Research on the Monitoring of Physiological Indexes of Freestyle Skiers before and after Competition

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Abstract: In order to understand the physiological characteristics of freestyle skiers before and after the competition and the alteration in their physical functions, a series of physiological indexes related to sports and health of freestyle skiers before and after the competition were examined in this study. 12 excellent athletes aged 9-18 years-old preparing for the 2022 Winter Olympic Games in the Hebei Provincial ski team were included. It was found that: 1. The average red blood cell volume, red blood cell distribution width, platelet distribution width, levels of glutamic pyruvic transaminase, glutamic oxaloacetic transaminase, high-density lipoprotein cholesterol and creatine sarcosidase in the athletes were significantly reduced after the competition. Glucose level in the athletes increased significantly after the competition. 2. The physiological indexes, such as the levels of urea, lipoprotein (a), creatine sarcosidase, testosterone and the ratio of testosterone to cortisol, are significantly different between the athletes of different genders before or after the competition; 3. The physiological indexes such as platelet count, platelet distribution width, the levels of glutamic oxaloacetic transaminase, cortisol and the ratio of testosterone to cortisol of skiers are significantly different between the athletes of younger and the elder age before or after the competition. It guides us to monitor the state and alterations of skiers according to the change patterns of these physiological indicators, so as to guide the exercise intensity and rehabilitation training of skiers.
***Keywords*:** skiing; before and after the competition; physiological indexes; sports; recovery

1. Introduction

1.1 Research background of topic selection

The life activities of the human body are affected by many aspects, including the nervous system, the endocrine system and so on. During exercise, the internal environment of the human body undergoes tremendous changes, including the physical and chemical state of cells, the changes in substances inside cells, and the secretion and metabolism of cells. Changes in the physical indicators of skiers may have a greater impact on the performance of skiers, and their physical health status and post-exercise physical rehabilitation training have a greater relationship with the performance of skiers. In the increasingly fierce competition, how to arrange exercise intensity and how to carry out rehabilitation after training is of great significance to the competition training of long-distance athletes. Before and after the competition, various physiological indicators of the skier's body will change to a certain extent, and different physiological indicators will cause the skier's state and performance to be different. By studying the changes of related physiological indicators before and after exercise, this paper hopes to play a positive role in guiding the exercise intensity and rehabilitation training of skiers.

1.2 Monitoring significance of physiological indicators

In this paper, the physiological indicators of freestyle skiers in Hebei Province were tested twice before and after the competition. Among them, there are 5 male athletes (2 persons aged 9-13 belong to the younger age group, 3 persons aged 14-18 belong to the older age group), and 7 female athletes (4 persons aged 9-13 belong to the younger age group and 3 persons aged 14-18 belong to the older age group). Physiological indicators detected include blood routine in whole blood: white blood cell count, red blood cell count, hemoglobin determination, hematocrit, the average red blood cell volume, the average hemoglobin content, the average hemoglobin concentration, red blood cell distribution width-SD, red blood cell distribution width-CV, platelets count, the average platelet volume, platelet specific volume, platelet distribution width, large platelet ratio, lymphocyte count, monocyte count, neutrophil count, eosinophil count, basophil count, lymphocyte ratio, monocyte ratio, neutrophil ratio, eosinophil ratio, basophil ratio, alanine aminotransferase, aspartate aminotransferase, glucose, triglycerides, total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, apolipoprotein A1, apolipoprotein B, apolipoprotein A1/B, lipoprotein(a), urea, creatine kinase, testosterone, and plasma cortisol.

Red blood cells play an important role in transporting oxygen in the body. During exercise, skiers need to consume a

lot of oxygen to supply the body's metabolism and energy needs. Therefore, various indicators of red blood cells are greatly affected by exercise. Hemoglobin is a binding protein composed of hemoglobin molecules and heme, and is an important substance for oxygen transport in the body[1]. Studies have found that hemoglobin is an indicator of aerobic exercise capacity and a sensitive indicator of training load[2]. The detection of mean red blood cell volume and red blood cell volume distribution width has important guiding significance for the identification of anemia in patients in medicine. The monitoring of red blood cells and hemoglobin-related indicators of skiers can be used to guide the training of skiers and prevent the occurrence of anemia in skiers.

