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# Effect of APS on Hormones Regulating Blood Glucose in Active Rats

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## Abstract

The paper aims to discuss the influence of Astragalus Polysacharin (APS) on hormones regulating blood glucose in active rats. The experiment was conducted to detect the plasma insulin and glucagon concentrations in swimming rats in different states. The result of the experiment showed that the ASP-injected rat group had higher plasma insulin and glucagon concentration, compared with that of the pure-water-drinking rat group (control group). After one-hour swimming, the APS-injected rat group had higher glucagon concentration than that of the control group ($P < 0.05$); when just fatigued, the APS-injected group showed evidently higher plasma insulin concentration, compared with the control group ($P < 0.01$). The conclusion is drawn that APS can enhance the release of plasma insulin and glucagon in active rats; promote their compatibility effect in the process of glycogen synthesis and storage, hence increasing glycogen reserves. It can delay fatigue caused by hypoglycemia, and accelerate physical recovery from exercise-induced fatigue.

**Key words:** APS; Insulin; Glucagon; Rats

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## INTRODUCTION

According to traditional Chinese medicine (TCM), spleen is the core of human activities, generating "qi" (or vitality). Spleen determines the performance of limbs and muscle, therefore, is closely related to physical activities. Astragalus is a representative Chinese medicine for tonifying spleen and reinforcing "qi", frequently used in clinical medicine. Astragalus is slightly sweet, slightly warm in nature. It can reinforce "qi", enhance immunity, induce diuresis to reduce edema, and eliminate toxins. According to modern pharmacology, astragalus provide 14 microelements necessary for health, including polysaccharides, saponins, flavonoids, alkaloids, various amino acids, vitamins, selenium, zinc, and iron. Among them, astragalus polysaccharides (APS), is regarded as the major bioactive component of astragalus. Experiments and clinical researches (Shao, Xu, & Dai, 2004) have shown that APS can increase immunity, reduce blood pressure, and regulate blood sugar level. It also has anti-stress, anti-tumor, anti-virus, anti-radiation, anti-oxidant functions. With the means of an experiment, the paper aims to discuss the influence of APS in astragalus on hormones regulating blood glucose in swimming rats, in the hope of providing scientific evidence for clinical application of astragalus in the field of sports medicine.

## 1. MATERIALS AND METHOD

### 1.1 Animals in the Experiment & Their Grouping

Select 80 male Wistar rats, aging 8 weeks, and weighing 200±15g. They were provided by the Laboratory Animal Center of Shandong Traditional Chinese Medicine University. These rats were fed with national-standard fodder, and pure drinking water. The animal room was kept quiet, with temperature at 20-25℃, and humidity at 40-50%.

Train the rats to swim every other day. Altogether they were trained for three times, each lasting 10min, 20min, and 30min respectively. The swimming pool made of glass fiber reinforced plastics measured 150*60&70cm, 60cm in depth, with water temperature at 36±1℃. The swimming training was conducted at 10 a.m.. After swimming, the rats were dried with towel.

The rats were randomly divided into two big groups: the control group A, and the APS-injected group B. There were 5 sub-groups in each big group, namely the inactive one, the one-hour swimming one, the just fatigued one, the one-hour resting one after fatigue, the 12-hour resting one after fatigue. Group B had an intraperitoneal injection of 78.125mg/kg APS at 8 a.m. for four consecutive days; while group A had an equal amount of normal saline injection for four consecutive days. Two hours after the last injection, the rats were made swimming, except the inactive sub-groups. (The standard of judging whether the rats were fatigued: rats sank to the bottom of the swimming pool for more than 10s without returning to the surface, and could not complete righting reflex on a flat surface).

### 1.2 Selecting Material

The rats were killed by a decapitator. Their blood was drawn and put into centrifuge tubes. After one hour at the room temperature, the blood was coagulated. Use a bamboo stick to strip off the blood clots from the interior surface of the tubes, so that serum would precipitate. Put serum into a low-temperature centrifuge and keep the centrifuge working at 3000 rpm/min for 15 min. Keep serum at -20℃ and preserve it for later use.

### 1.3 Index Measuring & Data Processing

Concentration of serum insulin and glucagon: use enzyme-immunoassay method. The test kit was provided by Shanghai Maisha Biotechnology Limited. The measuring of indexes strictly conformed to the specification on the test kit, and before the experiment the measuring skill was practiced.

All the data was presented in the form of "average number±standard deviation" ($\bar{X}$ ±S). Independent sample T was used for testing. Significant difference: P<0.05. The univariate analysis between the two groups indicated that only the average score of somatization was significantly different (P=0.01). All statistics was processed on the statistical software SPSS for Window 13.0.

## 2. RESULT OF THE EXPERIMENT

### 2.1 Comparison of Length of Time for the Rats to Be Fatigued

Comparison of length of time for the two groups to be fatigued, the fatigue time for Group B was lengthened (p>0.05).

