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The effect of six months training on weight, body fatness and serum lipids in apparently healthy elderly Dutch men and women

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OBJECTIVE: To investigate the effect of a six-months training program on changes in body weight and lipid concentrations, and their interrelationship in elderly people.
DESIGN: Intervention study. The elderly subjects were randomly assigned to a control group or one of two supervised aerobic training groups, either all round activities or ergometer cycling, both exercising 3–4 times a week for six months.
SUBJECTS: 229 elderly men and women, aged 60–80 y.
MEASUREMENTS: Various fatness parameters by anthropometry, serum lipids and peak power output.
RESULTS: During the intervention, no significant changes were observed in weight or body fatness in subjects of the training groups. Serum high density lipoprotein (HDL), low density lipoprotein (LDL) and total cholesterol and triglycerides tended to change in a favourable direction in the elderly of the intervention groups, but only triglyceride concentration in women of the cycle ergometer group (mean difference with controls: −0.24 mmol/L, 95% confidence interval (CI): −0.45, −0.03) and total serum cholesterol and HDL-cholesterol concentrations in subjects of the all-round activity group, (−0.32 mmol/L, 95% CI: −0.63, −0.01 and −0.15 mmol/L, 95% CI −0.25, −0.05, respectively) were significantly reduced as compared to controls. Regression analysis showed that the intervention-control difference in change of all lipids was independent of changes in weight, body fat and previous engagement in sport activity.
CONCLUSION: Regular physical exercise in an elderly population resulted in favourable changes in serum lipid concentrations that were not significant, but no change in body weight or fatness. Change in lipid concentration could not be attributed to change in weight or body fat.

Keywords: elderly; body fat; weight; training; lipoproteins

Introduction

Advancing age is associated with profound changes in body composition. Body fat mass increases substantially,[1–3] while skeletal muscle mass decreases.[4] The age-associated increased fat mass accumulates mainly in the trunk.[5] Accumulation of fat mass in the abdominal region has been associated with development of atherosclerosis, insulin resistance, hyperlipidemia, hypertension and the occurrence of cardiovascular disease and diabetes mellitus in men[6–8] and women.[6–11]

The fat mass increase with ageing, results mainly from declining physical activity (and a declining metabolic rate) coupled with an energy intake not matched to the declining need.[12–14] Both cross-sectional and training intervention studies, suggest a beneficial impact of physical activity on both body composition[9,15–18] and lipid profile (particularly HDL-cholesterol and triglycerides)[19–23] among elderly people. It is unclear if the association between physical activity level and lipid level is mediated by weight loss,[21,24–27] or independent of weight changes.[28,29]

Until now, several training intervention studies have been conducted among non-obese healthy elderly men and women, investigating the effect on plasma lipid concentration or body weight. However, most of the studies had small sample sizes and did not relate the changes in lipid profile with changes in body composition. In this study, we investigated the effect of regularly performed aerobic exercise, on plasma lipids in a large group of elderly Dutch men and women, randomly assigned to an intervention group or a sedentary control group. In addition, we investigated the role of body weight and body fat in this association.

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Methods

Subjects

Eight hundred and twenty nine elderly patients, aged between 60–80 y, of two general practitioners and residents of Arnhem, the Netherlands, were asked to participate in an intervention study on the effect of training on cardiovascular risk factors. The general practitioners had selected these subjects using the following exclusion criteria: subjects with myocardial infarction or stroke in the past two years, insulin dependent diabetes mellitus, unstable angina pectoris, heart failure and hypertension, were not eligible.

One hundred and fifty two men and 166 women volunteered for participation (43% of the invited men and 35% of the invited women). All volunteers provided informed consent according to the guidelines of the Medical Ethical Committee of the Agricultural University of Wageningen. Compared to refusers, volunteers were somewhat younger (men 68.5±5.5 y *vs* 71.5±5.6 y, women 67.8±5.4 y *vs* 70.5±5.4 y) and less often considered themselves inactive as compared to their peers (men 49% *vs* 77%, women 48% *vs* 77%). The volunteers were screened by a physical examination, consisting of a resting supine and upright 12-lead electrocardiogram (ECG) and blood pressure measurement. Subjects without signs of present cardiovascular disease, underwent a graded maximal exercise test. Elderly with ischaemic response (ST-depression > 2 mm) or those who were limited by heart failure during the exercise test, were excluded from the study. In total, 39 men (25.7%) and 50 women (30.1%) were excluded for medical reasons (of whom 66% had abnormal ECG, 12% used beta blockers and 22% had other medical complications), which left us with a study population of 113 men and 116 women.