Platelets are small pieces of biologically active cytoplasm shed from the cytoplasm of mature megakaryocytes in the bone marrow. The effect of exercise on platelet function is bidirectional. Short-term strenuous exercise activates platelets, while regular aerobic exercise inhibits platelets[3]. Detecting the state of platelets during exercise can be used to monitor the exercise intensity and exercise conditions of skiers, so as to make appropriate adjustments to the exercise training plan to meet the needs of the body and facilitate the recovery and adaptation of the body.

Creatine kinase, also known as phosphocreatine kinase, exists in human skeletal muscle, brain, cardiac muscle and other tissues. It is an important catalytic enzyme in the process of energy conversion and ATP synthesis in cells. Experimental studies have found that the increase in serum creatine kinase activity after exercise is related to the following factors: exercise intensity, exercise time, exercise type, training level, and gender[4]. Serum creatine kinase is very sensitive to exercise intensity, so in order to prevent overtraining, the training intensity can be adjusted scientifically and reasonably according to the changes in serum creatine kinase value[2].

Transaminase is an indicator of liver function. Studies have found that physical exercise, excessive activity and fatigue may transiently increase alanine aminotransferase, aspartate aminotransferase levels, and intense military training can lead to liver and muscle damage[5]. By measuring the levels of alanine aminotransferase and aspartate aminotransferase, the liver metabolism of skiers can be monitored.

Blood urea is a metabolite of protein. Under normal physiological conditions, nitrogen-containing substances such as proteins and amino acids are first removed from amino groups during catabolism, and ammonia is converted into urea in the liver, and blood urea is excreted from the kidneys through the blood circulation. Blood urea is related to human body function, degree of fatigue and load[6].

High-density lipoprotein cholesterol is an indicator of blood lipid metabolism, which can transport cholesterol from extrahepatic tissues to the liver for metabolism. Exercise training improves lipid metabolism, including significantly higher high-density lipoprotein cholesterol levels in young women aged 18-24[7].

The endocrine system is composed of human endocrine glands and some organs, tissues and cells with endocrine function. It is an important regulatory system of the human body. Exercise can affect the body's endocrine. After a lot of exercise training, the body's hormone secretion levels will change, resulting in hormone changes in the blood. Testosterone is a major male hormone that promotes anabolism in the body. It is secreted by the testes of men or the ovaries of women. It can promote protein synthesis, increase the number of red blood cells, improve the body's oxygen supply and transportation capacity, and promote metabolism. Cortisol is a steroid glucocorticoid secreted by the adrenal cortex. It is an important hormone that promotes catabolism in the body. It has a strong proteolytic effect[8], and it also plays an important role in regulating glucose metabolism during exercise[9]. Therefore, the balance of testosterone and cortisol hormones is very important for exercise training.

2. Changes of physiological indexes of skiers

2.1 Changes of physiological indexes of skiers before and after competition

Based on the comparative analysis of the physiological indexes of all skiers before and after the competition, we found that compared with those before the competition, the average red blood cell volume, red blood cell distribution width-SD, red blood cell distribution width-CV, platelet distribution width, glutamic pyruvic transaminase, glutamic oxaloacetic transaminase, high density lipoprotein cholesterol and creatine kinase levels decreased after the competition, while the level of glucose increased (Table 1). And there are significant differences in these changes (Figure 1). Therefore, it can be judged that before the training process, the metabolism of skiers is exuberant, the ability of red blood cells to carry oxygen is higher, and the contents of creatine kinase, glutamic pyruvic transaminase and glutamic oxaloacetic transaminase are higher in the blood environment, so as to catalyze the regulation of the body's exuberant metabolic response. After the competition, there are significant changes in the function of red blood cells to transport oxygen and the morphology of platelets. These parameters may be beneficial to the repair of vascular micro-injury and the regulation of permeability[10]. By judging the physiological status of skiers through data analysis, relevant training adjustments or guide rehabilitation training can be

made.

