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Lipidemic Profile of Athletes and Non-Athletes With Similar Body Fat

Anatoli Petridou, Despina Lazaridou, and Vassilis Mougios

Although chronic exercise is generally believed to improve the lipidemic profile, it is not clear whether this is due to exercise training or to other determinants such as the usually low body fat of athletes. The aim of the present study was to compare the lipidemic profile of young lean athletes and non-athletes matched for percentage body fat. Fourteen endurance athletes and fourteen sedentary men participated in the study. Participants provided two blood samples at the beginning and end of a 7-d period, during which they recorded physical activity and food intake. Athletes had significantly higher energy expenditure and energy intake but not significantly different macronutrient composition of their diet from non-athletes. No significant differences were found in serum triacylglycerol, total cholesterol, high-density lipoprotein cholesterol and low-density lipoprotein cholesterol concentrations between groups. These data suggest that athletes and non-athletes with similar body fat do not differ in their lipidemic profiles.

Key Words: cholesterol, HDL, LDL, triacylglycerols

Dyslipidemia is one of the major risk factors for the development of coronary heart disease. Although positive effects of physical exercise on serum lipids have been identified in numerous studies, results from cross-sectional studies become equivocal when several confounding variables are considered (reviewed in reference 5). These variables include body mass, body composition, dietary habits, lifestyle, alcohol use, and smoking.

With regard to body composition, studies have shown that body fat is associated with serum lipid concentrations. In particular, it is positively correlated with triacylglycerols (TG) and low-density lipoprotein cholesterol (LDLC), and negatively correlated with high-density lipoprotein cholesterol (HDLC) (11, 14-16, 19). On the other hand, there are studies showing that the amount of exercise is more important in decreasing the atherogenic risk than the decrease in body fat (9, 14). Likewise, serum lipid concentrations did not change significantly despite a reduction in body fat with exercise training (18) and did not differ among athletes of different body fat (8).

Based on the limited number of studies that have considered body fatness while examining the effect of exercise on the lipidemic profile, and the discrepancies

The authors are with the Dept of Physical Education and Sport Science, Aristotle University of Thessaloniki, 541 24 Thessaloniki, Greece.

among them, the aim of the present study was to investigate whether young lean endurance athletes (as most of the endurance athletes are) have a different lipidemic profile from sedentary individuals of similar age and percentage body fat. Although atherosclerotic cardiovascular disease is not a leading cause of death among young lean individuals, a healthy effect of exercise on blood lipids, even when they are normal at a young age, might prevent the accumulation of causes that will lead to cardiovascular disease at an older age. In addition, as exercise is an independent factor for altering the lipidemic profile, it would be interesting to see whether it has the power to affect blood lipids even in a population group that usually displays normal values.

Methods

Subjects

Twenty-eight men, age 18 to 26, who responded to a public invitation participated in the study. Half were athletes practicing endurance sports (rowing, long-distance swimming, and aerobic dancing) and had been training for at least 1 y, at least 5 d per week and at least 1 h per day. The other half did not participate in any training program and were chosen from a larger pool to have the same percentage body fat as the athletes. Subjects were not suffering from any apparent acute or chronic illness, were not taking any medication or dietary supplements, were not dieting, and were not smoking. All subjects were informed orally and in writing of the design and potential risks of the research, and consented to participate. The study was designed and carried out according to the guidelines of the University of Thessaloniki Ethics Committee.

Design

Subjects visited the laboratory initially to complete a health history and physical activity questionnaire, as well as have their body fat measured. If they fit the inclusion criteria described above, they provided a blood sample and were given forms along with detailed instructions on how to record their 24-h physical activity and food intake for the following 7d. Physical activity was recorded to verify the division into athletes and non-athletes, and food intake was recorded to compare the composition of food between groups. Subjects were asked not to modify their usual way of life during the test period. Subsequently they visited the laboratory to return the completed forms and provide a second blood sample. The purpose of the second blood sampling was to minimize the error attributable to the biological variability in serum lipid concentrations (13).

