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The Women on the Move Through Activity and Nutrition (WOMAN) Study: Final 48-Month Results

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Abstract

The Women on the Move through Activity and Nutrition (WOMAN) study was designed to test whether a nonpharmacological intervention including qualitative and quantitative dietary changes to induce weight loss and increased physical activity levels would reduce blood triglyceride levels and number of low-density lipoprotein particles (LDL-P). Such decreases in lipoproteins and other risk factors could reduce or slow progression of subclinical cardiovascular disease (CVD). Study participants were randomized to either the intervention (Lifestyle Change) or assessment (Health Education) group. Most of the intervention ended at the 30-month visit. The last 48-month examination was completed in 9/2008. There was very substantial weight loss and increased exercise during the first 30 months of the trial resulting in significant decreases in CV risk factors. Most of the intervention effect was lost through 48 months. Weight loss was 3.4 kg in Lifestyle Intervention and 0.2 kg in the Health Education at 48 months ($P = 0.000$). There were no significant changes at 48 months in lipid levels, blood pressure (BP), glucose, insulin, or in the subclinical measures of coronary calcium, carotid intima media thickness, or plaque. There was a significant decrease in long-distance corridor walk time in the Lifestyle vs. Health Education groups. Significant lifestyle changes can be achieved that result in decreases in CV risk factors. Whether such changes reduce CV outcomes is still untested in clinical trials of weight loss or exercise. Long-term maintenance of successful lifestyle changes, weight loss and reduced risk factors is the hurdle for lifestyle interventions attempting to prevent CV and other chronic diseases.

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Disclosure

The authors declared no conflict of interest.

Introduction

The Women on the Move through Activity and Nutrition (WOMAN) study was designed to test whether a nonpharmacological intervention including qualitative and quantitative dietary changes to induce weight loss and increased physical activity levels would reduce blood triglyceride levels and the number of low-density lipoprotein particles (LDL-P). Such a decrease in lipoproteins and other risk factors could reduce or slow the progression of subclinical cardiovascular disease (CVD). Study participants ($n = 508$) were randomized to either the intervention (Lifestyle Change) or assessment (Health Education) group.

The rationale for this study was based on previous findings from the Healthy Women Study that hormone therapy (HT) (conjugated equine estrogen (CEE) or CEE with medroxyprogesterone acetate (CEE + MPA)) resulted in an increase in blood triglyceride levels (1). This increase in triglycerides was directly related to an increase in weight and central obesity, as measured by waist circumference, and was associated with high levels of small LDL-P and total LDL-P (2). Recent studies have reported that both fasting and nonfasting triglyceride levels are risk factors for CVD (3). We previously reported in the Women's Healthy Lifestyle Project (WHLP) that weight gain could be reduced or prevented from pre- to postmenopause, resulting in lower risk factor levels and progression of carotid intimal medial thickness (IMT) over time (4).

This paper reports the final results at 48 months of the WOMAN study. A detailed study design, rationale, recruitment, and study methods and preliminary results to 18 months have been previously published (5–13). The results of the first 18 months of the trial showed substantial reduction of risk factors, including 17 lb weight loss and significant decrease in triglycerides 25 mg/dl, insulin 2.4 μU/ml, systolic blood pressure (BP) 7.4 mm Hg and LDL-P 99 nmol/l as compared to the Health Education group (12). An important question was whether these successful short-term changes could be maintained through 48 months.

The study was approved by the University of Pittsburgh institutional review board (#000356) and all subjects gave informed consent. Funding for this study was provided by the NHLBI (grant no. R01 HL066468).

Methods and Procedures

Study participants and design

Recruitment—A total of 96,839 direct mailings were sent to women age 52–62 beginning in 2002. There was a 4% response rate ($n = 8,320$) and 4,206 were contacted, 978 women attended initial screening and 34.7% ($n = 508$) postmenopausal women were recruited for the trial (2003–2010). The trial was originally planned for 5 years. However, it took about 1.5 years to complete recruitment for the trial and follow-up was therefore lowered to 4 years (48 months).