Table 1. Changes in the physiological indicators of skiers before and after the competition

Physiological indicators (units)	Pre-match average	Post-match average	Difference between post-match and pre-match averages
Average red blood cell vohume(fL)	89.72	89.23	-0.43
Red blood cell distribution width-SD(fL)	40.68	39.75	-0.93
Red blood cell distribution width-CV(%)	12.41	12.23	-0.18
Platelet distribution width(%)	12.94	12.6	-0.34
Alanine aminotransferase(U/L)	12.55	10.23	-2.32
Aspartate aminotransferase (U/L)	22.81	20.53	-2.28
HDL-C (mmol/L)	1.54	1.33	-0.21
Creatine kinase (U/L)	204.03	159.1	-44.93
Ghucose (mmol/L)	4.36	4.75	0.39

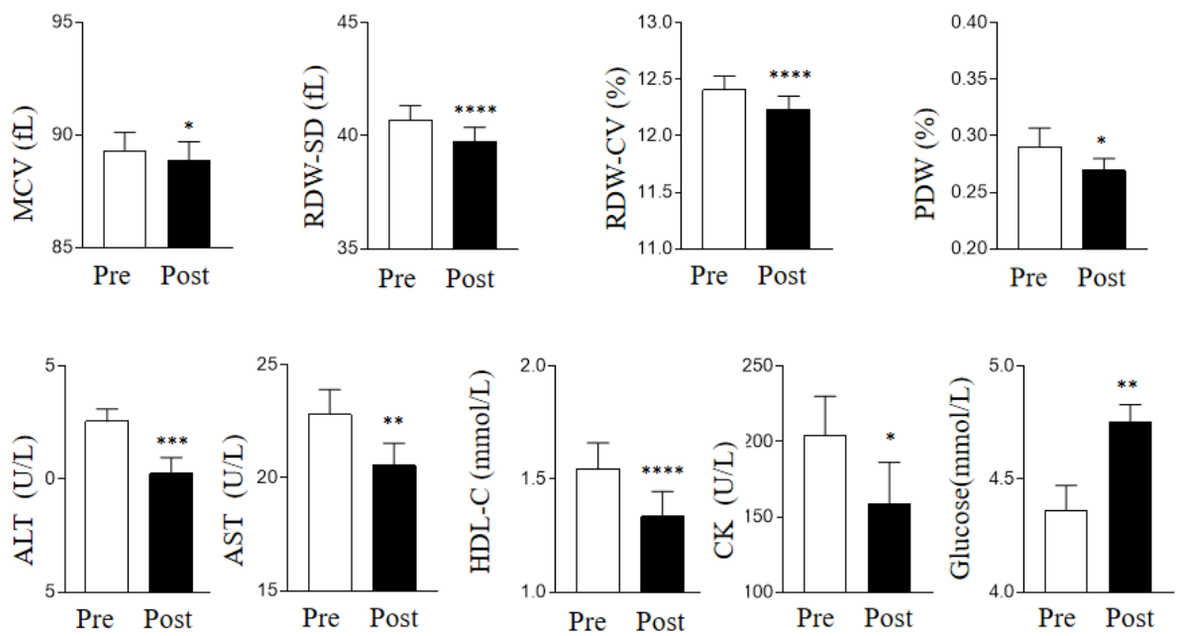

Figure 1. The changes of physiological indexes of skiers before and after the competition. The data were collected by skiers during training in Qinhuangdao, including the monitoring results of 5 male athletes (13-18 years old) and 7 female athletes (9-17 years old). *p <0.05, **p<0.01, ***p<0.001, ****p<0.0001, respectively.

2.2 Changes of physiological indexes of female skiers before and after competition

Then, we made a statistical analysis of the pre-match and post-match data of the female players. As shown in figure 2, for female team members, the average red blood cell volume, red blood cell distribution width, platelet distribution width, glutamic pyruvic transaminase, glutamic oxaloacetic transaminase and creatine kinase levels decreased significantly, while glucose levels increased. this is consistent with the changes of physiological indexes of all athletes before and after the competition. In addition, the average platelet volume and large platelet ratio of female players also decreased after the competition. It is suggested that there are significant changes in the function of red blood cells to transport oxygen and the morphology of platelets during the sports training of female skiers. Focus on the monitoring of the above indicators, it is helpful to arrange the training plan and intensity suitable for female skiers, replenish energy timely and appropriately, and play a certain guiding role in the rehabilitation of the body after exercise.