Body Composition

Body mass was measured to the nearest 0.1 kg by an electronic balance (Seca, Hamburg, Germany) at both visits to the laboratory. Height was measured to the nearest 0.1 cm by a stadiometer fixed to the balance. We estimated body fat by measuring four-terminal bioelectrical impedance through a Bodystat 1500 apparatus (Douglas, UK). Because bioelectrical impedance is influenced by the amount of

body water, the subjects were asked to abstain from water or other drinks for at least 4 h, physical exercise for at least 12 h, and caffeine-containing beverages as well as sauna for at least 24 h before the measurement. In addition, we estimated body fat by measuring the thickness of 3 skinfolds and used the equation of Jackson and Pollock (10) to calculate body density as well as the equation of Siri (17) to calculate percentage body fat. All skinfold thickness measurements were performed by the same highly experienced researcher with Harpenden metal calipers from British Indicators (West Sussex, UK).

Lipidemic Profile

Subjects provided venous blood samples in the sitting position from a forearm vein into plain evacuated tubes between 9 and 9:30 AM after an overnight fast. After clotting, serum was prepared by centrifugation at 1500 × *g* for 10 min and was stored at –20 °C until analysis. TG and total cholesterol (TC) were assayed by enzymic spectrophotometric methods through the use of reagent kits from Best (Athens, Greece). HDLC was determined the same as TC after precipitation of very low-density and low-density lipoproteins with a reagent from Böhringer (Mannheim, Germany). These biochemical parameters were determined in duplicate with simultaneous use of a control serum from Böhringer. Each parameter was assayed on a single day to eliminate inter-assay variability. Intra-assay coefficients of variation for TG, TC, and HDLC were 1.8, 1.2, and 1.2%, respectively. From the values corresponding to the two blood samples drawn from each subject, the average was calculated and was used for further analysis. LDLC was calculated according to Friedewald et al. (7). TC/HDLC (considered an atherogenic index) was also calculated.

Physical Activity Analysis

Physical activity records were reviewed with the subjects and were corrected if unusual or unreasonable duration of activities had been recorded. Physical activity records were analyzed by assigning metabolic equivalents (METs), that is, multiples of resting metabolic rate (RMR) to each activity based on a compendium of energy costs (1). The average MET for each subject was calculated by summing the products of the MET value for each activity by the time that it was practiced and dividing the sum by the total time. Daily energy expenditure was calculated by multiplying the average MET by the RMR, which was estimated by two different methods. The first was based on fat-free mass (FFM) and the equation RMR = 500 + 22 × FFM (3). We calculated two RMR values in this way by using the FFM values derived from the 2 methods of body fat assessment. The second method of estimating RMR was based on two different equations, one for athletes, RMR = 9 × weight (kg) + 1170 × height (m) – 857, and one for sedentary individuals, RMR = 15.4 × weight (kg) – 27 × height (m) + 717, as proposed by De Lorenzo et al. (4).

Dietary Analysis

Dietary records were analyzed for energy intake in Microsoft Access by the use of a food database created in our laboratory on the basis of published data (6).

Statistical Analysis

Results are reported as the mean ± standard deviation. The distribution of all dependent variables was examined by the Shapiro-Wilk test and was found not to differ significantly from normal. Significant differences between groups were detected by two-tailed Student's *t*-test for independent observations. Linear correlation analysis was performed by Pearson's product-moment correlation. The level of statistical significance was set at $\alpha = 0.05$. SPSS software (version 10.0) was used for all analyses (SPSS, Inc., Chicago, IL).

Results

Subject characteristics are presented in Table 1. There were no significant differences between athletes and sedentary subjects with regard to age, height, percentage body fat, and fat mass. Athletes had significantly higher body mass, body-mass index, and FFM. The 2 methods of body fat measurement gave very similar results. Body mass changed minimally, and not significantly, during the week of recording physical activity and food intake (by 0.2 kg in the athletes and –0.3 kg in the non-athletes).

