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Effect of aerobic exercise and ginsenosides on lipid metabolism in diet-induced hyperlipidemia mice

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KEY WORDS exercise; hyperlipidemia; ginseng; glycosides; malondialdehyde; superoxide dismutase; lipids

ABSTRACT

AIM: To study the effect of aerobic exercise and its combination with Gin (ginsenosides from stems and leaves of ginseng) on lipid metabolism in diet-induced hyperlipidemia mice. **METHODS**: The mouse hyperlipidemia model was set up by feeding high cholesterol diet. Unloaded swimming was designed to be a manner of aerobic exercise. The effects of aerobic exercise and its combination with Gin on total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDL-c) in serum, malondialdehyde (MDA), and superoxide dismutase (SOD) in liver tissue were measured; the thymus and liver were weighed. **RESULTS**: (1) The mouse hyperlipidemia model was set up successfully; TC and MDA increased ($P < 0.05$) but HDL-c and SOD decreased ($P < 0.05$); the liver weight increased and the thymus weight reduced; fatty liver was found; (2) aerobic exercise reduced TC but increased MDA and HDL-c in cholesterol-rich diet mice; the liver weight did not reduce, and fatty liver did not clear up; and (3) when aerobic exercise combined with Gin, TC and TG decreased markedly ($P < 0.01$), and MDA also decreased ($P < 0.05$); SOD and HDL-c increased markedly ($P < 0.01$); the thymus weight increased and the liver weight decreased to normal level; fatty liver cleared up. **CONCLUSION**: Aerobic exercise could lower serum lipid to some extent but could not satisfactorily regulate lipid metabolism. When combined with Gin, aerobic exercise could better lower serum lipid, regulate lipid metabolism, promote antioxidation, and enhance immune activity.

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INTRODUCTION

A number of studies have revealed that low and middle intensive exercise might lower the level of serum lipid in hypercholesterolemic patient and improve the clinical manifestation of atherosclerosis[1,2]. But it was less reported that aerobic exercise might affect lipid metabolism of experimental hyperlipidemia animals. Although Gin (ginsenosides from stems and leaves of ginseng) had the effects of regulating lipid and reducing serum MDA contents in high cholesterol diet fed rats[3], it was not reported whether aerobic exercise plus Gin could bring better effect on lipid metabolism in hyperlipidemia mice. So our study was mainly focused on this field.

MATERIALS AND METHODS

Reagents Cholesterol was purchased from Guangdong Southern Chemical Plant; Gin (light yellow powder, dissoluble in water, methanol, and alcohol) from Yanji Pharmaceutical Factory; Deoxycholic acid Na-salt from Shanghai Chemical Reagent Factory; MDA and SOD test-kit from Nanjing Jiancheng Biology Institute.

Experimental mouse model and treatment Kunming mice (18 - 22 g, male, obtained from Guangdong Animal Experimental Center of China, Certificate № 97A045) were divided into 4 groups and administered with drugs as shown in Tab 1. Mice in Group 1 (Control) were fed on mice chew pellets. The other 3 groups were fed on high cholesterol diet which consisted of 77 % mice chew pellets + 3 % cholesterol + 10 % yolk + 10 % lard + 0.2 %

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deoxycholic acid Na-salt. Gin was dissolved with NS (Tab 1).

Tab 1. Experimental groups and treatment.

Group	Diet and drug
Ⅰ	Control (lab mice chew pellets, ip NS)
Ⅱ	Hyperlipidemia model (high cholesterol diet, ip NS)
Ⅲ	Aerobic exercise (high cholesterol diet, ip NS)
Ⅳ	Aerobic exercise + Gin (high cholesterol diet, ip Gin 60 mg·kg^{-1})

Exercise method and statistics Unloaded swimming manner was used 10 min·d^{-1}, five days a week. Water temperature was (29 ± 2) ℃[4]. Mice were given Gin or NS every morning and swam in the afternoon. All of the experimental mice were killed after feeding 20 d. Blood samples for measurement of TC, TG, and HDL-c were collected from eye vein. The thymus and liver were weighed and liver morphology was observed. Statistical analysis was done with t test.

RESULTS

TC, TG, and HDL-c in serum The changes of serum TC, TG, and HDL-c in the four groups were shown in Tab 2.

Tab 2. Changes of serum TC, TG, and HDL-c. $\bar{x} \pm s$.
$^{a}P > 0.05$, $^{b}P < 0.05$ *vs* **Group Ⅰ.**
$^{e}P < 0.05$, $^{f}P < 0.01$ *vs* **Group Ⅱ.**

Group	n	TC/ mmol·L^{-1}	TG/ mmol·L^{-1}	HDL-c/ mmol·L^{-1}
Ⅰ	10	2.86 ± 0.30	0.55 ± 0.23	0.55 ± 0.12
Ⅱ	9	4.45 ± 0.12^{b}	0.69 ± 0.18^{a}	0.38 ± 0.17^{b}
Ⅲ	9	3.34 ± 0.41^{be}	0.59 ± 0.12	0.57 ± 0.20^{e}
Ⅳ	9	2.87 ± 0.23^{f}	0.21 ± 0.08^{f}	0.75 ± 0.28^{f}

The changes of MDA, SOD, liver and thymus weight The concentrations of MDA and SOD in liver tissue, the liver and thymus weight were shown in Tab 3.