Eligible women were between the ages of 52 and 62 years, had a BMI of 25–39.9 kg/m^2, waist circumference >80 cm diameter, BP <140/90 mm Hg, with or without antihypertensive therapy, not on lipid-lowering drug therapy, LDL cholesterol (LDL-C) between 100 and 160 mg% and no history of CVD. Participants had an eligibility interview and two additional screening clinic visits before randomization. During the second screening visit, carotid ultrasound, arterial pulse wave velocity, coronary calcium by electron beam tomography and bone mineral density by dual energy X-ray absorptiometry were measured. Participants then completed a 3-day food record, which was used by the nutritionist for counseling, the Connor Diet Habit Survey to evaluate eating habits, and a Food Frequency Questionnaire (FFQ). Physical activity was measured using the past year version of the

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Modifiable Activity Questionnaire (MAQ), an interviewer-administered questionnaire (5,14).

Changes in lifestyle and risk factors were measured at baseline, 6, 18, 30, and 48 months. Pulse wave velocity and bone mineral density were repeated at 18 and 48 months and the coronary calcium and carotid ultrasound at 48 months (5).

The CEE+MPA arm of the Women's Health Initiative was stopped prematurely, within the first 5 months of participant recruitment for the WOMAN study. Accordingly, women who had already been randomized in the WOMAN study were advised to discontinue HT use, whereas women randomized after the publication of the results of Women's Health Initiative were allowed to enter the trial after discontinuation of HT use.

The WOMAN study, therefore, had three groups of women: those who entered the trial on HT and stayed on it through the trial, mostly on CEE-Alone; those who went off HT after randomization; and women who were on HT before randomization but had stopped by the time of randomization.

Randomized groups

Health Education group—The Health Education group had a series of six seminars during the first year of participation and then several times per year through 36 months. Most of these sessions focused on women's health and not specifically on CV risk factors.

Lifestyle Change group—The intervention has been previously described. It was built on studies such as the WHLP (15) and the Diabetes Prevention Program (DPP) (16). The intervention was primarily group-based and was facilitated by a multidisciplinary team of nutritionists, exercise physiologists, and psychologists. Contact was frequent throughout the program with 40 visits during the first year and a minimum of 12 monthly visits in year 2 and beyond. The intervention program, however, was stopped because of lack of continued funding for the intervention at ~3 years (36 months). Therefore, the results from baseline to 48 months include a period of time where there was little or no intervention (i.e., 36–48 months).

Dietary goals for the intervention (Lifestyle Change) group were to reduce the saturated fat to <7% of total energy or <10 g/day, reduction in total energy intake to 1,300 cal or 1,500 cal when baseline body weight was >175 lbs to support a 10% loss of weight and a decrease in waist circumference. They were also encouraged to increase the use of foods high in soluble fiber and nutrient-dense, high-volume, low-caloric foods such as fruits, vegetables, and whole grains. Also, during the first year of the intervention consumption of functional foods such as stanol esther-containing margarines, soy products and *n*-3 fatty acids from fish were encouraged (5).

At baseline, caloric intake estimated using the FFQ was ~2,000 calories, 33% of calories were from fat, 10.5% from saturated fat, and 10 g/1,000 calories from fiber. This was similar to eating habits of women in the United States and did not differ between the Health Education and Lifestyle Change group (5,12). By 18 months, the amount of fat in the diet had been reduced by 31% in the Life-style Change group and 12% in the Health Education and saturated fat by 36% in Lifestyle Change and 13% in Health Education, all statistically significant. Women reported 14% decrease in total calories in both groups. The FFQ was not repeated after 18 months.

Physical activity was measured by the MAQ which assesses leisure and occupational activities. We focused on the leisure activity estimate as there was little reported occupational activity in our study population. Study participants were asked to identify if they participated in a variety of specific activities, such as walking for exercise, at least 10 times over the past year (12 months). For each activity identified, they were asked which months they had participated in that specific activity over the past year and then estimated the number of times each month and length of time that they spent doing the specific activity. Physical activity levels were calculated as the product of the duration and frequency of each activity (in h/week), weighted by an estimate of the metabolic equivalent (MET) of that activity and summed for all activities performed. Leisure physical activity data were expressed as metabolic equivalent h/week (MET h-week) (14). Baseline median leisure time physical activity based on the MAQ was 11.4 MET · h/week and was similar for the Health Education and Lifestyle Change groups (12).