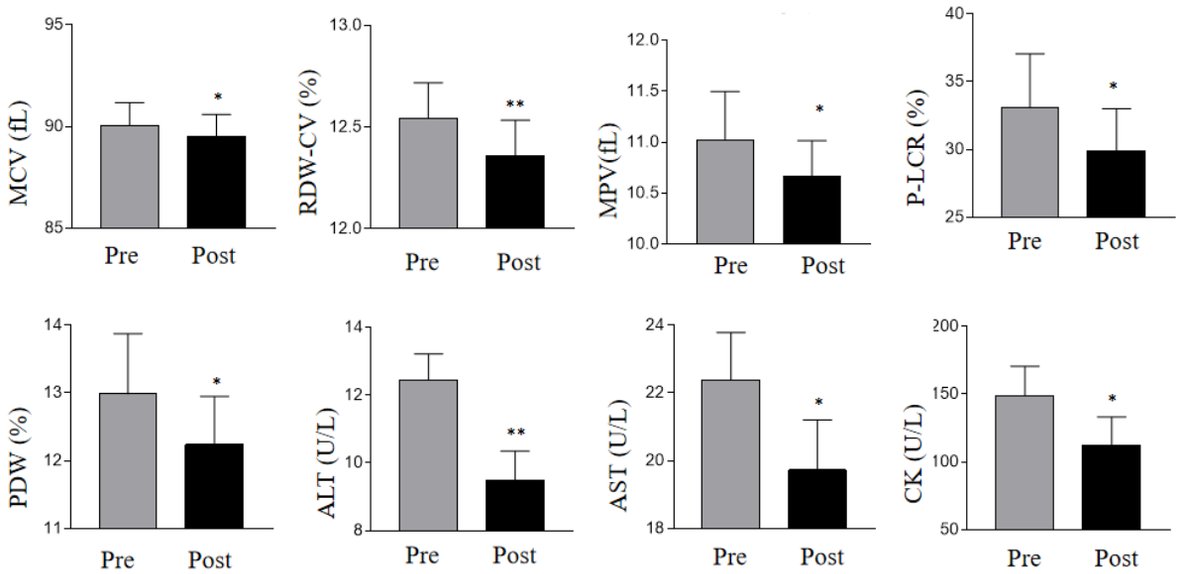

Figure 2. The changes of physiological indexes of female skiers before and after the competition. The data are the monitoring results of 7 female athletes (9-17 years old) collected by skiers during their training in Qinhuangdao. *p<0.05, **p<0.01.

2.3 Changes of physiological indexes of skiers of different genders

In order to detect the differences of physiological indexes of skiers of different genders, we compared and analyzed the physiological indexes of male and female athletes before and after the competition. Figure 3 shows that before the competition, the urea, lipoprotein (a), creatine creatine enzyme, testosterone and the ratio of testosterone to cortisol of female team members decreased significantly compared with male team members. After the game, compared with male team members, the values of lipoprotein (a), creatine creatine (a), testosterone and testosterone / cortisol decreased significantly. The level of blood urea reflects the catabolism of nitrogenous substances such as proteins and amino acids and is related to the function of the liver. There are gender differences in body fat level and lipid metabolism level, and lipoprotein (a) is related to lipid metabolism. Accordingly, there are differences in lipoprotein (a) between male and female athletes, including before and after the competition. We also found that there was a significant difference in creatine kinase between