The data in Tab 2 and Tab 3 showed that TC, MDA, and the liver weight increased but HDL-c, SOD, and the thymus weight decreased in Group Ⅱ.

Tab 3. Level of MDA and SOD in liver tissue and weight of liver and thymus. $\bar{x} \pm s$.
$^{b}P < 0.05$, $^{c}P < 0.01$ *vs* **Group Ⅰ.**
$^{e}P < 0.05$, $^{f}P < 0.01$ *vs* **Group Ⅱ.**

Group	n	MDA/ μmol·L^{-1}	SOD/ kU·L^{-1}	Liver weight/g	Thymus weight/mg
Ⅰ	10	3.9 ± 0.6	2.75 ± 1.20	1.67 ± 0.39	86 ± 10
Ⅱ	9	4.9 ± 0.9^{b}	1.45 ± 0.88^{b}	2.66 ± 0.28^{b}	54 ± 4^{b}
Ⅲ	9	6.0 ± 1.2^{bc}	1.68 ± 0.21^{b}	2.86 ± 0.43^{b}	55 ± 8^{b}
Ⅳ	9	3.7 ± 1.0^{e}	3.46 ± 1.23^{f}	1.91 ± 0.51^{e}	84 ± 6^{e}

Compared with Group Ⅰ, all the changes were significant ($P < 0.05$) except TG, of which increasing was not significant; fatty liver was found. Compared with group Ⅱ, aerobic exercise (Group Ⅲ) reduced TC but increased HDL-c ($P < 0.05$) and MDA ($P < 0.01$). But the liver weight did not decrease, and fatty liver did not clear up. Aerobic exercise + Gin (Group Ⅳ) reduced TC, TG, MDA, and the liver weight but increased HDL-c, SOD, and the thymus weight, the changes of MDA, the liver, and thymus weight were remarkable ($P < 0.05$), the changes of TC, TG, HDL-c, and SOD were more significant ($P < 0.01$). The fatty liver cleared up.

DISCUSSION

The research has shown that the serum TC lowered significantly in SD rats after 10-wk intensive training[5]. In our study, the mice hyperlipidemia model was set up successfully by feeding on high cholesterol diet for 20 d. Aerobic exercise alone lowered TC but increased HDL-c markedly. It showed that aerobic exercise may lower serum lipid to some extent. However, MDA increased but SOD lowered in the liver tissue, because during a long-term exercise, the body consumes 20-40 times more oxygen than normal, and produces more oxygen free radicals (OFR). The more OFR is produced, the more serious the harm to cell membrane is. Meanwhile, the rising in OFR level in tissue suggests the rising in level of MDA. However, in our study, the level of SOD in liver tissue lowered, because OFR increased and there was more consumption of SOD. These results showed that aerobic exercise alone did not eliminate OFR and antioxidate effectively. The result did not conform to

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the reference[3] completely.

The liver is the only organ that synthesizes cholesterol and transfers it. The liver weight did not decrease and fatty liver did not clear up in aerobic exercise group. These showed that aerobic exercise alone could not enhance the transfer of cholesterol effectively. When aerobic exercise combined with Gin (Group IV), the results of experiments were as shown in Tab 2 and Tab 3: TC, TG, and MDA lowered significantly, SOD increased, and the fatty liver cleared up. The liver weight decreased and the thymus weight increased. The figures showed that aerobic exercise plus Gin could lower serum lipid, regulate lipid metabolism, and promote antioxidation, and the combined application of the two was more effective than aerobic exercise alone.

In addition, cholesterol rich diet and aerobic exercise reduced the thymus weight, but aerobic exercise plus Gin increased the thymus weight. The results showed that aerobic exercise plus Gin might enhance the immune activity to some extent.

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有氧运动合用人参皂苷对饮食性高脂血症小鼠脂质代谢的影响

R972.6

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关键词 运动; 高脂血症; 人参; 糖苷; 丙二醛; 超氧化物歧化酶; 脂质

目的: 研究有氧运动及其合用人参茎叶皂苷(Gin)对饮食性高脂血症小鼠脂质代谢的影响. **方法**: 通过喂养高胆固醇饲料 20 天建立高脂血症模型, 以无负重游泳作为有氧运动方式, 观察有氧运动及其合用 Gin 时对高脂状态下小鼠的影响. **结果**: (1)高胆固醇饲料喂养 20 天, 小鼠血清 TC, MDA 升高, HDL-c 和 SOD 降低, 高脂血症模型建造成功. 肝重量增加, 有脂肪肝出现, 胸腺重量减轻. (2)有氧运动降低 TC, 升高 MDA 和 HDL-c, 肝重量不减轻, 脂肪肝存在. (3)有氧运动合用 Gin 时, TC, TG 和 MDA 均降低($P<0.05$), HDL-c 和 SOD 显著升高($P<0.01$), 肝重量减轻和胸腺重量接近正常, 脂肪肝消失. **结论**: 单纯有氧运动可在一定程度上降低血脂, 但不能很好调节脂质代谢, 当有氧运动合用 Gin 时, 其降脂调脂和抗氧化作用才更明显, 并可能有一定的减慢机体衰老过程的作用.

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