

EXPERIMENTAL INVESTIGATIONS

Aerobic exercise-induced changes in body composition and blood lipids in young women

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Key words: aerobic training; cycling ergometry; body composition; blood lipids.

Summary. The objective of the study was to assess changes in body composition, blood lipid and lipoprotein concentrations in 18–24-year-old women during the period of two-month aerobic cycling training.

Material and methods. Young, healthy, nonsmoking women ($n=19$) volunteered to participate in this study. They were divided in two groups: experimental (E, $n=10$) and control (C, $n=9$). The subjects of group E exercised 3 times a week with intensity of the first ventilatory threshold and duration of 60 min. The group C did not exercise regularly over a two-month period of the experiment. The subjects of group E were tested before and after 2, 4, 6 and 8 weeks of the experiment. The participants of group C were tested twice with an eight-week interval.

Results. Body weight, body mass index, body fat mass, and triacylglycerol (TAG) concentration decreased and high-density lipoprotein cholesterol (HDL-ch) concentration increased after the 8-week training program in the experimental group ($P<0.05$). Blood total cholesterol (Tch) and low-density lipoprotein cholesterol (LDL-ch) concentrations did not change significantly. Body weight and body mass index started to decrease after 2 weeks of the experiment, but significant changes were observed only after 6 and 8 weeks. Body fat mass was significantly decreased after 2 and 8 weeks of aerobic training. A significant increase in HDL-ch concentration was observed after 4, 6, and 8 weeks. A significant decrease in TAG concentration was observed after 2-week training. No significant changes in all the parameters except TAG (it was slightly increased) were seen in the control group.

Conclusions. The two-month aerobic cycling training (within VT1, 60-min duration, three times a week) may induce significant changes in the parameters of body composition – body weight, body mass index, body fat mass, and blood lipids – in young women. The following significant changes were observed: TAG level decreased after 2 weeks, body mass and body mass index decreased after 6 weeks, body fat mass decreased and HDL-ch level increased after 8 weeks. Peak oxygen uptake increased after 4 weeks.

Introduction

Obesity, blood high-density lipoprotein cholesterol (HDL-ch) level lower than normal, increased low-density lipoprotein cholesterol (LDL-ch) and triacylglycerol (TAG) concentrations are risk factors for cardiovascular diseases (CVDs) (1). Systematic physical activity is known to produce an effect on many risk factors for CVDs. Persons who do aerobic exercises regularly have higher HDL-ch concentration as compared to sedentary subjects (2). During the course of various programs of physical activity, a decrease in total cholesterol (Tch), TAG, and LDL-ch levels and an increase in

HDL-ch level were observed (2–4). However, some researchers observed only insignificant changes in lipid and lipoprotein concentrations after exercise training (5). Some studies detected an increase in HDL-ch concentration in blood without weight loss (6), while other researchers associated an increase in HDL-ch level, namely, with a decrease in body weight (7). Dancy et al. (8) observed higher HDL-ch concentration in more physically active women. Others detected an increase in HDL-ch level in middle-aged men after 4-month fast walking or yoga; however, Tch did not change (9). Tch and TAG levels significantly diminished in middle-aged

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men after six-week training, but HDL-ch and LDL-ch concentrations did not vary (10). Furthermore, there is limited evidence about the period of regular exercising needed to produce these health-related changes. Most of the studies have compared parameters before and after application of training program with typical duration of 8 and more weeks. Recent studies have shown changes in TAG and HDL-ch levels even after one aerobic training session (11), so it might be expected that some changes in blood lipid and lipoprotein concentrations as well as body composition may occur earlier than after 8 or more weeks.

The aim of the study was to determine the changes in body composition, blood lipid and lipoprotein concentrations in 18–24-year-old women over a 2-month period of aerobic cycling training.

Material and methods

Studied subjects. A total of 19 female students of Vytautas Magnus University who were healthy,

did not smoke, and without previous exercising and history of taking contraceptives agreed to participate in the study (Table 1). The permission to perform the study was obtained from the Regional Committee of Bioethics (June 29, 2006; No. BE-2-38).

Organization of the study. The subjects of the experimental group exercised three times per week with an intensity of the first ventilatory threshold (VT1) and 60 minutes in duration. The women of the control group did not exercise. The participants were asked not to take part in any other physical activity and not to change nutrition habits.

The studied subjects of the experimental group visited a laboratory every second week in the morning without taking breakfast (in fasting state). The study was carried out over a 2-month period. The parameters of the participants of the control group were assessed before and after 8 weeks.

Methods. *Determination of body composition.* Body weight, body mass index (BMI), and body fat mass were determined using a Tanita body composition analyzer TBF-300.

