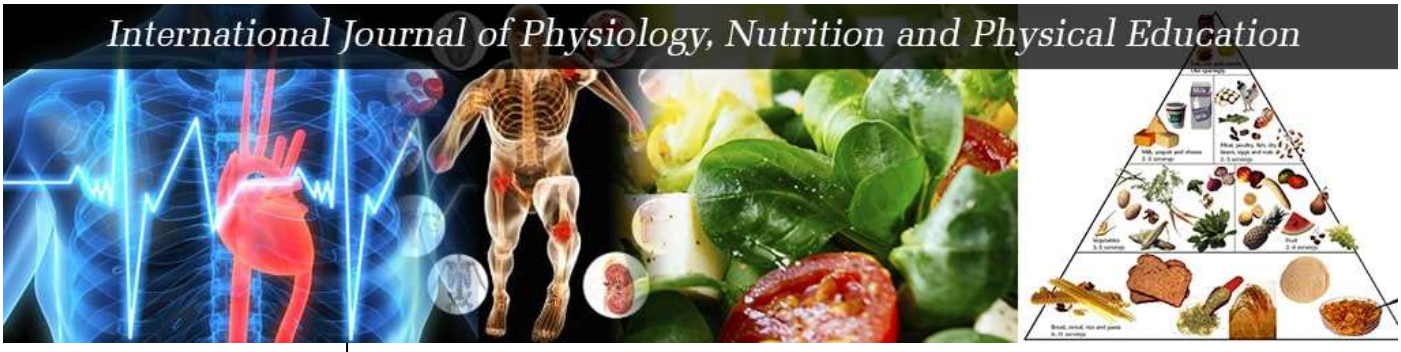

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Investigation on the effects of endurance exercise training on plasma HDL cholesterol levels depend on levels of triglycerides

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Abstract
The purpose of the present study was to compare the responses of numerous lipoprotein-lipid variables to a 16-week endurance exercise training program in men categorized on the basis of baseline TG and HDL cholesterol concentrations: (1) low TG and high HDL cholesterol (normolipidemia), (2) low TG and low HDL cholesterol (isolated low HDL cholesterol), (3) high TG and high HDL cholesterol (isolated high TGs), and (4) high TGs and low HDL cholesterol (high TG/low HDL cholesterol). A series of physical and metabolic variables was measured before and after the training program in a sample of 200 men enrolled in the Health, Risk Factors, Exercise Training. At baseline, men with high TG/low HDL cholesterol had more visceral adipose tissue than did men with isolated low HDL cholesterol and men with normolipidemia. The 0.4% (not significant) exercise-induced increase in HDL cholesterol levels in men with isolated low HDL cholesterol suggests that they did not benefit from the "HDLraising" effect of exercise. In contrast, men with high TG/low HDL cholesterol showed a significant increase in HDL cholesterol levels (4.9%, $p<0.005$). Whereas both subgroups of men with elevated TG levels showed reductions in plasma TGs (˜-15.0%, $p<0.005$), only those with high TG/low HDL cholesterol showed significantly reduced apolipoprotein B levels at the end of the study (-6.0%, $p<0.005$). Multiple regression analyses revealed that the exercise-induced change in abdominal subcutaneous adipose tissue (10.6%, $p<0.01$) was the only significant correlate of the increase in plasma HDL cholesterol with training in men with high TG/low HDL cholesterol. Results of the present study suggest that regular endurance exercise training may be particularly helpful in men with low HDL cholesterol, elevated TGs,and abdominal obesity.

Keywords: HDL cholesterol, triglycerides, exercises training, coronary heart disease

Introduction
Endurance activities, often referred to as aerobic, increase your breathing and heart rates. These activities help keep you healthy, improve your fitness, and help you perform the tasks you need to do every day. Endurance exercises improve the health of your heart, lungs, and circulatory system. They also can delay or prevent many diseases that are common in older adults such as diabetes, colon and breast cancers, heart disease, and others. Physical activities that build endurance include:

- Brisk walking or jogging
- Yard work (mowing, raking)
- Dancing
- Swimming
- Biking
- Climbing stairs or hills
- Playing tennis or basketball

Regular endurance exercise is a widely recognized modality to raise plasma HDL cholesterol levels, which is one of the metabolic adaptations contributing to the reduced risk of coronary heart disease (CHD) observed among physically active and fit individuals. Although a low plasma HDL cholesterol concentration is often accompanied by an elevated triglyceride (TG) level associated with abdominal obesity and an insulin resistance-hyperinsulinemic state, some

individuals are characterized by low HDL cholesterol levels without obesity or hypertriglyceridemia, a condition that has been referred to as isolated hypoalphalipoproteinemia. Previous studies from our laboratory have shown that subjects with isolated low HDL cholesterol were neither characterized by hyperinsulinemia nor by visceral obesity. Although studies have suggested that patients with isolated low HDL cholesterol syndrome may be at increased CHD risk, it appears very difficult to increase HDL cholesterol levels in these individuals by diet, weight loss, or pharmacotherapy. Because subjects with isolated low HDL cholesterol have normal body weight and fat content, we have hypothesized that they may be less responsive to endurance exercise–induced improvements of the lipoproteinlipid profile than are subjects with low HDL cholesterol, elevated TG concentrations, abdominal obesity, and hyperinsulinemia. Therefore, the aim of the present study was to compare the lipoproteinlipid responses to a 20-week endurance exercise training program in men with low HDL cholesterol levels but with or without high TG concentration.