The results of the serum lipid analysis are shown in Table 2. There were no significant differences between athletes and non-athletes in fasting TG, TC, HDLC, LDLC, or TC/HDLC. The coefficients of biological variation based on the two blood samples taken from each individual were 37% for TG, 12% for TC and HDLC, 18% for LDLC, and 13% for TC/HDLC.

The analysis of daily energy expenditure is shown in Table 3. RMR, METs, and total energy expenditure of the athletes were significantly higher compared to

Table 1 Characteristics of Participants

	Non-athletes ($n = 14$)	Athletes ($n = 14$)
Age (y)	22.4 ± 2.4	21.5 ± 1.4
Height (m)	1.81 ± 0.06	1.83 ± 0.05
Body mass (kg)	70.2 ± 8.8	81.2 ± 10.1*
Body-mass index (kg/m^2)	21.4 ± 2.1	24.2 ± 2.2*
Sum of 3 skinfolds (mm)	36.4 ± 11.3	33.2 ± 10.9
Body fat (%)[a]	10.2 ± 2.5	9.9 ± 2.5
Fat mass (kg)[a]	7.3 ± 2.3	8.2 ± 2.9
Fat-free mass (kg)[a]	63.0 ± 7.2	73.0 ± 7.9*
Body fat (%)[b]	10.1 ± 3.5	9.1 ± 3.3
Fat mass (kg)[b]	7.3 ± 3.1	7.6 ± 3.4
Fat-free mass (kg)[b]	62.9 ± 6.5	73.6 ± 7.7*

*Significantly different from non-athletes, $P < 0.01$
[a]Based on bioelectrical impedance
[b]Based on skinfold thickness

Table 2 Serum Lipid Analysis

	Non-athletes			Athletes		
	1st sample	2nd sample	Average	1st sample	2nd sample	Average
TG (mmol/L)	0.80 ± 0.43	0.60 ± 0.23	0.70 ± 0.28	0.75 ± 0.23	0.73 ± 0.26	0.74 ± 0.18
TC (mmol/L)	4.43 ± 0.96	4.12 ± 0.79	4.28 ± 0.79	4.20 ± 0.58	3.89 ± 0.70	4.05 ± 0.59
HDLC (mmol/L)	1.49 ± 0.31	1.36 ± 0.25	1.42 ± 0.25	1.50 ± 0.22	1.36 ± 0.24	1.43 ± 0.22
LDLC (mmol/L)	2.57 ± 0.76	2.49 ± 0.83	2.53 ± 0.75	2.35 ± 0.63	2.20 ± 0.82	2.28 ± 0.69
TC/HDLC	3.03 ± 0.58	3.12 ± 0.84	3.06 ± 0.64	2.87 ± 0.64	2.98 ± 0.92	2.92 ± 0.73

Note. TG, triacylglycerols; TC, total cholesterol; HDLC, high-density lipoprotein cholesterol; LDLC, low-density lipoprotein cholesterol; TC/HDLC, ratio of total cholesterol to high-density lipoprotein cholesterol.

Table 3 Analysis of Daily Energy Expenditure

	Non-athletes	Athletes
RMR (kcal)[a]	1886 ± 159	2106 ± 174*
RMR (kcal)[b]	1884 ± 144	2120 ± 169*
RMR (kcal)[c]	1748 ± 136	2015 ± 144*
METs	1.44 ± 0.16	1.85 ± 0.24*
Total energy expenditure (kcal)[a]	2722 ± 475	3895 ± 600*
Total energy expenditure (kcal)[b]	2718 ± 449	3919 ± 582*
Total energy expenditure (kcal)[c]	2522 ± 431	3723 ± 531*

Note. RMR, resting metabolic rate; MET, metabolic equivalents. *Significantly different from non-athletes, $P < 0.005$. [a]Based on reference 2 with fat-free mass derived from bioelectrical impedance measurements. [b]Based on reference 2 with fat-free mass derived from skinfold thickness measurements. [c]Based on reference 3.

their sedentary counterparts. The RMR estimates by the different methods described above were similar and highly correlated ($r > 0.95$), averaging 1839 kcal for the non-athletes and 2080 kcal for the athletes. Likewise, the total energy expenditure averaged 2654 and 3846 kcal, respectively.