Ergometry. To determine VT1, the subjects performed continuously increasing cycling exercise using an Ergoline (Germany) cycle ergometer. The power reached 20 W during the first three minutes, and then it was started to increase by 2 W every 5 s. The test was performed until the subject refused to continue due to fatigue or failed to maintain cycling frequency. Gas exchange parameters were recorded during the

Table 1. Characteristics of the studied subjects

Variable	Experimental group (n=10)	Control group (n=9)
Age, years	20.6 (2.3)	21.4 (2.7)
Height, cm	172 (6.1)	171.2 (5.1)
Body weight, kg	70.5 (13.5)	63.1 (5.9)
VO _{2max} , mL/kg/min	29.9 (4.0)	33.69 (4.74)

Table 2. Body composition, blood lipid and lipoprotein concentrations, and maximal oxygen uptake before the experiment and every second week after the experiment in the experimental group

Parameter	Before experiment	After 2 weeks	After 4 weeks	After 6 weeks	After 8 weeks	% change in the parameter after 8 weeks
Body weight, kg	70.52 (13.52)	70.05 (13.28) <i>P</i> =0.066	69.76 (13.71) <i>P</i> =0.059	69.55 (13.35)* <i>P</i> =0.024	69.49 (13.30)* <i>P</i> =0.038	–1.5
Body mass index, kg/m ²	23.71 (3.96)	23.56 (3.81) <i>P</i> =0.074	23.48 (3.91) <i>P</i> =0.126	23.38 (3.87)* <i>P</i> =0.028	22.23 (3.80)* <i>P</i> =0.028	–6.2
Body fat mass, %	31.59 (8.93)	31.49 (9.06) <i>P</i> =0.878	30.97 (9.37) <i>P</i> =0.083	30.80 (9.06) <i>P</i> =0.092	29.71 (8.54)* <i>P</i> =0.016	–6.0
Tch, mmol/L	4.35 (0.70)	4.40 (0.60) <i>P</i> =0.593	4.21 (0.70) <i>P</i> =0.406	4.47 (0.74) <i>P</i> =0.678	4.48 (0.57) <i>P</i> =0.065	+3
HDL-ch, mmol/L	1.40 (0.43)	1.42 (0.51) <i>P</i> =0.593	1.42 (0.35) <i>P</i> =0.593	1.47 (0.46) <i>P</i> =0.207	1.65 (0.44)* <i>P</i> =0.011	+17.9
LDL-ch, mmol/L	2.57 (0.67)	2.79 (0.48) <i>P</i> =0.313	2.42 (0.48) <i>P</i> =0.374	2.69 (0.59) <i>P</i> =0.514	2.55 (0.62) <i>P</i> =0.674	–0.8
TAG, mmol/L	0.84 (0.18)	0.65 (0.27)* <i>P</i> =0.050	0.80 (0.23) <i>P</i> =0.477	0.68 (0.17)* <i>P</i> =0.015	0.62 (0.29)* <i>P</i> =0.049	–26
VO _{2max} , mL/kg/min	29.9 (4.0)	31.3 (4.2) <i>P</i> =0.074	33.6 (4.1)* <i>P</i> =0.006	34.8 (4.8)* <i>P</i> =0.005	34.7 (5.4)* <i>P</i> =0.01	+16

*Significant difference as compared to baseline values (*P*<0.05).

test using a portable gas analyser Oxycon Mobile (Germany). VT1 was identified as work intensity, above which ventilatory oxygen equivalent started to increase without a concomitant increase in ventilatory CO₂ equivalent. Peak oxygen uptake (VO_{2max}) was considered as the highest average VO₂ during 20 seconds of continuously increasing cycling exercise.

Biochemical analysis of the blood. Blood sampling was performed in fasting state in the morning using sterile tubes and disposable needles. Blood samples were analyzed for Tch, HDL-ch, TAG concentrations using the standard enzyme assay with a SPOTCHEM TM EZ sp-4430 (ARKRAY, Japan) biochemical analyser. LDL-ch concentration was calculated using the Friedewald formula:

$$\text{LDL-ch} = \text{Tch} - \text{HDL-ch} - (0.45 \times \text{TAG}) \quad (12).$$

Statistical analysis. The mean values and standard deviations of parameters were calculated. The nonparametric Wilcoxon test was used to evaluate the differences between testings. *P* values of less than 0.05 were considered statistically significant. Analysis was performed using MS Office Excel 2003 and Statistica for Windows software.

Results

An 8-week physical activity programme (aerobic cycling of 60 minutes in duration, 3 times per week within VT1) resulted in a 26% decrease in TAG level and a 17.9% increase in HDL-ch level without

significant changes in Tch and LDL-ch levels. Body weight, BMI, and body fat were also decreased by 1.5%, 6.2%, and 6.0%, respectively (Table 2).