Randomization and follow up

All 229 eligible subjects were randomly assigned to one of three protocols: a cycle ergometer group (48 men and 48 women), an all-round activity group (25 men and 22 women) or a control group (40 men and 46 women) (for details see 'Training'). Husbands and wives were randomised together. Four subjects from the cycle ergometer group and one subject from the all-round activity group had missing values on the pre-intervention lipid measurement and were excluded. In addition, two subjects of the all-round activity group were excluded from all analyses because of extreme dieting and weight loss. Therefore baseline data are presented for: cycle ergometer group, 92 subjects, all-round activity group, 44 subjects and control group, 86 subjects.

During the intervention, 31 subjects (32% of 96) withdrew from the bicycling program (15 subjects due to motivation problems, 13 for medical reasons and three for other reasons), 11 subjects (23% of 47) left the all-round activity group (seven had time restraints and four for medical reason) and four subjects (5% of 86) withdrew from the control group (all family circumstances). Musculoskeletal problems were by far the most important medical reason for a premature halt (63%). Intervention effects are therefore presented for: cycle ergometer group, 61 subjects; all-round activity group, 33 subjects and control group, 82 subjects.

Training

Subjects in the cycle ergometer group performed aerobic training for six months, four times a week for 30 min. They exercised at a heart rate corresponding to 70% of their peak work rate, which was individually determined in the baseline peak power output. The subjects received at home a bicycle ergometer with a pulse rate recording device. Adherence to bicycle protocols was determined in three ways: as a proportion of the target intensity, as an average percent of target days per week and as a proportion of target time spent in every training session. The rate of adherence for each measurement was similar for men and women, namely; training intensity (97% and 98%, respectively), frequency (86% and 81%, respectively) and time spent (94% and 84%, respectively).

Subjects in the all-round activity group gathered three times a week for six months, for a 45 min training session, led by an experienced sports instructor. The training consisted of aerobic exercise (ball games, exercise to music), callisthenics and flexibility exercises. The attendance in the all-round group was 72% for men and 81% for women.

Subjects in the control group were asked to maintain their habitual activities during the intervention period, but were not restricted from undertaking more physical activity, if desired.

All participants were free to choose their own diet for the full period of the intervention.

Measurements

The measurements were performed identically before and after the intervention period.

Body mass index (BMI). Body height was measured (to the nearest 0.005 m) using a wall-mounted measuring tape, with the subjects standing without shoes. Body weight was measured on a calibrated weighing scale to the nearest 0.5 kg, with the participants clothed in underwear.

Body fat. Body fat was estimated using the equation of Durnin and Womersley,[30] based on the sum of four skinfolds: triceps (halfway between the acromion and the olecranon), biceps (same level as triceps, directly above the centre of the cubital fossa), subscapula (about 2 cm below the tip of the scapula, at an angle of 45° to the lateral side of the body), supra-iliac (just above the iliac crest, in the axillary line). In addition, we measured skinfolds over the quadriceps (halfway between the iliac crest and the patella in a vertical line) and fibula (on the fibula at the level of the greatest circumference). Skinfolds were measured in triplicate on the left side of the body with a Harpenden skinfold calliper (Holtain/Tanner-Whitehouse, Holtain Ltd, Crymmych, UK). Pre- and post-measurements were performed by one person.

Serum lipids. A sample of blood was drawn between 09.00–10.00 h, with the fasted subject in sitting position for at least 30 min. Serum was obtained and stored at −80°C. Total cholesterol was analysed via the enzymatic CHOD-PAP-Monotest method of Boehringer, triglycerides concentration via the GPO-PAP method of Boehringer and high-density lipoprotein (HDL-cholesterol) was measured according to the method of Lopez Virella *et al.*[31] Low-density lipoprotein (LDL-cholesterol) was calculated using the Friedewald[32] formula.

Peak power output. The peak power output (Wmax) was measured on a bicycle ergometer. The initial work load was 60 Watt for men and 30 Watt for women. Every three minutes, work load was increased by 30 Watt. This protocol was applied in order to obtain a near steady state at each level and to perform cardiovascular screening simultaneously. The test was stopped when the subjects were exhausted or when there was a medical indication for a premature halt. Peak power output was determined through interpolation, by summing up 10 Watt for every extra full minute of cycling on a certain work load.