The physical activity component of the lifestyle intervention began after the first 6 months of group initiation. The physical activity intervention was delayed for the first 6 months because of the very intensive dietary intervention at the beginning of the trial, including frequent sessions, meal preparations, very low saturated and trans fat and calorie intake. A recent comparison of delayed vs. nondelayed physical activity intervention documented no significant differences in weight loss among obese individuals in an intensive intervention similar to the WOMAN study (15). The content was based on the experience with the DPP and previous clinical trials that targeted healthy, middle-aged women (16–18). It was a stepped care approach to reach 150 min/week of moderate intensity physical activity as the standard minimum goal for all women. Women who reached the minimum goal were then encouraged to increase to 180 min and then to 240 min/week. Resistance training of large skeletal muscle groups was also encouraged to facilitate beneficial body composition changes and bone health.

CV risk factors—At baseline and 6, 18, 30, and 48 months, total LDL, high-density lipoprotein cholesterol (HDL-C), triglycerides, glucose, and insulin were determined by conventional enzymatic methods. Lipo-protein subclasses were determined by nuclear magnetic spectroscopy.

Coronary artery calcification—An Imatron C-150 Scanner (Imatron, South San Francisco, CA) was used to obtain 30–40 contiguous 3-mm thick transverse images of the heart. Coronary calcium scores were calculated according to the Agatston method. The electron beam tomography scans from this laboratory had high reproducibility, with an intraclass correlation of 0.99 (19).

Carotid ultrasound—Carotid ultrasound images were taken from the near and far walls of the distal common carotid artery (1 cm proximal to the carotid bulb), and the far walls of the carotid bulb. IMT measures were performed electronically. The mean of all average readings across the eight locations (four on each side) comprises the average IMT. The mean of the maximum reading from each segment was also calculated (20).

Walking performance—The 400-m walk test is a component of the long-distance corridor walk that utilizes a 400-m course consisting of 10 laps along a hallway (40 m/lap) with cones set 20 m apart. Participants were instructed to walk “at a pace that you can maintain for the full 10 laps” and standard encouragement was given at each lap. The 400-m walk test was previously shown to be highly reproducible for women, correlation coefficient 0.95 (confidence limits 0.92, 0.97, $P < 0.0001$) and significantly associated with measured ($P = -0.56$; $P < 0.001$) VO_2max in a study including healthy, middle-aged women, and with risk of clinical coronary heart disease and death in older women (13,21).

Statistical methods of analysis—A detailed description of the statistical methods has been published (4). Changes in variables over time were expressed as a difference in values between follow-up and baseline. Depending on normality of distribution, either *t*-tests or Mann–Whitney tests for comparing continuous variables at baseline, 48-month followup, and change in risk factors over time by randomized group assignment. There was little difference in results by whether analysis based on means or medians (nonparametric tests). Mean differences are shown throughout the paper. There were few women lost to follow-up during the trial and such women were excluded from the analysis. Eight women with coronary calcium score ≥400 Agatston units were excluded from the analysis because they were at very high risk and referred to their physicians for pharmacological therapy for lipid-lowering, antihypertensive therapy, etc. as required by the institutional review board approval for the study. A repeated measure mixed model was used to evaluate average differences across 6-, 18-, 30-, and 48-month visits.

The power calculations have been previously published (5).

Results

Approximately 90% of the participants completed at least part of the 48-month visit, 92% of Health Education and 87% of Lifestyle Change (n.s.). Four hundred twenty-five (84%) had repeat coronary calcium scan, 432 (85%) carotid ultrasound and 401 of 432 (89%) had baseline and repeat LDCW. There were no statistically significant differences between those who completed or did not complete the 48-month visit (Table 1). Among the 52 women who did not complete the 48-month visit, 12 had only a baseline visit and then dropped out, 4 had only their 6 month visit, 2 were deceased, and 7 had moved out of the area.