In the experiment group, body weight started to decrease after two weeks, but a significant decrease was observed only after 6 (*P*=0.024) and 8 (*P*=0.038) weeks. BMI also started to decrease from the second week of the experiment, but significant differences were observed after 6 (*P*=0.028) and 8 (*P*=0.028) weeks. Fat body mass was decreased significantly only after 8 weeks (*P*=0.016) (Table 2).

Significant changes in HDL-ch level were also observed only after 8 weeks (*P*=0.011). TAG concentration in blood significantly declined after 2 (*P*=0.050), 6 (*P*=0.015), and 8 (*P*=0.049) weeks. In the control group, no changes in the parameters examined were seen except for TAG level, which was significantly higher after 8-week period (Table 3).

Discussion

The results of the study demonstrated that aerobic cycling training program (two-month cycling of 60 minutes in duration, 3 times per week with an intensity of VT1) caused a decrease in body weight, fat mass, blood TAG level and an increase in HDL-ch level without significant changes in Tch and LDL-ch levels in young female students. The time course of observed changes was different. TAG level was significantly decreased after two weeks, body weight and BMI after 6 weeks, body fat mass and HDL-ch level after 8 weeks.

This is the first study where time course of changes in body composition, blood lipid profile, and aerobic power were compared during the period of 8 weeks of aerobic cycling training in young women. There are data about acute changes in TAG and HDL-ch levels following 24 and 48 hours after exercise (11). Lactate threshold intensity, which is near to that of VT1, might appear to be the threshold intensity of acute aerobic exercise (expending 350 kcal) necessary to induce a significant increase in HDL (13). Therefore, significant changes in TG level after two weeks of training in our study may be explained by such rapid effect of exercise on this variable. The decrease in TAG, Tch, and LDL-ch levels was observed after four weeks in other study (14), but the subjects had dyslipidemia or obesity, and exercise was combined with diet modifications in that study. Despite this, the authors also did not observe significant changes in HDL-ch level. This is in accordance with our data and shows that period needed for such changes is longer.

Table 3. Body composition, blood lipid and lipoprotein concentrations, and peak oxygen uptake in the control group

Parameter	Before experiment	After 8 weeks	% change in the parameter after 8 weeks
Body weight, kg	63.1 (5.99)	63.70 (6.82) <i>P</i> =0.593	+0.9
Body mass index, kg/m ²	21.0 (1.94)	21.20 (1.93) <i>P</i> =0.362	+0.9
Body fat mass, %	23.73 (4.99)	23.51 (5.25) <i>P</i> =0.514	-0.9
Tch, mmol/L	3.96 (0.62)	4.13 (0.40) <i>P</i> =0.236	+4.3
HDL-ch, mmol/L	1.48 (0.24)	1.42 (0.29) <i>P</i> =0.441	-4.1
LDL-ch, mmol/L	2.24 (0.53)	2.35 (0.46) <i>P</i> =0.286	+4.9
TAG, mmol/L	0.54 (0.27)	0.79 (0.39)* <i>P</i> =0.017	+46.3
VO _{2max} , mL/kg/min	33.69 (4.74)	33.17 (4.08) <i>P</i> =0.441	-1.5

*Significant difference as compared to baseline values (*P*<0.05).

Excessive body weight and BMI are directly related to morbidity and mortality from cardiovascular diseases (15). Physical activity is one of the methods to decrease body weight, BMI, and body fat mass (16). This was confirmed by our study. Scientists observed that aerobic training-induced decrease in body weight was a result of reduction in body fat (17). Fogelholm et al. and Romijn et al. (18, 19) reported that dynamic, aerobic physical loads of moderate intensity had the most effective impact on fat body mass reduction due to an increase in the activity of enzymes of aerobic oxidation. During exercises and after them, triacylglycerol of the adipose tissue is mobilized for energetic purposes, which results in the change of fat mass (19). Physical activity may not only enhance aerobic capacity, which is important for the cardiovascular system and metabolism, but also helps to deplete excess of energy (20) and increase basal metabolism (21).

LeMura et al. investigated the effect of a 16-week aerobic training on young women and found out that body fat mass was significantly reduced (13%), TAG concentration was decreased ($P < 0.05$), and HDL-ch and VO_{2max} were increased by 23% and 25%, respectively (22). In our study, these changes were smaller, maybe due to a shorter duration of the experiment (Table 2). George et al. summarized the results of 27 studies on the impact of aerobic exercises on lipid and lipoprotein concentrations and detected a decrease in Tch, LDL-ch, and TAG by 2%, 3%, and 5%, respectively, but an increase in HDL-ch by 3% (23).

