Beijing North Institute of Biological Technology.

2.4.3. Skeletal muscle tissue injury indices

Creatine kinase (CK) and lactate dehydrogenase (LDH) activities, both measured using products from Bio Sino Bio-Technology & Science Inc.

2.4.4. Liver function indices

Alanine aminotransferase (ALT), aspartate aminotransferase (AST), and γ-glutamyl transpeptidase (γ-GT), all measured using products from Bio Sino Bio-Technology & Science Inc.

2.4.5. Electrolyte balance indices

Potassium, sodium, calcium, and magnesium.

2.5. Main detection instruments

Serum testosterone, cortisol, and ferritin were measured using an FT-613 automatic 125I radioimmunoassay counter; urea, CK, LDH, ALT, AST, γ-GT, calcium, and magnesium were measured using an OLYMPUS AU400 automatic biochemical analyzer; potassium and sodium were measured using a MEDICA Easylyte PLUS Na/K/Cl analyzer; RBC, Hb, MCH, and MCHC were measured using a Sysmex KX-21 hematology analyzer. All instruments were medical devices from the Clinical Laboratory of the 253rd Hospital of the PLA.

2.6. Statistical analysis

Data are presented as mean ± standard deviation ($\bar{x} \pm s$). Comparisons within and between groups were performed using the t-test. A P-value < 0.05 was considered statistically significant.

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3. Results

3.1. Effects of L v Jian sports drink on protein metabolism indices

During the experiment, testosterone decreased in the control group, whereas it increased in the experimental group. Significant differences were observed in the male experimental group at week 2 ($P < 0.05$) and in the female experimental group at week 4 ($P < 0.05$). No significant differences were found in other intragroup or intergroup comparisons ($P > 0.05$) (see Table 2).

During the experiment, cortisol showed a slight increase in the control group, whereas it decreased slightly in the experimental group. Intergroup comparisons between the two groups were highly significant at pre-experiment, week 2, and week 4 ($P < 0.01$). However, no significant differences were found in intragroup comparisons at various time points within either group ($P > 0.05$), indicating that the subjects in the two groups were not at the same baseline level for this indicator prior to the experiment, and that L v Jian sports drink had little effect on cortisol. Urea decreased in both groups, with a highly significant intergroup difference at week 4 ($P < 0.01$). In the control group, significant differences were observed between pre-experiment and week 4, as well as between week 2 and week 4 ($P < 0.05$). No significant differences were found in other intergroup or intragroup comparisons ($P > 0.05$) (see Table 3).

Table 2 Serum Testosterone in Athletes at Baseline, Week 2, and Week 4($\bar{x} \pm s$,ng/ml)

Gender	n	Control group (n=25)			Experimental group (n=25)		
		Baseline	Week 2	Week 4	Baseline	Week 2	Week 4
Male	30	5.75±1.75	4.99±1.38	5.50±2.24	5.88±1.39	6.21±1.44	5.97±1.49
Female	20	0.64±0.25	0.61±0.24	0.52±0.14	0.60±0.24	0.70±0.28	0.77±0.39

Table 3 Cortisol and Urea at Baseline, 2, and 4 Weeks ($\bar{x} \pm s$)

Parameter	Control group (n=25)			Experimental group (n=25)		
	Baseline	Week 2	Week 4	Baseline	Week 2	Week 4
Cortisol (ng/ml)	497.00±130.00	507.00±126.00	529.00±82.00	393.00±60.00	369.00±69.00	382.00±63.00
Urea (mmol/L)	5.71±1.30	5.50±1.18	4.76±0.83	5.84±1.26	5.52±1.19	5.60±1.07

3.2. Effects of L v Jian sports drink on oxygen-carrying capacity-related indices

During the experiment, Hb, RBC, MCH, MCHC, and ferritin decreased in both groups. In the control group, a significant difference was found between pre-experiment and week 4 for Hb ($P < 0.05$). No significant differences were observed in other intragroup or intergroup comparisons ($P > 0.05$) (see Table 4).

