Study on the Effects of the Rhodiola Reagent on Improving Exercise Endurance and Exercise Fatigue Resistance

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Abstract

This paper studies the effects of compound Rhodiola reagent on eliminating exercise fatigue and improving exercise endurance by taking mice test and athlete application test. The results show that under medium and high doses of Rhodiola, the exercise abilities of mice improve significantly. The swimming time of the high dose group is increased by about 20.8% ($P<0.05$) compared with that of the control group; the climbing time of medium dose group is about 32.16% ($P<0.05$) longer than that of the control group. Low dose of Rhodiola reagent can significantly increase the hepatic glycogen content of mice ($P<0.01$), and at the same time significantly increase their muscle glycogen content ($P<0.05$); medium dose of Rhodiola reagent can effectively stabilize the blood sugar content of mice ($P<0.05$), and significantly decrease the level of BUN after exercise ($P<0.05$). Taking Rhodiola reagent can help maintain normal physiological functions, reduce the production of corticosterone, maintain hormone balance, and significantly reduce blood lactic acid content. The results of athlete application test show that after ingestion of the reagent, athletes' hemoglobin level increases significantly ($P<0.05$), but the BUN level is relatively low ($P<0.05$). From this, we can see that the compound Rhodiola reagent can also make human bodies well resist exercise fatigue and improve their exercise endurance.

Keywords: compound Rhodiola reagent, exercise fatigue resistance, exercise endurance, mice test.

1. INTRODUCTION

Exercise fatigue refers to a condition that after substantial exercise, organs in the human body are under greater loads, oxygen demand is increased significantly, and physiological functions and organs in the body cannot be maintained at a normal level. In the long run, organs such as skeletal muscle, cardiac muscle, liver, kidney and brain will suffer from peroxidation damages, exercise oxidative stress and other sequelae. Therefore, it is of great significance to actively prevent and treat the negative impacts of exercise fatigue on the body.

At present, there are two major measures to prevent exercise fatigue: one is physical intervention, including catching up on sleep, restorative training after exercise and adaptive training, but studies have shown that these methods are not quite effective to the recovery of fatigue; the other is drug intervention. Drugs that have been proven effective in eliminating exercise fatigue and improving exercise abilities include tea polyphenols (Singal et al., 2005) and grape seed extract (Sehirli et al., 2008), coenzyme NADH (Kishi et al., 1999; Martín-Romero et al., 2002; Fernandes et al., 2000), Eucommia extract (Yen et al., 2002), morida officinalis polysaccharide (Zhang et al., 2009) and ginsenosideRb1 (Mook-Jung et al., 2001). Traditional Chinese medicines like ginsenoside (Tang et al., 2008), Ginseng polysaccharides (Wang et al., 2010), Radix Rehmanniae polysaccharide (Tan et al., 2012), acanthopanaxsenticosus (Huang et al., 2011), eucommiaulmoides and betulin (Steele et al., 1999) also have certain anti-fatigue effects, but due to complex composition, the exact mechanism still requires further studies. Rhodiolarosea is one of the traditional Chinese medicinal materials. It can facilitate the hydrolysis of protein, activate anaerobic glycolysis, reduce the consumption of glycogen in brain and muscle, effectively increase the red blood cell and hemoglobin counts in blood, and increase RNA and the total protein content in muscle, thereby providing resistance to exercise fatigue. Now it has been widely used clinically (Panossian et al., 2010; Darbinyan et al., 2000).

This paper studies the effects of compound Rhodiola reagent on eliminating exercise fatigue and improving exercise endurance by taking mice test and athlete application test. The results show that the compound Rhodiola reagent can also make human bodies well resist exercise fatigue and improve their exercise endurance.

2. TEST MATERIALS AND METHODS

2.1 Test drugs and reagents

Rhodiola reagent is made from Rhodiola, Astragalus and Radix Paeoniae Alba, extracted with alcohol for 5 times, and dissolved in distilled water to the required concentration; membrane rupture solution, lactate standard solution, buffer solution; urea nitrogen reagent kit, glucose meter, transmission electron microscopy, whole blood lactate kit, BUN kit and hepatic/muscle glycogen kit.