Due to the effect of aerobic load, the changes in total cholesterol Tch and LDL-ch levels in our studied subjects were insignificant. However, it does not contradict the findings of other researchers who determined that Tch concentration was similar, if compared athletes with physically inactive people, but active people had a higher HDL-ch concentration because of long-term activity (24). The results

obtained suggest that aerobic exercises (aerobic cycling training of 60-min duration) increase HDL-ch concentration if a person trains three times a week. An increase in HDL-ch level maybe also related to a decrease in body weight. The increase in HDL-ch concentration is promoted by energy depletion during training (25). Brownell et al. found that physical load of moderate intensity (approximately 60% of VO_{2max}) with a caloric expenditure of 1200 kcal of energy for a week (30-min sessions, 3 times weekly) can increase HDL-ch concentration in blood (26). Energy expenditure in our studied subjects during a training week was similar. LDL-ch level did not change significantly after 2-month experiment in our study (Table 2). Some authors compared LDL-ch concentration between physically active and passive subjects and did not find any significant differences (27), while the others determined that LDL-ch concentration in blood of physically active subjects was 7–12% lower as compared to subjects who did not exercise (28).

Many authors state that one-time exercises increase the rate of TAG excretion from metabolism due to an increase of enzyme lipoprotein lipase activity, which is proportional to work intensity and duration (29).

Conclusion

The two-month aerobic cycling training (within VT1, 60 minutes in duration, three times a week) may induce significant changes in body composition and blood lipid levels in young women and can be applied as a preventive measure to reduce the risk of cardiovascular diseases.

The time needed to produce significant changes in the parameters investigated is as follows: 2 weeks for triacylglycerol level, 4 weeks for peak oxygen uptake, 6 weeks for body weight and body mass index, and 8 weeks for body fat mass and high-density lipoprotein cholesterol level.

Merginių kūno sandaros ir kraujo lipidų pokyčiai, sąlygoti aerobinių pratimų poveikio

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Raktažodžiai: aerobiniai pratimai, veloergometrija, kūno sandara, kraujo lipidai.

Santrauka. *Tyrimo tikslas.* Nustatyti 18–24 metų merginių kūno sandaros, kraujo lipidų pokyčius per du mėnesius aerobinių pratimų.

Tirtųjų kontingentas ir tyrimo metodai. Jaunos, sveikos, nerūkančios merginos (n=19) sutiko dalyvauti

šiam tyrimu. Jos buvo suskirstytos į dvi grupes: tiriamųjų (T, n=10) ir kontrolinę (K, n=9). Aštuonias savaites tiriamosios grupės merginos tris kartus per savaitę po 60 min. suko veloergometro pedalus pirmojo ventiliacinio slenksčio intensyvumu. Kontrolinės grupės merginos fizinio aktyvumo pratimų neatliko. Tiriamosios grupės merginos testus atliko prieš eksperimentą ir praėjus 2, 4, 6, 8 savaitėms po eksperimento. Kontrolinės grupės merginos buvo tiriamos dukart aštuonių savaitių intervalu.

Rezultatai. Nustatyta, kad tiriamosios grupės merginų kūno masė, kūno masės indeksas (KMI), kūno riebalų masė bei kraujo triacilglicerolio (TAG) koncentracija sumažėjo, o didelio tankio lipoproteinų cholesterolio (DTL-ch) koncentracija padidėjo per aštuonias pratimų savaites ($p<0,05$). Bendrasis kraujo cholesterolis (Bch) ir mažo tankio lipoproteinų cholesterolis (MTL-ch) išliko panašūs. Kūno masė ir KMI pradėjo mažėti po dviejų eksperimento savaitių, tačiau reikšmingai pakito tik po šešių ir aštuonių savaitių. Kūno riebalų masė reikšmingai sumažėjo po dviejų ir aštuonių savaitių aerobinių pratimų. Didelio tankio lipoproteinų cholesterolio (DTL-ch) reikšmingas padidėjimas kraujyje nustatytas po 4, 6 ir 8 savaitių. Triacilglicerolio (TAG) reikšmingas sumažėjimas nustatytas po dviejų pratimų savaitių. Visi parametrai, išskyrus TAG (jis nežymiai padidėjo), kontrolinėje grupėje reikšmingai nepakito.

Išvada. Dviejų mėnesių aerobinių pratimų veloergometru (pirmojo ventiliacinio slenksčio intensyvumu, trukmė – 60 min., tris kartus per savaitę) gali sukelti reikšmingus kūno sandaros, t. y. kūno masės, KMI, riebalinės kūno masės ir kraujo lipidų: DTL-ch, TAG pokyčius jaunoms moterims. Ištirtų rodiklių reikšmingų pokyčių laiko seka: TAG sumažėjo po dviejų savaitių; kūno masė, KMI sumažėjo po šešių savaitių; kūno riebalų masė sumažėjo, o DTL-ch padidėjo po aštuonių savaitių. Maksimalus deguonies sunaudojimas padidėjo po keturių aerobinių pratimų savaitių.

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