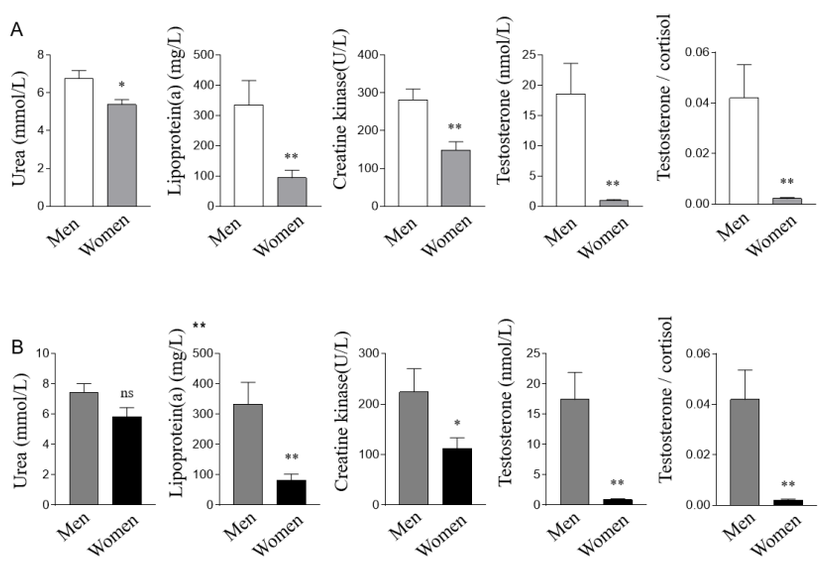

Figure 3. The differences of physiological indexes between male and female freestyle skiers before and after the competition. The pre-competition (A) and post-competition (B) data were collected by skiers during training in Qinhuangdao, including the monitoring results of 5 male athletes (13-18 years old) and 7 female athletes (9-17 years old). ns, no significant difference, * p<0.05.

male and female athletes, which was consistent with the correlation between creatine kinase level and gender reported in literature[4]. Testosterone is the main male sex hormone and hormone that promotes assimilation. Adult men secrete 20 times more testosterone than adult women. Therefore, the testosterone and the ratio of testosterone to cortisol of female skiers are significantly lower than those of male skiers. These results suggest that through the monitoring of these indicators, we can comprehensively consider the gender differences of skiers in order to formulate different training programs and rehabilitation exercises suitable for individual athletes.

2.4 Changes of physiological indexes of skiers at different ages

In order to find out the relationship between these physiological indexes and the stage of physical development, we also compared and analyzed the pre-match and post-match data of the players aged 9-13 years old in the lower age group and 14-18 years old in the higher age group. Figure 4 shows that before the competition, compared with the older group, the platelet distribution width and testosterone / cortisol ratio decreased significantly, while the platelet count and the level of glutamic oxaloacetic transaminase increased significantly in the younger group. After the competition, compared with the elderly group, the ratio of testosterone to cortisol decreased significantly, while the platelet count, glutamic oxaloacetic transaminase and cortisol increased significantly in the younger group. Compared with the older group of skiers, there is a large gap in the degree of physical development in the younger group. Most of testosterone is secreted by sexual organs, and the secondary sexual characteristics of the younger group are not fully developed, so the content of testosterone is lower than that of the older skiers. Glutamic oxaloacetic transaminase catalyzes the transformation of glutamic acid and oxaloacetic acid, which is also an important link in the metabolic process. Before and after the competition, the amount of glutamic oxaloacetic transaminase in the young group increased, suggesting that the oxidizing energy supply of the skiers in the younger group is more intense, and the energy supply can be arranged properly.