Table 4 Oxygen-Carrying Capacity Indices at Baseline, 2, and 4 Weeks ($\bar{x} \pm s$)

Parameter	Control group (n=25)			Experimental group (n=25)		
	Baseline	Week 2	Week 4	Baseline	Week 2	Week 4
Hb(g/L)	147.0±12.0	142.0±17.0	138.0±15.0	142.0±17.0	138.0±17.0	136.0±18.0
RBC($\times 10^{12}$/L)	5.0±0.4	4.8±0.5	4.7±0.5	4.9±0.5	4.7±0.5	4.7±0.5
MCH (p g)	29.7±1.2	29.5±1.9	29.1±2.0	29.3±2.9	29.5±2.8	29.2±2.7
MCHC(g/L)	371.0±8.0	369.0±12.0	366.0±11.0	366.0±17.0	367.0±19.0	366.0±18.0
Ferritin(ng/L)	81.5±61.6	78.0±66.7	69.7±57.6	66.0±55.4	58.4±48.8	58.4±49.3

3.3. Effects of L v Jian sports drink on skeletal muscle damage indices

During the experiment, CK increased initially and then decreased, with a significant difference in the experimental group between week 2 and week 4 ($P < 0.05$). No significant differences were found in other

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intragroup or intergroup comparisons (P > 0.05). LDH activity in both groups decreased initially and then increased, with significant differences in intragroup comparisons between pre-experiment and week 2, as well as between week 2 and week 4 (P < 0.05). No significant differences were observed in other intragroup or intergroup comparisons (P > 0.05) (see Table 5).

Table 5 Skeletal Muscle Injury Markers at Baseline, 2, and 4 Weeks($\bar{x} \pm s$,U/L)

Parameter	Control group (n=25)			Experimental group (n=25)		
	Baseline	Week 2	Week 4	Baseline	Week 2	Week 4
Creatine kinase	171±110	184±137	135±56	194±162	257±306	121±48
Lactate dehydrogenase	157±33	122±22	164±30	153±24	123±25	157±28

3.4. Effects of L v Jian sports drink on electrolyte balance indices

During the experiment, no significant differences were found in potassium, sodium, calcium, or magnesium between the two groups at the same time points (P > 0.05). However, intragroup comparisons showed highly significant differences for sodium and magnesium between pre-experiment and week 4, as well as between week 2 and week 4 (P < 0.01), whereas no significant difference was observed between pre-experiment and week 2 (P > 0.05). These results indicate that the decline in serum sodium and magnesium was particularly pronounced after 2 weeks (see Table 6).

Table 6 Electrolyte Balance Indices at Baseline, 2, and 4 Weeks($\bar{x} \pm s$,mmol/L)

Parameter	Control group (n=25)			Experimental group (n=25)		
	Baseline	Week 2	Week 4	Baseline	Week 2	Week 4
Potassium	-	4.15±0.30	4.02±0.37	-	4.10±0.26	4.09±0.19
Sodium	142.00±4.00	141.00±2.00	135.00±3.00	139.00±4.00	141.00±2.00	136.00±3.00
Calcium	2.24±0.18	2.30±0.10	2.27±0.06	2.23±0.13	2.31±0.08	2.29±0.09
Magnesium	0.84±0.12	0.96±0.14	0.75±0.06	0.90±0.10	0.92±0.12	0.79±0.08

3.5. Effects of L v Jian sports drink on liver function

ALT, AST, andγ-GT levels in both groups remained below the upper limit of normal at pre-experiment, week 2, and week 4, indicating that this sports drink caused no damage to liver function.

4. Discussion

4.1. Mechanisms of exercise fatigue and anti-fatigue strategies

The mechanisms and patterns of exercise-induced fatigue, as well as effective anti-fatigue measures, have long been a major research focus in exercise physiology, nutrition, food science, and related disciplines both domestically and internationally. Currently, three primary mechanisms are recognized for the development of exercise fatigue: depletion of energy substrates, accumulation of metabolic byproducts, and disturbance of internal homeostasis. In addition to athletes' inherent physical fitness and scientifically designed training regimens, nutrition and supplementation represent effective anti-fatigue strategies. These approaches ensure the regulatory processes of the nervous, endocrine, and enzymatic systems, enabling various metabolic processes to proceed smoothly during exercise, thereby enhancing athletic performance, promoting post-exercise recovery, and safeguarding athletes' health.