Questionnaires on physical activity. Physical activity was measured with the Zutphen Study Questionnaire.[33]

Data analysis

Mean serum lipid concentrations, body weight, body fat, peak power output and lifestyle factors at baseline were compared between the control group and intervention groups. The association at baseline between body weight and body fat with lipid concentration, was studied using regression analysis. The effect of the exercise program on lipid concentration, weight, body fat and skinfolds, as well as on peak power output and participation in other activities, was tested using Dunnett's *t*-test, comparing changes in the intervention groups with changes in the control group. In addition, regression analysis with lipid change as dependent variate and intervention/control group (dummy) and confounders as independent variates, was used to estimate the training effects independent of changes in weight or body fat during the intervention. Three subjects were not fasting during the blood sampling and were excluded from data analysis regarding triglycerides. Data-analyses were performed with SAS 6.09 (Statistical Analyses System; SAS Institute Inc., Cary., USA: SAS/STAT user's guide 6, 1989).

Results

Baseline results

Table 1 presents baseline characteristics of subjects in the control group and intervention groups. Subjects in the all-round activity group, were on average slightly younger, reported higher physical activity and had a higher mean baseline peak power output, than the subjects in the control group. The remaining characteristics were not significantly different between the intervention and control groups. Nearly half of the population was already regularly engaged in sport activities at baseline (46% of the women and 41% of the men). Those subjects had a significantly higher mean serum HDL cholesterol (mean 1.23 mmol/L, s.e.m. 0.03 *vs* mean 1.12 mmol/L, s.e.m. 0.03, $P < 0.01$) and a significantly lower mean triglyceride concentration (mean 1.33 mmol/L, s.e.m. 0.06 *vs* mean 1.57 mmol/L, s.e.m. 0.07, $P < 0.05$). Table 2 shows the baseline association between serum lipids and body weight and percentage body fat. In men and women, body weight and percentage body fat were significantly associated with HDL-cholesterol

Table 1 Baseline characteristics of subjects in control and intervention groups (mean ± s.d.)

	Control n = 86	*Cycle ergometer n = 92*	*All-round n = 44*
Men (%)	53	50	48
Age (y)	69.4 ± 5.5	68.2 ± 5.3	65.2 ± 4.3
Height (m)	1.69 ± 0.86	1.70 ± 0.86	1.72 ± 0.97
Weight (kg)	69.8 ± 12.3	73.7 ± 9.1	75.0 ± 12.1
Body mass index (kg/m²)	24.6 ± 3.4	25.4 ± 2.7	25.1 ± 2.5
Body fat (%)	33.9 ± 6.2	35.3 ± 5.9	35.8 ± 7.0
Peak power output (Watt)	129.0 ± 39.9	139.7 ± 43.70	165.3 ± 49.4
Sport activity (min/week)	66 ± 126	89 ± 182	77 ± 98
Walking/bicycling (min/week)	364 ± 309	377 ± 316	409 ± 303
Participants active in sport (%)	38	42	57
Smokers (%)	23	23	23
Alcohol drinkers (%)	69	66	75

Table 2 Regression coefficients (s.e.m.) of baseline weight and body fat as independent and serum lipids (mmol/l) as dependent variate

	Total cholesterol	*LDL-cholesterol*	*HDL-cholesterol*	*Triglycerides*
Weight (kg)				
Men	0.08 (0.11)	0.02 (0.10)	−0.07* (0.03)	0.30* (0.11)
Women	0.05 (0.12)	0.08 (0.10)	−0.10* (0.03)	0.15** (0.06)
Body fat (%)[a]				
Men	0.04*** (0.02)	0.03 (0.02)	− 0.01** (0.005)	0.05* (0.02)
Women	−0.01 (0.02)	−0.01 (0.02)	−0.02* (0.01)	0.04* (0.01)

[a]Estimated by the sum of four skinfolds (equation of Durnin and Womersley[30]). $*P<0.01$; $**P<0.05$; $***0.05<P<0.10$.

Table 3 Mean pre- and post intervention (s.d.) lipid concentration, body composition, peak power output and time expenditure on physical activity, in subjects who completed the protocol