The analysis of energy intake is presented in Table 4. The athletes had significantly higher energy, carbohydrate, fat, and protein intake. The relative contribution of each macronutrient to total energy intake was not significantly different between groups. Finally, there was no difference in alcohol consumption between groups.

Discussion

In the present study, we compared the lipidemic profile of young lean endurance athletes and sedentary individuals matched for percentage body fat. As noted above, few studies have considered body fatness while examining the effect of exercise on the lipidemic profile, and their findings are equivocal. Although atherosclerosis is not a major health problem in young lean individuals, such as the ones examined here, exercise might act protectively against cardiovascular disease at an older age by promoting a healthier lipidemic profile from the early years on.

To ensure that the 2 groups differed markedly in energy expenditure, we asked them to record their physical activity for 1 wk. Indeed, the athletes had a higher energy expenditure by 1192 kcal daily, which was mainly (by 951 kcal) due to their participation in physical activities and adequate to cause changes in the lipidemic profile, as the relevant threshold of energy expenditure by exercise training is thought to be 1000 to 1500 kcal per week (5, 12).

Proposed factors affecting blood lipid concentrations, other than physical activity, include age, body composition, diet, alcohol consumption, and smoking (5, 12). To control for these confounding variables, first, we compared athletes and non-athletes of similar age, matched for percentage body fat. Second, we analyzed their diet for 1 wk. Athletes had higher energy intake (in accordance with their

Table 4 Analysis of Daily Energy Intake

	Non-athletes	Athletes
Energy (kcal)	2775 ± 394	4111 ± 1241*
Carbohydrate (g)	299 ± 60	495 ± 180*
Carbohydrate (% energy)	42.9 ± 5.1	47.6 ± 7.9
Fat (g)	116 ± 18	160 ± 62*
Fat (% energy)	37.7 ± 4.9	35.4 ± 7.6
Protein (g)	119 ± 23	163 ± 53*
Protein (% energy)	17.3 ± 3.0	15.9 ± 1.8
Alcohol (g)	9 ± 11	6 ± 4
Alcohol (% energy)	2.1 ± 2.5	1.1 ± 1.0

*Significantly different from non-athletes, $P < 0.01$.

higher energy expenditure) but did not differ in the distribution of energy among carbohydrate, fat, protein, and alcohol. Finally, subjects were non-smokers.

We found no significant differences in the lipidemic profile between athletes and non-athletes. This favors the hypothesis that low body fat plays a crucial role in the beneficial lipidemic profile of physically active individuals. It should be noted, however, that our findings refer to young individuals of low body fat. It is possible that significant differences in serum lipids would have been found between athletes and non-athletes of older age or higher body fat. It is also possible that more subjects would be required to detect significant differences in blood lipids if they existed. Nevertheless, based on our calculation of an average effect size of 0.63 for the differences in TG, TC, LDLC, and HDLC between athletes and non-athletes in the studies tabulated by Durstine et al. (5), we found that the sample size required to produce the recommended power of 0.8 at $\alpha = 0.05$ was 14 per group (2), equal to the sample size employed in the present study. With respect to TC and LDLC, our findings are in agreement with the majority of the evidence that these parameters do not differ between physically active and sedentary individuals of similar body fat (5).

In conclusion, serum TG, TC, HDLC, and LDLC concentrations did not differ significantly between young lean endurance athletes and sedentary individuals matched for percentage body fat. It would be interesting to further examine whether athletes and non-athletes, matched for body fat, differ in their lipidemic profile when they are older or have higher levels of body fat.

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