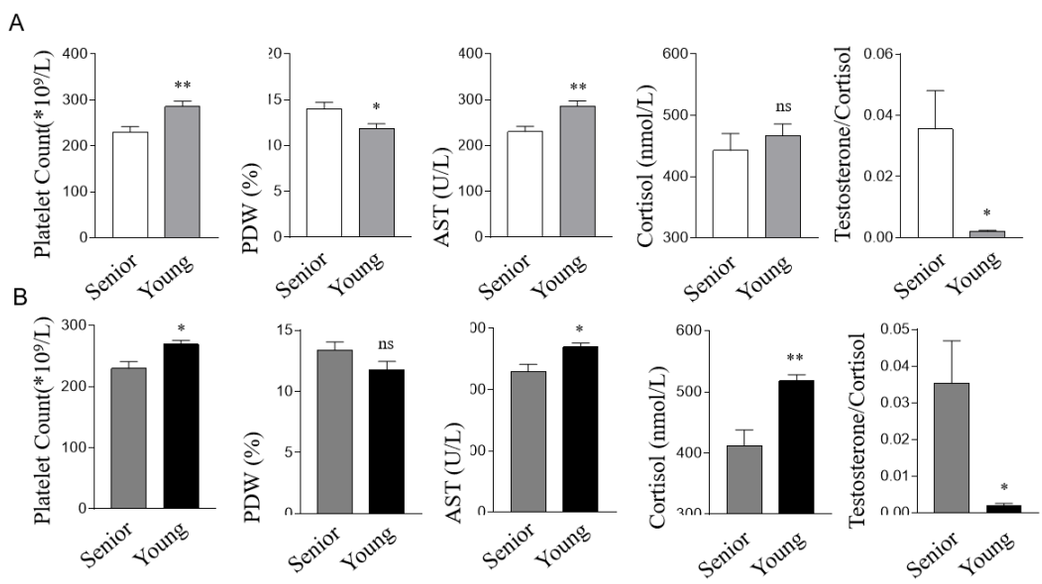

Figure 4. Differences in physiological indexes of freestyle skiers before and after the race between the older group and the younger group. Pre-race (A) and post-race (B) data were collected during the training period of skiers in Qinhuangdao. The elderly group included 6 athletes aged 14-18 years (including 3 males and 3 females), and the younger group included 6 athletes aged 9-13 years (including 2 males and 4 females). ns, no significant difference, * P < 0.05, ** P < 0.01.

We also compared the differences between the older group and the younger group after the race relative to the pre-race. As shown in Figure 5, in the older skier group, the mean hemoglobin concentration and glucose were increased, apolipoprotein A1/B was significantly increased, and erythrocyte distribution width-SD, erythrocyte distribution width-CV, erythrocyte specific volume, high-density lipoprotein cholesterol, apolipoprotein B, and alanine aminotransferase were significantly decreased after the race. Apolipoprotein B is one of the lipid components, which can carry lipids and mainly absorb low-density lipoproteins. Apolipoprotein is the main factor that determines the structure, function and metabolism of lipoproteins. It arranges and regulates lipoprotein metabolism and cholesterol balance in the body[11]. After exercise, high density lipoprotein cholesterol, apolipoprotein B, alanine aminotransferase decreased, considering that in skiing training, skiers have high glucose metabolism and high lipid metabolism. As can be seen from FIG. 6, compared with the pre-race, the red blood cell distribution width-SD, red blood cell distribution width-CV, monocyte count, alanine aminotransferase,

aspartate aminotransferase, high-density lipoprotein cholesterol and creatine myozyme were significantly decreased after the race, while cortisol was significantly increased in the young skier group. This indicates that the ability of the body to transport oxygen decreases, and a variety of enzymes involved in human metabolism decreases. Decreased levels of creatine myozyme affect ATP synthesis and energy conversion. Lipid metabolism is also adjusted to some extent. Cortisol levels increased significantly, indicating a dramatic breakdown of protein. It is suggested that half-day training is more beneficial to the growth and physical recovery of skiers than full-day training[8].