	Control $n=82$		*Intervention*[a] $n=94$		*Cycle ergometer* $n=61$		*All-round* $n=33$	
	pre	*post*	*pre*	*post*	*pre*	*post*	*pre*	*post*
Weight (kg)	70.3±12.6	70.1±12.7	74.4±12.6	74.2±12.7	74.1±8.6	73.9±8.7	75.0±12.2	74.9±11.5
Body fat (%)	34.2±6.1	34.4±6.2	34.2±6.1	34.4±6.2	34.2±6.0	34.5±6.2	35.8±7.2	35.6±7.3
Total cholesterol (mmol/L)	6.14±1.10	6.11±0.95	6.21±0.99	6.10±0.92	6.00±0.96	6.03±0.85	6.59±0.96	6.23±1.01*
HDL-chol (mmol/L)	1.18±0.30	1.28±0.33	1.16±0.38	1.25±0.34	1.10±0.25	1.27±0.33	1.26±0.31	1.21±0.35*
LDL-chol (mmol/L)	4.32±0.95	4.18±0.89	4.36±0.89	4.21±0.83	4.23±0.86	4.13±0.80	4.61±0.90	4.38±0.88
Triglycerides (mmol/L)	1.41±0.80	1.43±0.72	1.50±0.75	1.37±0.65	1.46±0.64	1.36±0.56	1.55±0.94	1.41±0.80
Peak power output (Watt)	131±40	131±45	156±45	169±50*	149±42	165±50*	167±49	178±50*
Sport activity (min/week)	61±82	46±120	95±158	228±169	93±182	208±171	99±103	266±161
Walking/cycling (min/week)	374±315	318±287	421±292	445±338	416±298	434±357	431±286	461±303

$*P<0.05$ *t*-test change in intervention group *vs* change in control group (Dunnetts *t*-test). [a]Intervention groups combined.

(inversely) and triglycerides ($P<0.05$), but not with LDL-cholesterol or total serum cholesterol. From all skinfolds, the truncal skinfolds (subscapular and supra-iliac) and the biceps were significantly associated with triglyceride concentration in both men and women and with HDL-cholesterol in women ($P<0.05$) (data not shown).

Intervention outcomes

Table 3 shows mean pre- and post intervention levels of body weight, body fat, lipid concentration and peak power output in men and women of the control and intervention groups.

Peak power output. The training program resulted in a significant increase in peak power output in both the cycle ergometer (+11%) and the all-round activity (+7%) group, as compared to the controls.

Body weight and body fat. Mean weight and body fatness were not significantly changed in the subjects of the intervention groups, compared with the controls. Mean change in the log transformed sum of skinfolds, was also not significantly different between intervention and control groups (cycle-control difference: −0.001 mm, 95% confidence interval (CI) −0.02 to 0.02 mm, allround-control difference: −0.01 mm, 95% CI −0.04 to 0.01 mm).

After including in the analysis only those subjects who were inactive in sport at baseline ($n=51$, 32 and 10 for the control, ergocycle and allround groups, respectively), effects became more pronounced. Then, mean change in arm circumference in the ergocycle group was significantly different from the controls: (cycle-control difference: −0.59 cm, 95% CI −1.07–−0.10) and a similar but non-significant difference was observed in the allround activity group (allround-control difference: −0.70 cm, 95% CI −1.45–0.05).

Serum lipids. Mean serum total cholesterol, HDL- and LDL cholesterol and triglyceride concentrations were changed in a favourable direction in both intervention groups, but only the reduction in mean triglyceride concentration in women of the intervention groups (−0.11, s.e.m. 0.06 mmol/L), and total serum cholesterol in subjects of the all-round activity group (−0.36 mmol/L, s.e.m. 0.11) were significant as compared to controls. Contrary to expectation, mean HDL cholesterol was significantly reduced among subjects of the all-round activity group (−0.05 mmol/L, s.e.m. 0.03). Adjustment for change in weight or body fat percentage, previous engagement in sport activities and baseline serum lipid concentration did not result in markedly different values of mean lipid change (data not shown). However, inclusion of only those subjects who were inactive in sport at baseline (control $n=50$, allround $n=10$) resulted in a greater allround-control difference in total serum cholesterol concentration (−0.68 mmol/L (95% CI −1.22–−0.14, unadjusted). Neither change in weight, nor body fat percentage were significantly associated with a change in lipid concentration. Also, exclusion of subjects using cholesterol-lowering drugs, did not affect the outcome of the study.

Discussion

In a group of apparently healthy Dutch men and women, aged 60–80 y old, we found that a supervised exercise program resulted in no effect on body composition and small effects on blood lipids. A significant reduction in mean triglyceride concentration was found in women, but not in men. In general, mean serum HDL-, LDL- and serum total cholesterol changed in a favourable direction in the intervention group, but changes were not significantly different from the changes in the control group. Training effects on lipids were not mediated by changes in body weight or total body fat, as was suggested by others.[21,24–26]