4.2. Pharmacological effects of the main components of L v Jian sports drink

Lycium barbarum (goji berry) is the mature fruit of Lycium chinense, a plant in the Solanaceae family. It has a sweet and neutral taste, is slightly cold in nature, and non-toxic, with effects of nourishing the kidney, moistening the lung, tonifying the liver, and improving eyesight. Wang Ningyuan et al. [1] reported that

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aqueous decoction of Lycium barbarum significantly enhanced the cold tolerance of mice in low-temperature environments, prolonged their hypoxia tolerance time under normal pressure, and extended their swimming time under high-temperature conditions, thereby improving anti-fatigue capacity. Cistanche deserticola has a sweet, sour, and salty taste, with effects of tonifying the kidney and benefiting essence. The Shen Nong Ben Cao Jing (Classic of Herbal Medicine) records that it "mainly treats five types of over exertion and seven types of injury, tonifies the middle, relieves cold-heat pain in the penis, nourishes the five viscera, strengthens yin, and benefits essence-qi." Ji Zhihua et al. [2] found that sports health beverages with Cistanche as the main component exhibited significant anti-fatigue effects without obvious influence on body weight gain.

4.3. Exercise fatigue metabolism and alkaline electrolytes

During vigorous exercise, skeletal muscle primarily obtains energy through glycogenolysis of muscle glycogen, with pyruvate as its metabolic product. Pyruvate accepts hydrogen from NADH, the coenzyme of glyceraldehyde-3-phosphate dehydrogenase, and is converted to lactate under the catalysis of LDH. The accumulation of lactate manifests as "exercise-induced acidemia," which is an early manifestation of exercise fatigue. If the increased lactate accumulates extensively in blood and muscle, it can cause a decrease in pH, reducing the binding capacity of troponin to calcium ions and decreasing the number of reactive actin sites, thereby impairing muscle contractility. Reduced pH can also inhibit the activity of phosphofructokinase, blocking the anaerobic energy supply pathway, decreasing ATP production, and resulting in insufficient energy sources for muscle contraction, which readily leads to fatigue [3]. While consuming muscle glycogen, the body simultaneously takes up blood glucose from the circulation, which can be replenished through hepatic glycogenolysis to maintain balance. Once muscle and liver glycogen are substantially depleted, blood glucose declines, leading to inadequate energy supply to the central nervous system and consequently causing generalized fatigue and decreased physical performance. Appropriate amounts of alkaline electrolytes can prevent and correct exercise-induced acidemia, regulate acid-base balance in the body, facilitate the elimination of exercise fatigue, and increase alkaline reserve, thereby improving athletic performance [4].

4.4. Effects of L v Jian sports drink on serum testosterone and blood indices

Androgens are closely related to athletic performance. Studies have shown that chronic exercise-induced fatigue can cause endocrine dysfunction, with the most prominent manifestation being a significant decrease in serum testosterone [5]. Low testosterone levels are an important factor contributing to functional decline and impaired athletic capacity. Hu Hui et al. [6] reported that both serum total testosterone and free testosterone levels decreased significantly after prolonged fatiguing exercise in humans. Testosterone is an important anabolic hormone in the human body that can prevent protein catabolism during fatigue and increase protein synthesis, thereby promoting muscle protein synthesis [7]. Vigorous exercise itself can cause damage to skeletal muscle cell membranes and structural proteins, which requires post-exercise protein synthesis for repair. The present study found that supplementation with L v Jian sports drink elevated serum testosterone levels in boxers and taekwondo athletes during intensive training. Therefore, theoretically, it could prevent protein catabolism during fatigue, facilitate rapid recovery from fatigue, and maintain physical strength and energy. Additionally, testosterone stimulates the secretion of erythropoietin [8], promoting erythrocyte production and benefiting functional improvement. The oxygen required for energy metabolism is carried by Hb in RBCs; higher RBC counts and Hb concentrations enhance the oxygen-carrying capacity of blood, enabling tissues to utilize more oxygen and generate more ATP, which facilitates aerobic oxidative energy supply, reduces lactate production, and enables timely transport of CO_2 produced in muscle tissue to the lungs for elimination, thereby preventing muscle fatigue caused by pH decline. These effects play a positive role in delaying the onset of fatigue and accelerating its elimination. Ferritin is one of the main storage forms of iron in the body, and serum ferritin levels are positively correlated with iron stores. Iron deficiency can impair Hb synthesis and affect oxygen transport. Numerous studies have demonstrated that both athletes and animals exhibit significantly decreased Hb levels during overtraining [9]. Ye Jianfei [10] reported that Hb decreased significantly during exhaustive training in rats, with a trend of continuous decline over time. The results of this study showed that although L v Jian sports