**Table 1**
**Comparison of Length of Time for the Two Groups to Be Fatigued**

| Group | Time (h) | N |
|---|---|---|
| Pure-water-drinking (Group A) | 6.11±1.80 | 24 |
| APS-injected (Group B) | 9.27±2.91* | 24 |

Notice: *means that compared with group A, P<0.05

### 2.2 Change of Concentration of Serum Insulin in Rats in Different States

When the rats were just fatigued, serum insulin concentration in group B was far more than that of group A (p<0.01); in other states, serum insulin concentration in group B was more than that of group A, without significant difference (P>0.05) (Table 2).

**Table 2**
**Comparison of the Change of Serum Insulin Concentration Between Group A and B in Different States** (ug/ml)

| Group | Inactive | Swimming for 1 h | Just fatigued | 1h rest after fatigue | 12h rest after fatigue |
|---|---|---|---|---|---|
| Group A | 5.49±0.43 | 5.38±0.52 | 3.99±0.36 | 4.50±1.05 | 5.96±0.46 |
| Group B | 5.94±0.91 | 5.49±1.22 | 4.99±0.39** | 5.14±1.23 | 6.88±4.56 |

Notice: **means compared with group A, P<0.01

### 2.3 Change of Concentration of Serum Glucagon in Rats in Different States

After 1h swimming, serum glucagon concentration in group B was far more than that of group A (P<0.05); in other states, serum glucagon concentration in group B was more than that of group A, without significant difference (P>0.05) (Table 3).

**Table 3**
**Comparison of the Change of Serum Insulin Concentration Between Group A and B in Different States** (ug/ml)

| Group | Inactive | 1h swimming | Just fatigued | 1h rest after fatigue | 12h rest after fatigue |
|---|---|---|---|---|---|
| Group A | 38.63±3.62 | 41.76±4.12 | 49.75±3.92 | 42.22±6.06 | 38.66±0.02 |
| Group B | 43.69±7.85 | 46.84±1.89* | 49.67±6.20 | 41.35±6.09 | 40.53±5.69 |

Notice: *means that compared with group A, P<0.05

## 3. ANALYSIS AND DISCUSSION

From the perspective of Chinese medicine, exercise-induced fatigue has symptoms like: being too tired to speak, dizziness, night sweat, palpitation, and weak pulse. A traditional Chinese medicine book mentioned that fatigue also exhausts people's "qi" (vitality), which can be complemented by APS. Therefore, this experiment aims at observing the curative effect of APS on exercise-induced fatigue. Some researchers have already proved that the Chinese medicine astragalus can enhance body's antihypoxic ability ( Yu, Zhang, & Shen, 2002); increase hepatic glycogen when rats are doing exercise; reduce the change of blood lactate caused by exercise (Cui, 2002). This experiment found that the fatigue time of the APS-injected rats was lengthened compared with the control group ($P<0.05$). The swimming time can reflect exercise ability of the animals, and enhanced exercise endurance is the best manifestation of improving anti-fatigue ability.

Insulin, a reserve hormone, is generated by islet β cells. Insulin plays an active role in the intermediate process of energy metabolism, promoting phosphorylation of glucose into glucose-6-phosphate, and its oxidation into pyruvic acid. By enhancing the function of phosphatase, insulin also enables pyruvic acid to generate Acetyl CoA. In addition, insulin accelerates the uptake of glucose into muscle cells, increasing muscle glycogens. Abundant researches have shown that strenuous exercise reduces serum insulin concentration, and its effect is associated with intensity and duration of the exercise (Zhang, 1996; Zhang, Guo, & Huang, 1996). In fact, the decrease of insulin during exercise makes biological sense: it can prioritize the hormone function, which accelerates glycogenolysis, and maintain blood glucose level. In addition, insulin prevents the uptake of glucose from blood by muscle, liver, and adipose tissue. Therefore, on one hand, insulin prevents glucose decrease; on the other hand, it prevents the resynthesis of glycogen and adipose in sports muscle and other tissues, and promotes glycogenolysis and lipolysis, facilitating the use of glucose and adipose. Prolonged exercise leads to the decrease of blood glucose level and insulin concentration. The result of Fang Sheng and Yang Kun's (Fang, Yang, & Lv, 2006) experiment on the effect of Kudzu root flavanone and intense endurance exercise on metabolism of carbohydrate and fat of rats showed that the serum insulin of fatigued rats had decreased sharply compared with that of the inactive rats. They think this may be related to the decrease of blood glucose caused by prolonged exercise. Strenuous exercise reduces insulin mainly by reducing blood glucose and increasing α-adrenoceptors (Galbo, Richter, Holst, & Christensen, 1977; Hua et al., 1990). In addition, the increased peripheral insulin clearance also contributes to the decrease of insulin. Björntorp (1981), marked by $I^{125}$, showed that the phenomenon of decreased serum Ins after exercise, was 1/3 contributed by fewer islet β cells, and 2/3 contributed by the increased peripheral insulin clearance.