2.2 Test Subject

Healthy male adult mice, with a body weight of (23±1.4) g; lab temperature: 20-25°C; relative humidity: 45%-70% RH; athletes: 20 provincial-level long-distance runners aged 19±1.6 years, randomly divided into test group and control group, with 10 in each group.

2.3 Mice burden-swimming and pole-climbing test

Burden-swimming test: tie a lead sheath which weighs 5% of the body weight to the tail of a mouse, put it in the swimming box, record the time from the point when the mouse begins to swim to the point when it dies; pole-climbing test: place the mouse on top of the fixed glass rod with a height of 40cm, and record the time from the point when the mouse begins to grasp the glass rod to the point when it falls. Take the test for 3 times and take the average value of the time as the final pole-climbing time.

2.4 Determination of hepatic/muscle glycogen and other indicators

30min after drugging the post-exercise mouse, kill it by cervical dislocation, take out the limb muscle and liver and determine the hepatic/muscle glycogen content of the mouse; in a second test, 30min after drugging the mice, put it in the swimming box at a constant temperature of 25°C to let it swim without burden for 60min. After 40min of rest, take an eyeball off the mouse to take blood samples and use the glucose meter to determine the change in the glucose content of the mouse; centrifugalize the blood to determine the BUN level. Use radioimmunoassay to determine serum testosterone and serum corticosterone.

2.5 Determination of mouse blood lactate

30 min after drugging the mouse, take 20 μL of blood sample from the mouse and mark it as B_1. After put it in the swimming box to swim for 15 min, take another 20 μL of blood sample and mark it as B_2; after 20 minutes of rest, take 20 μL of blood sample for the third time and mark it as B_3. The final blood lactate value can be expressed as:

$$BL = 0.5\times\left(B_1 + B_2\right)\times 10 + 0.5\times\left(B_2 + B_3\right)\times 20 \qquad (1)$$

3. TEST RESULTS AND ANALYSIS

Process the monitoring results with the software SPSS. The results are expressed as (x_a±S), where x_a is the mean value; S is the standard deviation. Compare and analyze groups by variance value. If P<0.05, the difference is significant; if P<0.01, the difference is extremely significant.

3.1 Effects of the Rhodiola reagent on the swimming and pole-climing time of mice

Table 1 Effect of Rhodiola Reagent on Exercise Ability of Mice

Group	Dose(g/kg)	Swimming time(min)	Pole-climbing time(min)
Control	0	7.8±1.82	2.55±0.61
Low dose	0.5	7.1±1.17	2.42±0.58
Medium dose	1.0	7.95±1.78	3.37±0.67[b]
High dose	2.0	9.85±1.69[b]	3.06±0.71

Note: compared with the blank control group, $^{b}p<0.05$.

Table 1 shows the effects of different doses of Rhodiola reagent on the exercise abilities of mice. The control group is fed with the same dose of distilled water as replacement of the drug. Results show that the swimming abilities of the mice under medium and high doses are improved significantly. The swimming time of the high dose group is increased by 20.8% (P<0.05) compared with the control group; the pole-climbing time of the medium dose group is 32.16% longer than that of the control group (P<0.05). A direct sign of exercise fatigue is lower exercise endurance. Results show that mediu and high doses of Rhodiola reagent can effectively prolong mice's resistance to exercise fatigue.

3.2 Effects of the compound Rhodiola reagent on hepatic/muscle glycogen and other indicators

Table 2 shows the effects of different doses of the Rhodiola reagent on hepatic/muscle glycogen in mice. It can be seen from the table that low dose of the Rhodiola reagent can significantly increase the content of hepatic glycogen (P<0.01), and medium dose can also increase the level of hepatic glycogen to a great extent (P<0.05). Low dose of the Rhodiola reagent can significantly increase the content of muscle glycogen (P<0.05) and medium dose can also effectively stabilize the blood glucose level after exercise (P<0.05), and significantly decrease the production of BUN after exercise (P<0.05).