HT use

A high percentage of participants (i.e., 64%, in the Lifestyle Change and 56% in the Health Education group) were on HT at baseline. By 48 months, 19% (n = 39) in the Lifestyle Change and 19% (n = 43) in the Health Education group were still on some type of HT.

Change in CVD risk factors by randomized group

There was a statistically significant greater weight loss and decrease in waist circumference in the Lifestyle Change as compared to Health Education at all four time periods and significant difference between randomized groups in leisure physical activity levels through 30 months (Table 2). The amount of weight loss was substantially reduced over time.

The goal of the study was a 10% weight loss. At 18 months, 42% of the Lifestyle Change group had at least a 10% weight loss vs. 9% of the Health Education but by 48 months, 21% of the Lifestyle Change, and 8% of the Health Education group had lost >10% of their body weight and 42% of the Lifestyle Change and 19% of the Health Education lost >5% of their body weight. Weight loss and change in waist circumference were both substantially greater at 30 months than at 48 months (Table 2).

At 30 months, the Lifestyle Change group had a significant increase in HDL-C and decreases in insulin, triglycerides, and glucose but not BP, LDL-C, or LDL-P as compared to the Health Education group (Table 3). The only statistically significant changes in risk factors at 48 months between the Lifestyle Change and Health Education groups was that the LDL-C declined more in the Health Education group than Lifestyle Change group (P = 0.03) (Table 3). This was likely due to the increased number of women in the Health Education group that were on lipid-lowering drug therapy. After exclusion of women on lipid-lowering drug therapy at 48 months, 17 (8%) in the Lifestyle Change and 45 (20%) in the Health Education, LDL-C increased 7.5 mg% in the Lifestyle Change and 6.3 mg% in Health Education baseline to 48 months. This increase in LDL-C was due, in part, to stopping of HT after randomization.

A repeat linear mixed model analysis of risk factor changes in Table 3 across all four time periods found that changes in systolic BP ($P = 0.048$), LDL-C ($P = 0.026$), triglycerides ($P = 0.92$), insulin ($P = 0.0001$), glucose ($P = 0.002$), and HDL ($P = 0.0001$) were significant between the Health Education and Lifestyle Change groups. The significant change is driven to a large extent by substantial changes in risk factors during the first 18 months.

Among women not on HT at baseline ($n = 152$) or on lipid-lowering drugs by 48 months, LDL-C decreased 6.7 mg% in the Lifestyle Change group at 6 months, 5.3 mg% at 30 months and 3.2 mg% at 48 months and increased 3.2 mg in the Health Education group at 6 months, 4.8 mg% at 30 months and decreased 0.7 mg% at 48 months, significant at 6 and 30 months between the two groups (Table 4). We evaluated the relationship of change in weight to risk factor differences baseline to 48 months among the Lifestyle Change women who were not on HT at baseline or on lipid-lowering drug therapy at 48 months, eliminating the confounding of drug therapy. Substantial weight loss through 48 months was associated with major decreases in LDL-C, insulin and glucose and increase in HDL-C (Table 4). The weight loss effect was less consistent for the Health Education group due, in part, to smaller percentage of women who lost substantial weight. There was a substantial increase in HDL-C with weight loss in both groups ($P = 0.06$, both groups).

The 400-m walk was repeated at 30 and 48 months as a measure of effect of physical activity intervention. The 400-m walk time increased 4.8 s (s.d. 39.5) at 30 months in the Health Education group and decreased 2.7 s (s.d. 30.4) in the Lifestyle Change group ($P = 0.04$). At 48 months, 400-m walk time increased 8.6 s (s.d. 42.0) in the Health Education group and decreased 2.0 s (s.d. 34.0) in the Lifestyle Change group ($P = 0.04$).