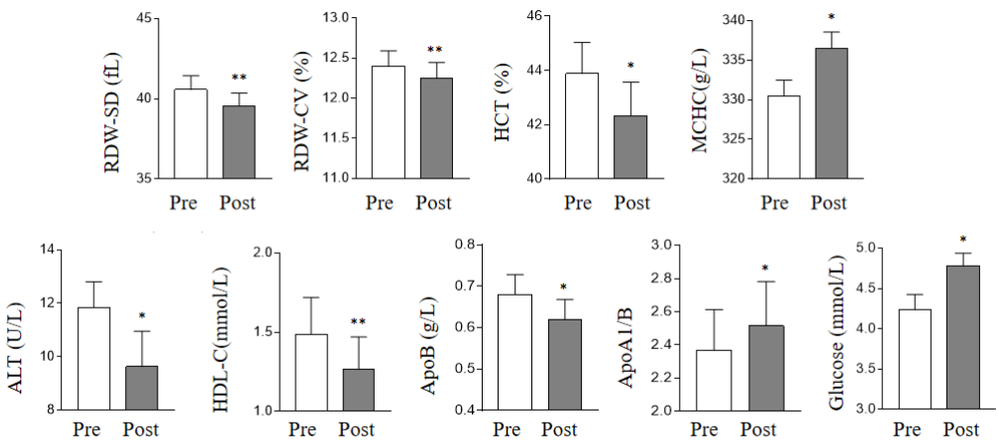

Figure 5. Differences in physiological indexes of freestyle skiers in the aged group before and after the race. The data were collected during the training period of skiers in Qinhuangdao, including the monitoring results of 6 athletes aged 14-18 years (including 3 males and 3 females). * P < 0.05, ** P < 0.01.

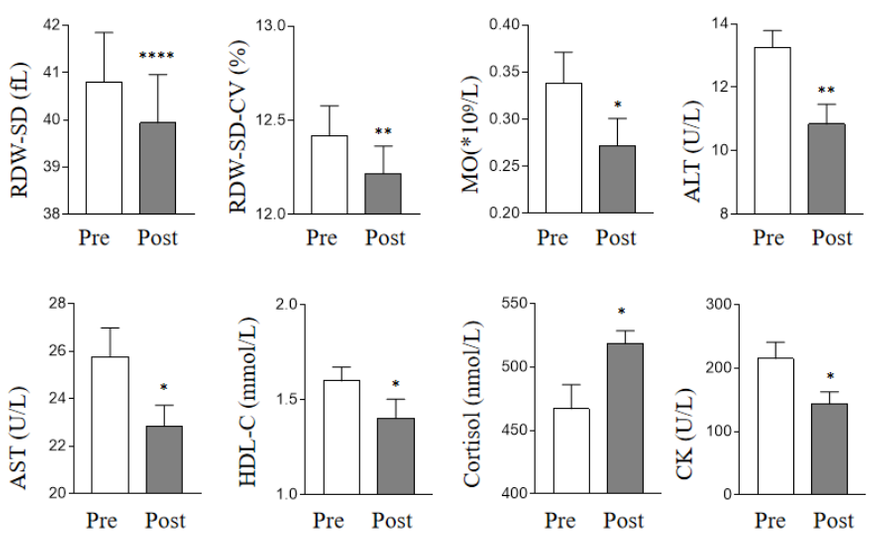

Figure 6. The difference of physiological indexes between junior freestyle skiers before and after the race. The data were collected during the training period of skiers in Qinhuangdao, and the younger group included the monitoring results of 6 athletes aged 9-13 years (including 2 males and 4 females). * P < 0.05, ** P < 0.01, **** P < 0.0001.

3. Discussion

(1) On skiing athletes before and after a series of physiological indexes related to sports and health monitoring after and carry on the overall analysis, it was found that the average red blood cells, red blood cell volume distribution width, platelet

distribution width, cereal third transaminase, aspertate aminotransferase, high-density lipoprotein cholesterol, creatine muscle enzyme levels decreased significantly after the game; Glucose levels increased significantly after the race.

(2) It was found that physiological indicators of lipoprotein (A), creatinine enzyme, testosterone and the ratio of testosterone to cortisol of skiers were significantly different between athletes of different genders before or after the race.

(3) It was found that the physiological indexes such as platelet count, platelet distribution width, the ratio of testosterone to cortisol, cortisol and glutamic-oxalate aminotransferase of skiers were also significantly different between the younger group and the youth group before or after the race.

(4) In the era of increasingly fierce sports competition, by monitoring the physiological indicators of skiers, the physical function of skiers can be well reflected, so as to scientifically and effectively judge the sports training of skiers. Timely understanding of the current situation of skiers is conducive to reasonable arrangement of training intensity, timely adjustment of training plan, promote physical rehabilitation, and timely supplement of nutrition and energy to improve sports performance to the greatest extent.

(5) In view of the gender and age differences in sports monitoring indicators, reasonable adjustments can be made according to different groups in the arrangement of training, so that skiers will have a better state and play a guiding role in physical rehabilitation training after training.

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