Table 2 Effects of Rhodiola Reagent on Hepatic/Muscle Glycogen, BUN and Blood Glucoseof Mice

Group	Dose (g/kg)	Hepatic glycogen (Mg/g)	Muscle glycogen (Mg/g)	BUN (mmol/L)	Blood glucose (mmol/L)
Control	0	1.755±0.597	0.474±0.056	8.451±0.593	4.28±0.7
Low dose	0.5	3.205 ± 0.477^{c}	0.566 ± 0.029^{b}	7.722±0.691	4.3±0.5
Medium dose	1.0	2.439 ± 0.521^{b}	0.504±0.058	7.518 ± 0.894^{b}	5.7 ± 0.4^{c}
High dose	2.0	1.989±0.703	0.531±0.048	7.989±0.753	5.08±0.5

Note: compared with the blank control group, $^{b}p<0.05$; $^{c}p<0.01$.

The hepatic/muscle glycogen and blood glucose amount in the body can greatly affect the body's exercise fatigue resistance, so from Table 2 it can be seen that the Rhodiola reagent can effectively stabilize the hepatic/muscle glycogen and blood glucose amount and improve the body's resistance to exercise fatigue.

3.3 Effects of the compound Rhodiola reagent on serum testosterone and corticosterone in mice

Table 3 shows the effects of the Rhodiola reagent on serum testosterone and corticosterone in mice. From the table, it can be seen that the serum testosterone levels of all test groups after being drugged with the Rhodiola reagent are lower than that of the control group; the corticosterone levels of all test groups after being drugged are not significantly different from that of the control group. Changes in the two indicators of all test groups are generally the same.

Table 3 Effects of the Rhodiola reagent on Serum Testosterone and Corticosterone of Mice

Group	Dose (g/kg)	Serum testosterone (nM)	Corticosterone (nM)
Control	0	5.18±1.82	101.4±15.57
Low-dose	0.6	4.15±1.47	105.44±15.71
Medium dose	1.2	4.41±1.53	105.3±13.55
High-dose	3.6	4.83±1.31	103.7±14.49

Testosterone secretion in the human body can facilitate the synthesis of nucleic acids and proteins, increase the hepatic/muscle glycogen content and enhance the body's immune function. Long-term exercise will reduce the serum testosterone level and increase the corticosterone level in the body. Taking the Rhodiola reagent can help maintain normal physiological functions, reduce the formation of corticosterone and maintain hormone balance in the body, thereby enhancing the exercise fatigue resistance.

3.4 Effects of the compound Rhodiola reagent on blood lactate in mice after exercise

Figure 1 shows the effects of the Rhodiola reagent on blood lactate in mice after exercise. The X coordinates 1-4 in the figure represent the low dose group, the medium dose group, the high dose group and the control group, respectively. It can be seen from the figure that the blood lactate of the mice after exercise has been increased to different extents. For mice under low dose, there are no obvious changes in the lactate contentin the three periods; for mice under medium and high doses, the blood lactate is significantly lower in the three periods, and the differences are extremely significant (P<0.01).

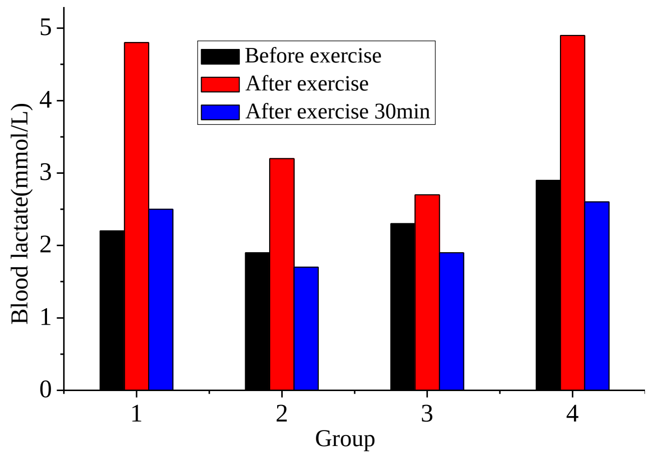

Figure 1. Effects of the Rhodiola Reagent on Blood Lactate of Mice

Indicators like hepatic/muscle glycogen content and blood lactate are typical indicators of body exercise fatigue. The blood lactate content is a characteristic quantity that reflects the collective aerobic metabolism ability and exercise fatigue elimination speed. From Figure 1 it can be seen that the use of the Rhodiola reagent can significantly prolong the swimming time of mice, enhance the endurance of mice, and significantly reduce the blood lactate content, indicating once again that the Rhodiola reagent is effective in providing resistance to exercise fatigue.