Change in subclinical CVD measures

Among the 129 women who had 0 coronary calcium at baseline, 61% still had 0 coronary calcium, 23% had coronary calcium of 1–5, 4.8% ($n = 10$) of 5–10 and 11% ($n = 23$) had scores >10. There was no difference by Lifestyle Change as compared to Health Education. Among women with some coronary calcium at baseline, increases in coronary calcium were similar in the Health Education group and Lifestyle Change group (no significant differences) (Table 5). There was also no evidence of an effect of weight loss on either the development of new coronary calcium or the progression of coronary calcium.

At baseline, 203 (72%) of the women had a plaque index of 0, 71 (16.9%) of 1, 32 (7.6%) of 2, 15 (3.3%) of three or more. Among the women with 0 plaque index at baseline, there was no difference in incidence of new plaque in the carotid artery 119 (75.8%) in the Health Education group and 95 (65.1%) in the Lifestyle Change group still had a 0 plaque. Similarly, there was no evidence of a change in plaque in the Lifestyle Change compared to Health Education group for women who had either 1 or 2+ plaque index at baseline (Table 5).

Change in either average or maximal carotid IMT between baseline and 48 months for the Lifestyle Change and Health Education groups was similar. At baseline, mean IMT was 0.728 mm in the Health Education and 0.714 mm in the Lifestyle Change group. At 48 months, the increase in the Health Education group was 0.067 and 0.078 mm in the Lifestyle Change ($P = 0.13$). Mean maximal wall thickness at baseline was 0.912 mm for the Health Education and 0.901 mm for the Lifestyle Change group and increased 0.091 mm for Health

Education and 0.107 mm for the Lifestyle Change group. The results were similar excluding women on lipid-lowering or antihypertensive drug therapy at 48 months.

Discussion

The WOMAN study is one of the few nonpharmacological intervention trials with long-term evaluation of the changes in weight, physical activity, diet, risk factors, and subclinical measurements of CV outcomes (22,23). The intervention was very successful in the short term, up to 6–30 months, but could not be maintained to the 48-month end of trial. The average 3.4 kg at 48 months, significant, was not enough to sustain risk factors changes. Successful long-term weight loss maintenance has been defined as losing at least 10% of initial body weight and keeping it off for at least 1 year. It is estimated that around 20% of overweight or obese persons are successful (22). In the WOMAN study, 31% at 30 and 21% at 48 months of women were successful weight losers (22). Failure to continue the intensive intervention may be the most important reason for the weight regain over time, especially after 30 months. Some of the weight loss effects had disappeared even between 18 and 30 months. It is likely that more frequent contact with participants, i.e., monthly, may be needed to sustain intervention. The lack of sustainability of intensive lifestyle interventions is consistent with other intervention studies (24). Obesity is a chronic condition and like other chronic diseases, i.e., elevated BP, glucose, lipids, may require continued interventions for a lifetime to sustain behavioral changes and weight loss.

There are other possible reasons for weight regain. One hypothesis is that changes in hormones or adipokines secondary to weight loss result in compensatory neural-hormonal changes, increase in hunger and inability to maintain dietary changes (25). A second possibility is that there is more efficient utilization of energy in muscle (26,27) as well as a decrease in lean body mass with weight loss and subsequent reduced metabolic rate. Thus, individuals maintaining the same caloric intake may begin to regain weight as they lose lean body mass.

We have previously reported both bone and muscle loss with weight loss. We have previously reported in the WOMAN study no relationship between blood levels at baseline of ghrelin, leptin, adiponectin, and regain of body weight. However, these peripheral measures may be insensitive to potential central nervous system effects (28).

It may be very difficult in an environment with substantial food availability to maintain dietary changes in the long term without very substantial continued behavioral intervention. There also may be substantial differences in eating behavior among populations, such as in the United States, France, Japan, etc. which may contribute both to obesity and the inability to maintain weight loss (29,30). These might include factors such as meal frequency, snack foods, eating out of the home, socialization, and time to eat meals. We are continuing analysis of some of our dietary information to try and see if differences in eating behavior may contribute to the inability to maintain weight loss independent of changes in specific foods. Unfortunately, measurement of total calories and changes in total calories is very difficult using either the FFQ or single or even multiple 24-h recalls. Caloric intake is underestimated by more obese individuals (31).