Although we anticipated more significant changes at the commencement of the study (particularly in HDL cholesterol and triglyceride concentration), the observed small (and often insignificant) changes may not be completely unexpected. Several explanations can be proposed. Firstly, the fairly large degree of within-subject biological variation (based on a single measurement) may influence the results.[34] Secondly, the training intervention may not have been long enough or vigorous enough to achieve significant lipid alterations. King *et al*[20] showed that elderly, aged 50–65 y, only increased HDL-cholesterol after two years of regular moderate training. They hypothesised that the time frame needed to achieve HDL-cholesterol changes, may be longer for the elderly than that reported previously for younger populations. Also the intensity of a training program is suggested as an important determinant of lipid change.[22,23] It has been proposed that mainly vigorous exercise training, may enhance lipoprotein lipase activity in adipose tissue, which accelerates turnover of triglycerides and enhances clearance of triglyceride rich lipoproteins. Thirdly, baseline lipid levels of our subjects were rather normal for elderly (65% had a total serum cholesterol concentration < 6.5 mmol/L and only 3% of the subjects had a serum total cholesterol concentration above > 8 mmol/L) and it is suggested that subjects with a raised lipid concentration, in particular, tend to experience lipid alterations induced by exercise.[35] This might also explain the reason for observing a change in mean total serum cholesterol among subjects of the all-round activity group and not in the exercise bicycle group. It should be noted however, that part of it may be a consequence of regression to the mean. Fourthly, smaller changes may be expected in older compared to middle aged subjects, as suggested by Katzel *et al*.[25] Finally, our study population consisted of a large group of elderly subjects who were already active in sport at baseline and therefore smaller effects of training may be expected. Particularly in the all-round activity group, which consisted of a considerable proportion of exercisers (57%) as compared to the other groups (about 40%). When we included only those subjects in the analysis who were inactive at baseline, some of the effects became slightly more pronounced.

In this study we used anthropometric measurements, which are relatively easy to perform, cheap and feasible in large field studies. However, the accuracy of predicting body fat from skinfolds is limited[36] and measurement errors may have occurred. Although pre- and post- measurements were performed by one person, errors may have occurred in the estimated changes but, assuming non differentiality, this would most likely lead to an underestimation of the interrelationships. Even so, correction for an inappropriately measured variable may be inadequate. The absence of weight changes may be explained by a loss of fat mass coinciding with increase in muscle mass in our subjects.

Change in peak power output (9%) was somewhat lower than reported in other studies,[22,23] but since our group was not completely sedentary at baseline (shown by the relatively high baseline values of peak power output), improvement in physical fitness was expected to be somewhat smaller. Of importance, is the observation that mean time spent on sport activity increased during the intervention, which indicates that the elderly subjects in the intervention groups did not exchange their old sport activities for the new training program. Also time spent walking and bicycling did not decrease in the intervention groups. We may therefore conclude that the intervention program was successfully followed and a considerable difference in activity with the control group was achieved.

Selective drop out

Of the 229 men and women enrolled in the intervention study, 46 (20%) dropped out, mainly in the intervention groups. Men who dropped out of the study had a lower baseline serum total cholesterol concentration (mean 5.36 mmol/L, $P < 0.05$) and women who stopped prematurely gave themselves a lower score for health status, had more symptoms of depression and were less active in sport, compared to the subjects who completed the protocols ($P < 0.05$). To investigate possible bias, by selective drop out, we have applied a general linear mixed model, which estimates mean effects, corrected for non random missing data, using maximum likelihood.[37] These results did not differ markedly from the results presented in Table 3. Presumably, drop out in our study did not bias the results to a great extent.

Contamination of control group

Change in lifestyle (nutrition and physical activity) among subjects in the control group can not be ruled out. It is possible that some subjects increased their activity levels during the intervention. To investigate a possible contamination of the control group, we performed a regression analysis in which the effect of change in time spent on sport activity (h/week) in the past six months (including the intervention) on lipid concentration and body weight was investigated, disregarding the intervention assignment. In this way, changes in activity, relative to baseline activity, for each subject in both control and intervention groups could be distinguished. The gender-adjusted regression analysis showed that a one hour increase in sport per week, was associated with a significant decrease in mean serum total (-0.06 ± 0.02 mmol/L) and LDL-cholesterol (-0.04 ± 0.02 mmol/L) ($P < 0.05$). Mean triglyceride concentration was reduced (-0.02 mmol/L), but not significantly ($P = 0.24$). Adjustment for change in weight (kg) or percentage body fat and initial sport activity in the model, did not markedly affect the beta coefficient for change in sport activity.

Conclusion

In summary, a six months community based intervention program, resulted in minor alterations in the lipid profile and no change in body weight of healthy subjects, aged 60–80 y. However, considering the previously described beneficial effect of regular exercise on physical functioning of the elderly and reported effects on other coronary heart disease risk factors, such as fibrinolysis, regular physical activity remains an important preventive measure to increase the quality and quantity of life of older individuals. Especially in the elderly it seems undisputedly important for maintaining health and independence.

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