Methodology

Endurance Exercise Training Program

The training program has already been extensively described. Participants trained under supervision in the clinical centers on a cycle ergo meter (Universal Aerobic cycle) for 60 sessions by using the same standardized training protocol. They were required to complete the 60 sessions within 21 weeks. They could not exercise >1 session per day, >4 sessions per week, or <1 session per week. As well, they could not get ahead by >2 sessions or fall behind by >2 sessions. Participants who knew that they might miss a few sessions were encouraged to train 4 times per week for 2 weeks to build up a reserve. Program adherence was monitored several times per week. Participants were contacted when they appeared to be falling behind, and a plan was developed to bring them back on schedule as soon as possible.

To determine each person's training intensity, heart rate (HR), power output, and oxygen intake (VO2) obtained during the 3 baseline cycle ergo meter tests were plotted to determine the average HR and power output associated with 55%, 65%, 70%, and 75% of his/her maximum VO2 (VO2max) before training. These HR and power output values were then used throughout the training program. Training sessions during the first 2 weeks began at an HR associated with 55% VO2max for 30 minutes. Either duration or intensity was then increased each 2 weeks until the 14th week of training, when participants exercised at the HR associated with 75% of their initial VO2max for 50 minutes. This was then maintained for the next 6 weeks.

Statistical Analysis

Pearson product moment correlation coefficients were used to quantify associations between variables. Men were divided into 4 subgroups according to baseline fasting plasma TG and HDL cholesterol concentrations:

1) Normolipidemia (n=62)
2) Isolated low HDL cholesterol (n=38)
3) Isolated high TGs (n=38)
4) High TG/low HDL cholesterol (n=62).

Cutoff values were 1.34 and 0.92 mmol/L for TG and HDL cholesterol, respectively, which corresponded to the 50th percentiles of their respective distributions. Differences among men with various baseline fasting lipoprotein-lipid phenotypes were tested for significance by using ANOVA with the Duncan multiple range test. Paired t tests were used to examine the significance of the changes in physical and metabolic variables within each subgroup of men. In all analyses, $p<0.05$ was considered significant. Analyses were conducted with the SAS statistical package.

Result and analysis

Table 1: Shows the baseline pre training plasma lipoprotein profile of the 4 subgroups of men

Variables	Normolipidemia Isolated Low	HDL Cholesterol	Isolated High	TGs
Subjects	62	38	38	62
TGs, mmol/L	0.94±0.22	0.93±0.22	1.77±0.39	2.45±1.09
HDL C mmol/L	1.12±0.14	0.81±0.07**	1.05±0.21	0.75±0.10
Apo A-1 g/L	1.23±0.12	1.01±0.10	1.28±0.12	1.07±0.12
ApoB, g/L	0.77±0.20	0.73±0.19	1.05±0.20	1.06±0.22

Table shows the baseline pre training plasma lipoprotein profile of the 4 subgroups of men. Although men with high TG/low HDL cholesterol had higher plasma TG (by design), cholesterol, and apo B concentrations than did normolipidemic men, men with isolated low HDL cholesterol levels had lower plasma cholesterol and apoA-I levels but similar apoB levels compared with the levels in normolipidemic men. Thus, the higher total cholesterol/HDL cholesterol ratio noted among subjects with isolated low HDL cholesterol resulted solely from the very low HDL cholesterol concentrations. However, high plasma cholesterol and low HDL cholesterol levels contributed to the high total cholesterol/HDL cholesterol ratio observed in men with high TG/low HDL cholesterol compared with normolipidemic men. Men with high TG/low HDL cholesterol were also clearly hyperinsulinemic and, presumably, more insulin resistant at baseline than were the other subgroups of subjects.

Discussion

It is well established that low plasma HDL cholesterol levels are associated with an increased risk of CHD.19,20 Indeed, a low HDL cholesterol concentration has been shown to be the most prevalent abnormality of the Lipoprotein-lipid profile reported among men with documented CHD.21 In this regard, the recently published results of the Veterans Affairs High-Density Lipoprotein Intervention Trail (VAHIT) Study 36 clearly show that pharmacotherapy aimed at increasing plasma HDL cholesterol levels reduces the risk of CHD, even in the absence of any change in plasma LDL cholesterol levels; this latter finding is commonly observed when CHD patients with low HDL cholesterol levels are treated with a fibrate such as gemfibrozil.

Summary

In summary, results of the present study suggest that regular endurance exercise is particularly helpful to improve the lipid lipoprotein profile of men with low HDL cholesterol levels along with abdominal obesity and elevated TG concentrations. However, it appears that subjects with low HDL cholesterol levels as an isolated trait are much less

responsive to endurance exercise training; at least as far as their plasma lipoprotein profile is concerned. This finding is concordant with the common observation that it is very difficult in clinical practice to increase the cholesterol content of HDL among subjects with low HDL cholesterol concentrations, when the latter is an isolated lipoprotein characteristic.

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