We hypothesized that weight loss, exercise, and subsequent changes in risk factors would prevent the development of new coronary calcium or reduce the progression among most of the women with low levels of coronary calcium at baseline. There was, however, no difference in the incidence of new coronary calcium between the Lifestyle Change and Health Education groups nor any evidence of a relationship between the amount of weight loss and either the development of new coronary calcium or progression of coronary calcium although the number of women in the study with substantial weight loss is low and therefore the power is limited. Furthermore, the rate of development of new coronary calcium was consistent with previous observations in studies of postmenopausal women. The intervention had no effect on development of new carotid plaque or change in present plaque.

Weight loss resulted in a substantial change in cardiovascular risk factors at 48 months, as shown in Table 4. Unfortunately, only a small percentage of women were able to maintain substantial weight loss. A successful long-term weight loss program could result in effective risk factor changes and possibly decreased CVD.

There are no long-term randomized clinical trials in “healthy” individuals that demonstrate that a physical activity intervention reduces the risk of CVD. Evidence-based observational studies support the benefit of increased physical activity and “fitness” (32–34). The long-distance corridor walk was used as an outcome measure rather than repeat maximal or submaximal exercise testing because of costs and greater likelihood of women completing the test. Decreased 400-m walk time was significantly greater in the Lifestyle Change as compared to the Health Education group and was directly related to the amount of reported physical activity and weight loss. Measures of physical function may be more amenable to changes in exercise, weight, etc. and become the primary end point in these trials.

This is one of the longest nonpharmacological weight loss trial in a “healthy population.” The critical unanswered questions are whether weight loss, at least 10% of body weight, can be maintained for a substantial number of overweight and obese adults by nonpharmacological approaches and whether such changes will result in decreased incidence of CVD (35). It will remain extremely difficult to test lifestyle changes and reduced morbidity and mortality until there are improved methods to sustain the interventions for many years. The Look AHEAD trial results (36) may be available in a few years and provides some answers about the benefits of weight loss on CVD and total mortality, at least for diabetics.

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Table 1

Comparison of baseline characteristics of participants who completed or did not complete the study at 48-month evaluation: 456 completed, 52 not completed

Risk factors at baseline	Completed 456 (88%)	s.d.	Not completed 52	s.d.	Total	s.d.
Age (years)	57	3.7	57	3.0	57	
Black	11%		13%		11.2	
BMI (kg/m^2)	31	3.8	30	3.6	30.8	3.8
Waist circumference (cm)	106	11.4	103	9.5	105.9	11.2
SBP (mm Hg)	124	13.43	126	14.3	124.1	16.7
Past year leisure time activity (MET h/week)	15	13.2	18	17.0	15.0	13.6
400 meter walk time (s)	312	40.7	309	34.4	311.4	36.1
HDL-C (mg%)	60	14.5	59	11.2	60.0	14.2
LDL-C (mg%)	128	25.2	128	25.4	128.0	25.2
Triglycerides (mg%)	142	74.4	152	80.5	142.8	75.0
LDL-P (μmol/l)	1,390	303.3	1,431	352.2	1,394.9	308.5
Antihypertensive medication use (%)	23		29		23.6	
Hormone therapy use (%)	62		60		60	59.8
Current smoker (%)	5		12		6	6.1

HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; LDL-P, low-density lipoprotein particle; MET, metabolic equivalent tasks; SBP, systolic blood pressure.