The result of this experiment showed that after one-hour non-weight-bearing swimming, serum insulin concentration slightly decreased, accompanied by slight decrease of blood glucose and glycogen. The uptake of glucose from blood by muscle glycogen slightly increased. Hepatic glycogen can be resolved into blood glucose. When the rats were just fatigued, serum insulin decreased evidently, and had significant difference from the control group ($P<0.01$). The experiment also showed that during the prolonged exercise, after 90~150 min, blood glucose was dropping remarkably. Prolonged exercise leads to huge consumption of muscle glycogen. During the exercise, the uptake of extracellular glucose by skeletal muscle increases, so as to meet the energy demand of muscle, which inevitably leads to blood glucose decrease. In order to maintain relative stability of blood glucose, the body adopts endocrine regulation (glucocorticoid and glucagon secretion increase, and the secretion of insulin is suppressed), enhancing liver gluconeogenesis and glycogenolysis. Thus hepatic glycogen decreases and hepatic glucose output increases. Increased α-adrenoceptors and increased peripheral insulin clearance also suppress secretion of insulin. During the rest, insulin content was on a rise; after 12 hours, insulin level was remarkably higher than that of the just-fatigue moment ($P<0.01$). Compared with the inactive states, there was no significant difference ($P>0.05$). The recovery of blood glucose concentration and risingα-adrenoceptors can promote the release of insulin.

The experiment also found that the insulin level of group B was constantly higher than that of group A. When the rats were just fatigued, insulin level of group B was significantly higher than that of group A ($P<0.01$). It was conjectured that astragalus can stimulate islet β cell to secrete insulin. The increase of insulin can facilitate synthesis of glycogen, and increase its reserve, which lengthens rats' swimming time before fatigue and enhances their exercise performance. In the meanwhile, it maintains the supply of energy, delaying fatigue. In clinical medicine, astragalus is the main component of the majority of traditional Chinese medicines treating diabetes. In combining the traditional Chinese medicine with western medicine, He (1995) also adopts astragalus and has achieved curative effect. When Huang et al. (2000) were making research on the effect of compound ganoderma lucidum hypoglycemic capsule(mainly composed by lucid ganoderma, astragalus, and pseudo-ginseng) on treating diabetes, they found that the capsule can reduce blood glucose, improve sugar tolerance, promote the release of serum insulin.

Glucagon is generated by islet αcell. It is a metabolic hormone, promoting decomposition. It strongly promotes glycogenolysis and neoglycogenesis, increasing blood glucose concentration. The majority researches (Yang, 1998; Conlee, Hickson, Winder, Hagberg, & Holloszy, 1978; Fell et al., 1980) show that, intense and prolonged exercise dramatically increases glucagon, while moderate exercise does not. The result of this experiment showed that when the rats were just fatigued, their serum glucagon concentration was evidently higher than that of the control group ($P<0.01$), and higher than that of the one-hour-swimming group ($P<0.05$). At the same time, blood glucose concentration dropped due to exercise. The decrease of released insulin also reduced its suppression to glucagon. During the rest, blood glucagon concentration was on a decline. The result of the experiment on the effect of quercetin on metabolism of trained rats conducted by Liu, Xiong, and Zhang (2005), showed that serum glucagon and growth hormone concentration of active group and just-fatigued group increased, compared with the inactive group. The result of the experiment on the effect of rosemary extract and intense endurance training on sugar reserve in rat's body conducted by Xiong and Zhang (2004), showed that serum glucagon level in the rats, which received intense endurance training, was higher than that of the inactive control group.

In the experiment on the effect of the hypoglycemic capsule (composed by ginseng, astragalus, Coptis chinensis, and leech) on diabetic rats (caused by streptozotocin), Zhang et al. (2004) found that the capsule could reduce plasma glucagon. In this experiment, serum glucagon concentration of the APS-injected group was higher than that of the pure-water-drinking group, which was also in line with the blood insulin concentration change. During exercise, insulin decreased, glucagon increased, which facilitated body's mobilization of glycogen. Therefore, blood glucose increased during exercise, so as to prevent hypoglycemia. However, glycogen reserve would drop dramatically. The experiment proved that drop of glycogen reserve is one of the main reasons contributing to fatigue. In the experiment, the decrease of insulin and the increase of glucagon of the APS-injected group were both moderate, which ensured the relative stability of blood glucose concentration in considerable time. The phenomenon could be explained by two hypotheses: first, after APS injection, the body was more sensitive to glucagon, while less sensitive to insulin; second, after APS injection, the body started to preserve glycogen, as so to maintain high blood glucose concentration, which affects secretion of hormones. Further research is needed in order to figure out which hypothesis is right.

## CONCLUSION

The result of the experiment showed that the Chinese medicine astragalus promoted the release of serum insulin and glucagon of rats, maintained the blood glucose concentration during the exercise, reduced the risk of exercise-induced hypoglycemia, and delayed fatigue. Astragalus can promote the compatibility effect of insulin and glucagon in the process of glycogen synthesis and storage, increasing the reserve of muscle glycogen, reducing the direct uptake of blood glucose by skeletal muscle during exercise, providing enough energy for body consumption during exercise, therefore delaying fatigue.

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