3.5 Effects of the compound Rhodiola reagent on the recovery of athletes after exercise

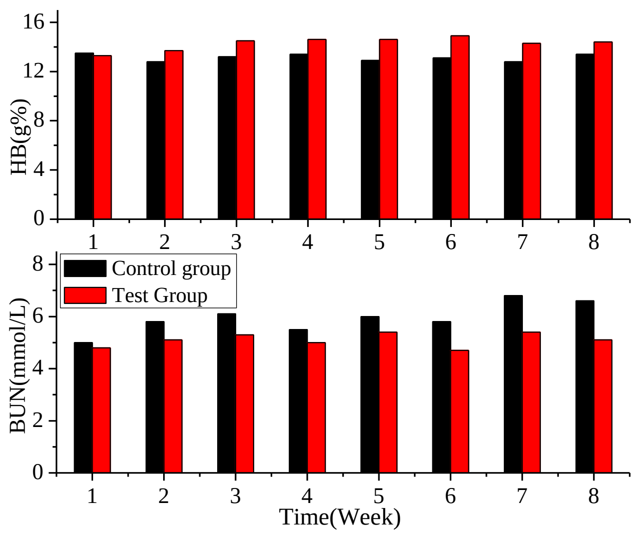

Figure 2. Effects of the Rhodiola Reagent on Blood Lactate of Human

This section further analyzes the effects of the compound Rhodiola reagent on the human body's resistance to exercise fatigue. Figure 2 shows the contents of BUN and Hbin the test group and the control group within 8 weeks. The test group take the compound Rhodiola reagent twice a day, and the control group take the same dose of saline. 20 athletes attend normal training every day. From the figure, it can be seen that the hemoglobin levels of the athletes in the test group after taking the Rhodiola reagent are significantly increased ($P<0.05$), and the BUN levels remain at a relatively low level ($P<0.05$). Results of the questionnaire survey on 10 athletes in the test group show that after taking the Rhodiola reagent, they sleep better and demonstrate obviously better adaptability to the training compared with the control group. Therefore, the compound Rhodiola reagent can also improve the human body's resistance to exercise fatigue and enhance exercise endurance.

4. CONCLUSIONS

This paper studies the effects of compound Rhodiola reagent on eliminating exercise fatigue and improving exercise endurance by taking mice test and athlete application test respectively. The conclusions are as follows:

(1) Under medium and high doses of Rhodiola, the exercise abilities of mice improve significantly. The swimming time of the high dose group is increased by about 20.8% ($P<0.05$) compared with that of the control group; the climbing time of the medium dose group is about 32.16% ($P<0.05$) longer than that of the control group. Medium and high doses of Rhodiola reagent can effectively prolong mice's exercise fatigue resistance.

(2) Low dose of Rhodiola reagent can significantly increase the hepatic glycogen content of mice ($P<0.01$), and at the same time significantly increase their muscle glycogen content ($P<0.05$); medium dose of Rhodiola reagent can effectively stabilize the blood sugar content of mice ($P<0.05$), and significantly decrease the level of BUN after exercise ($P<0.05$).

(3) Taking Rhodiola reagent can help maintain normal physiological functions, reduce the production of corticosterone, maintain hormone balance, and significantly reduce blood lactic acid content. The results of athlete application test show that after ingestion of the reagent, athletes' hemoglobin level increases significantly ($P<0.05$), but the content of nitrogen in blood and urine is relatively low ($P<0.05$). From this, we can see that the compound Rhodiola reagent can also make human bodies well resist exercise fatigue and improve their exercise endurance.

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