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Table 2

Change in weight, waist circumference, percent weight change, and physical activity: Lifestyle Change and Health Education at 6, 18, 30, and 48 months

		6 Months			18 Months			30 Months			48 Months		
		N	**Mean**	**s.d.**	*N*	**Mean**	**s.d.**	*N*	**Mean**	**s.d.**	*N*	**Mean**	**s.d.**
Weight change in kg	Health Education	223	−1.2	4.3	213	−1.6	5.5	212	−0.4	5.4	230	−0.2	5.6
	Lifestyle Change	215	−7.8	4.4	208	−7.8	7.1	208	−5.7	7.5	216	−3.4	7.2
Waist circumference change in cm	Health Education	223	−2.4	4.7	213	−3.6	6.3	211	−2.8	6.0	228	−4.3	6.8
	Lifestyle Change	215	−8.6[a]	5.7	208	−9.8[a]	7.7	207	−8.3[a]	8.3	215	−7.7[a]	8.5
≥ 10% Weight loss	Health Education		8			9			9			8	
	Lifestyle Change		47			42			31			21	
Leisure time[b] physical activity MET h/week	Health Education	216	−4.1	14.0	204	0.56	13.0	204	0.02	15.7	223	−0.02	16.1
	Lifestyle Change	211	−1.0[a]	11.1	203	5.9[a]	10.9	207	4.1[a]	13.3	210	1.9	12.5

MET, metabolic equivalent tasks.

[a] $P < 0.05$.

[b] Physical activity induction began after 6 months.

Table 3

Change in risk factors from baseline to 6, 18, 30, and 48 months, total sample excluding women with baseline coronary calcium ≥ 400 ($n = 8$)

	6 Months		18 Months		30 Months		48 Months	
	LC	HE	LC	HE	LC	HE	LC	HE
	Mean (s.d.)		Mean (s.d.)		Mean (s.d.)		Mean (s.d.)	
SBP (mm Hg)	−7.2 (13.2)[a]	−2.4 (13.2)	−2.4 (1.4)	−1.6 (14.5)	−1.6 (14.7)	0.4 (14.6)	0.3 (14.8)	−0.6 (15.2)
LDL-C (mg%)	−1.6 (25.8)[a]	7.3 (26.8)	3.4 (26.4)[a]	10.0 (31.7)	0.8 (30.0)	4.5 (36.9)	3.4 (32.0)[a]	−3.2 (33.2)[a]
HDL-C (mg%)	−2.9 (11.0)[a]	−0.1 (10.7)	1.1 (10.1)	1.6 (11.7)	2.2 (11.5)[a]	−0.3 (13.4)	3.1 (11.5)	1.5 (11.8)
Triglycerides (mg%)	−25.7 (55.9)[a]	−13.4 (51.5)	−19.8 (57.1)	−10.4 (51.7)	−26.5 (59.3)[a]	−10.1 (54.7)	−14.0 (57.1)	−9.2 (59.6)
Insulin (μU/ml)	−2.6 (4.8)[a]	0.4 (7.2)	−1.4 (5.3)[a]	0.9 (6.7)	−0.3 (5.2)[a]	2.0 (7.0)	−0.3 (5.0)	0.8 (6.6)
Glucose (mg/dl)	1.0 (8.3)[a]	3.0 (9.2)	1.7 (9.1)[a]	4.1 (11.0)	4.3 (9.3)[a]	7.4 (10.8)	7.3 (11.0)	9.8 (17.5)
NMR HDL-P (μmol/l)	−2.2 (5.3)[a]	0.3 (5.1)	0.7 (5.0)[a]	1.8 (5.6)	−0.1 (5.0)	0.4 (5.4)	−1.2 (5.6)	−0.5 (5.7)
NMR LDL-P (nmol/l)	−98.3 (243.3)[a]	−37.9 (247.3)	−49.0 (283.8)[a]	15.7 (297.2)	−52.7 (305.3)	−51.8 (333.3)	−36.3 (322.2)	−73.5 (339.2)
NMR small LDL-P (nmol/l)	−73.1 (322.5)	−56.9 (283.6)	−24.0 (377.3)	6.4 (335.5)	−78.7 (374.3)	−87.4 (406.0)	−38.9 (383.9)	−55.8 (390.3)

HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; LDL-P, LDL particle; MET, metabolic equivalent tasks; NMR, nuclear magnetic spectroscopy; SBP, systolic blood pressure.

[a] $P < 0.05$ for comparison between groups.

