A comparative analysis of the dynamics of carbohydrate metabolism in ski-racers during training with alternating middle altitude hypoxia/normoxia and normoxia

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Abstract. The purpose of the article is to analyze the dynamics of indicators of carbohydrate metabolism at rest in ski-racers with different training programs. Materials and methods: 17 male ski-racers aged 18–23 years participated in the study. The first group (1) consisted of cross-country skiers with training under conditions of alternating middle altitude hypoxia (May-August-October) and normoxia (n = 7); the second group - cross-country skiers with training under conditions of normoxia (n = 10). The study was conducted in the preparatory (July) and competition period (December). Indicators of carbohydrate metabolism (glycogen level, glucose concentration, lactic acid concentration and blood acid status (pH)) were obtained with a non-invasive AMP blood analyzer (Ukraine). Results: it was established that by the competition period in the 1st group of ski-racers there was a decrease in glucose concentration by 6.66% (p> 0.05) and lactic acid by 10.00% (p> 0.05); in athletes of the 2nd group an increase in lactic acid by 12.50% (p <0.05) and glucose by 7.40% (p> 0.05) was recorded. Conclusion: the combined regime of middle altitude hypoxia and normoxia allowed increasing aerobic energy supply by the competition period. The trend of a decrease in the concentration of glucose and lactic acid in athletes of the 1st group in the competition period indicated a decrease in insulin secretion and an increase in the activity of lipolysis enzymes.

Keywords - glucose, lactic acid, energy supply, hypoxia, normoxia, skiers

I. INTRODUCTION

The role of carbohydrates in providing muscle activity is to be an energy source during physical exertion of submaximal power [1]. However, this mode of muscle activity results in oxygen deficiency as the role of anaerobic glycolysis increases. And since under anaerobic conditions the activity of all cellular ATPases is associated with the functioning of glycolysis, acidosis develops rapidly. Today it is proved that hydrogen ions lower the pH level and change electrical signals in the muscles and nerves. This slows down energy reactions as a result of a decrease in the functioning of enzymes. A weakening of muscle contraction occurs, and a pronounced decrease in pH leads to a significant loss of contractility [2, 3]. However, there are some facts that prove that the level of activity of hydrogen ions (H +) plays a major role in the efficiency of adaptation of the athlete's body systems. Lactate is a leading element in carbohydrate metabolism due to its influence on intracellular and intercellular interaction [5]. Therefore, in conditions of middle altitude hypoxia, respiratory acidosis acts as an analogue to loads of submaximal power [6, 7, 8, 9].

II. MATERIALS AND METHODS

The study was carried out on the premises of the Research Center for Sports Science of the South Ural State University (NRU). 17 male ski-racers aged 18–23 years participated in the study. The first group (1) consisted of cross-country skiers with training under conditions of alternating middle altitude hypoxia (May-August-October) and normoxia (n = 7); the second group - cross-country skiers with training under conditions of normoxia (n = 10). The study was conducted in the preparatory (July) and competition period (December). Indicators of carbohydrate metabolism (glycogen level, glucose concentration, lactic acid concentration and blood acid status (pH)) were obtained with a non-invasive AMP blood analyzer (Ukraine).

III. Results and discussion

Regardless of the nature of muscular work, the first symptoms of tissue oxygenation disorders are changes in tissue energy supply and related changes in carbohydrate metabolism (Table 1).

TABLE I. DYNAMICS OF INDICATORS OF CARBOHYDRATE METABOLISM IN SKI-RACERS AT REST (M ± m)

Group	Glycogen (mg, %)	Glucose concentration (mmol / L)	Blood PH	Lactic acid concentration (mmol / L)
Preparatory period				
1	14.84 ± 0.05	5.10 ± 0.37	7.33 ± 0.01	1.10 ± 0.10
2	14.89 ± 0.04	4.59 ± 0.30	7.33 ± 0.01	0.96 ± 0.03
p	> 0.05	> 0.05	> 0.05	> 0.05
Competitive period				
1	14.74 ± 0.03	4.76 ± 0.40	7.32 ± 0.01	0.99 ± 0.10
2	14.82 ± 0.04	4.93 ± 0.15	7.33 ± 0.01	1.08 ± 0.07
p	> 0.05	> 0.05	> 0.05	> 0.05
Differences between periods (p)				
1	> 0.05	> 0.05	> 0.05	> 0.05
2	> 0.05	> 0.05	> 0.05	< 0.05

The table shows that in the preparatory period, in the skiers of the 1st group, compared to the 2nd group, the glycogen level was lower by 0.34% (p> 0.05), the concentration of glucose and lactic acid was higher by 10.00% (p> 0.05) and 12.73% (p> 0.05), respectively. The concentration of lactic acid in athletes of the 2nd group was below the reference values (0.99–1.38 mmol/l). In the competitive period, all indicators of carbohydrate metabolism in ski-racers were within physiological norms, but with lower values in the 1st group. Thus, in cross-country skiers of the 1st group, compared with the 2nd group, glycogen remained lower by 0.54% (p> 0.05), the concentration of glucose and lactic acid was lower by 3.57% (p > 0.05) and by 9.09% (p> 0.05), respectively.

By the competitive period, we have identified multidirectional dynamics of carbohydrate metabolism in ski-racers. The decrease in glucose and lactic acid concentrations by the competitive period in the 1st group, compared to the 2nd group, indicates an increase in the rate of oxidation of fatty acids and a decrease in the rate of glycolysis and, as a result, an increase in the aerobic energy supply of muscle activity. A decrease in glucose helps to delay the production of amino acids in the liver. This is stimulated by glucagon and cortisol [11]. In the 2nd group of athletes, there was an increase in lactate by 12.50% (p <0.05) and glucose by 7.40% (p> 0.05).

IV. Conclusion

An increase in anaerobic energy supply mechanisms in cross-country skiers of the 1st group as a result of middle altitude hypoxia determined the growth of the aerobic capacity of the body by the competitive period due to the increased role of lipolysis. The development of lactic acidosis under conditions of middle altitude hypoxia led to an increase in the activity of hydrogen ions (H +), which were a metabolic stimulus for changing the body's homeostasis. In the 2nd group of cross-country skiers, the dynamics of carbohydrate metabolism indicated the inefficiency of adaptation processes and a decrease in the body's reserve capacity by the competitive period. An increase in the concentration of lactate at rest in athletes of the 2nd group in the competitive period indicated the development of metabolic acidosis, which is accompanied by fatigue of the body and limitation of performance during intense physical exertion.

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