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drink supplementation could not prevent the decline in Hb, the difference compared with pre-experiment was not significant, whereas the control group showed a significant difference. This indicates that L v Jian sports drink supplementation can inhibit the decline in Hb caused by overtraining, thereby facilitating the maintenance or improvement of athletic function.

4.5. Effects of L v Jian sports drink on Creatine Kinase (CK)

CK is primarily distributed in skeletal and cardiac muscle cells. Under resting conditions, serum CK activity is very low; however, prolonged vigorous exercise can cause damage to skeletal muscle cells and structural proteins, leading to CK leakage and a marked increase in serum CK levels. These changes are sensitive and pronounced, making CK a commonly used indicator of physical energy expenditure [2,11,12]. The present study demonstrated that supplementation with L v Jian sports drink significantly reduced CK levels under high-intensity training conditions, suggesting that this beverage may exert certain protective effects on cell membranes or promote the repair of exercise-induced skeletal muscle damage, thereby reducing CK leakage from muscle cells, decreasing energy consumption during exercise, accelerating physical recovery, and exhibiting certain anti-fatigue properties.

4.6. Effects of L v Jian sports drink on cortisol, Urea, and LDH

Cortisol is a glucocorticoid primarily secreted by the zona fasciculata of the adrenal cortex, commonly used in functional studies of the hypothalamic-pituitary-adrenal (HPA) axis as well as in pathological and physiological research. Cortisol levels influence athletic performance to a certain extent; one of the endocrine characteristics of elite athletes is the ability to maintain relatively high cortisol levels during exercise [13]. Urea is an important end product of protein metabolism. Protein serves as a major structural component of the body, but under certain conditions also participates in energy metabolism. The magnitude of post-exercise blood urea elevation indicates the extent to which the body utilizes protein and amino acids for energy. The degree to which protein is mobilized as an energy reserve reflects the body's adaptive capacity. The stronger the adaptive capacity, the less protein is mobilized, resulting in lower urea production and decreased urea levels.

Conversely, when adaptive capacity is weak, more protein is mobilized, leading to increased urea levels; therefore, urea is commonly used as an indicator of training intensity [14,15]. Chronically elevated cortisol and urea levels, together with chronically decreased Hb and RBC counts, are generally associated with lower load tolerance capacity in athletes. During vigorous exercise, lactate produced by muscle glycogen glycolysis is ultimately eliminated through the Cori cycle via gluconeogenesis and converted to glucose for secondary energy supply. In this process, blood lactate enters the liver through circulation and is converted to pyruvate catalyzed by LDH. Therefore, increased LDH activity facilitates the rapid conversion and clearance of pyruvate and lactate, metabolic byproducts of the skeletal muscle glycolytic pathway during vigorous exercise, thereby restoring normal acid-base balance and contributing to the relief of exercise fatigue. The present study found that L v Jian sports drink had minimal effects on cortisol, urea, and LDH, possibly because the experiment was conducted during the athletes' normal intensive training, with relatively scientific training methods that did not induce significant physiological fluctuations or excessive fatigue. The body primarily relied on increased glycogen reserves, with adequate glucose available for energy supply. The subsequent increase in LDH activity also facilitated the rapid clearance of blood lactate.

5. Conclusion

In conclusion, supplementation with L v Jian sports drink increased serum testosterone levels, decreased CK, and inhibited the decline in Hb in boxers and taekwondo athletes during intensive training. These findings indicate that L v Jian sports drink can inhibit or shorten exercise-induced negative nitrogen balance, maintain or promote the synthesis of Hb and other normal proteins in the body, alleviate or delay other physiological changes caused by exercise, and contribute to the improvement of physical function and recovery from fatigue in athletes undergoing high-intensity training.

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