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Table 4

Changes in risk factors at 48 months by weight loss, Lifestyle Change, and Health Education groups—not on hormone therapy at baseline or on lipid-lowering drug therapy at 48 months

	Lifestyle Change group						
	N	**%**	**LDL-C (s.d.)[a] (mg%)**	**HDL-C (s.d.) (mg%)**	**SBP (s.d.) (mm Hg)**	**Glucose (s.d.)[a] (mg%)**	**Insulin (s.d.)[a] (μU/ml)**
Weight loss (kg)							
>9.1	9	12	−21.9 (22.0)	6.3 (10.9)	−1.6 (14.8)	−1.0 (6.3)	−4.0 (2.8)
4.5–8.6	15	21	−10.2 (30.1)	6.3 (9.3)	−5.6 (15.5)	2.4 (8.6)	−4.0 (5.3)
4.3–2.3	17	24	5.3 (22.0)	4.9 (7.6)	−6.6 (13.6)	6.9 (7.7)	− (5.7)
2.2–0	14	19	−3.1 (22.5)	1.2 (13.8)	3.4 (13.0)	4.7 (6.4)	−1.4 (5.0)
Weight gain (kg)							
0.5–17.9	17	24	3.5 (22.2)	−3.1 (9.5)	3.3 (13.0)	10.3 (8.7)	1.4 (6.3)
Total	72	100	−3.3 (25.0)	2.7 (10.6)	−1.5 (14.3)	5.5 (8.4)	−1.3 (5.7)

	Health Education group						
	N	**%**	**LDL-C (s.d.) (mg%)**	**HDL-C (s.d.) (mg%)**	**SBP (s.d.) (mm Hg)**	**Glucose (s.d.)[a] (mg%)**	**Insulin (s.d.) (μU/ml)**
Weight loss (kg)							
>9.1	6	8	−4.7 (15.8)	8.9 (13.9)	−6.7 (12.9)	−4.8 (7.7)	−6.6 (12.9)
4.5–8.6	11	14	−1.6 (28.0)	11.3 (16.7)	− (11.0)	7.1 (6.9)	−1.9 (4.1)
4.3–2.3	13	16	5.5 (27.0)	2.0 (6.4)	− (15.4)	1.9 (7.3)	−3.2 (9.7)
2.2–0	15	20	−13.0 (21.0)	0.4 (12.2)	−6.5 (9.6)	3.5 (9.8)	−1.3 (6.2)
Weight gain (kg)							
0.5–17.9	33	42	3.8 (21.0)	1.4 (9.5)	1.2 (14.4)	7.2 (9.7)	0.7 (6.3)
Total	78	100	−0.7 (24.0)	3.3 (11.6)	−1.2 (13.3)	4.7 (9.3)	−1.2 (7.5)

HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; SBP, systolic blood pressure.

[a] $P < 0.5$ within group difference by weight change.

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Table 5

Change in coronary calcium and carotid plaque at 48 months, Lifestyle Change and Health Education (excluding women with coronary calcium ≥ 400 at baseline)

	Change							
	Lifestyle Change				Health Education			
Baseline coronary calcium	***N***	**Mean**	**s.d.**	**Median**	***N***	**Mean**	**s.d.**	**Median**
0	100	04	13.0	0	108	04	10	0
1–<5	44	08	23	−1.0	53	08	31	−0.3
5–<10	23	21	57	−5.0	13	18	40	5
≥ 10	33	75	102	53	37	70	142	33

	Carotid plaque change to 48 months				
Baseline carotid plaque	***N***	**0**	**1**	**2**	**3+**
0					
Lifestyle Change	146	95	33	10	8
Health Education	157	119	22	11	5
1					
Lifestyle Change	38	12	12	6	8
Health Education	33	9	13	5	6
2					
Lifestyle Change	13	3	2	4	4
Health Education	19	1	2	9	7
3+					
Lifestyle Change	6	0	0	1	5
Health Education	8	0	0	1	7
Total					
Lifestyle Change	203	110	47	21	25
Health Education	217	129	37	26	25