

Effect of Exercise on Total and Intra-abdominal Body Fat in Postmenopausal Women

A Randomized Controlled Trial

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MORE THAN HALF OF THE US adult population is overweight or obese,¹ and the prevalence is particularly high among women. Obesity increases the risk of several chronic diseases, including coronary heart disease,² type 2 diabetes,³ hypertension,⁴ stroke,⁵ and some cancers, particularly colon cancer⁶ and postmenopausal breast cancer.⁷ Intervention strategies to combat this epidemic are needed. Physical activity may provide a low-risk method of preventing weight gain and promoting maintenance of weight loss in overweight and obese women.⁸ Unlike diet-induced weight loss, exercise-induced weight loss increases cardiorespiratory fitness levels.⁹

The Physical Activity for Total Health Study was a randomized, controlled, year-long intervention trial designed to examine the effects of exercise vs control on sex hormone concentrations (as biomarkers of breast cancer risk) among sedentary, overweight, postmeno-

Context The increasing prevalence of obesity is a major public health concern. Physical activity may promote weight and body fat loss.

Objective To examine the effects of exercise on total and intra-abdominal body fat overall and by level of exercise.

Design Randomized controlled trial conducted from 1997 to 2001.

Setting and Participants A total of 173 sedentary, overweight (body mass index ≥ 24.0 and $>33\%$ body fat), postmenopausal women aged 50 to 75 years who were living in the Seattle, Wash, area.

Intervention Participants were randomly assigned to an intervention consisting of exercise facility and home-based moderate-intensity exercise (n=87) or a stretching control group (n=86).

Main Outcome Measure Changes in body weight and waist and hip circumferences at 3 and 12 months; total body, intra-abdominal, and subcutaneous abdominal fat at 12 months.

Results Twelve-month data were available for 168 women. Women in the exercise group participated in moderate-intensity sports/recreational activity for a mean (SD) of 3.5 (1.2) d/wk for 176 (91) min/wk. Walking was the most frequently reported activity. Exercisers showed statistically significant differences from controls in baseline to 12-month changes in body weight (-1.4 kg; 95% confidence interval [CI], -2.5 to -0.3 kg), total body fat (-1.0%; 95% CI, -1.6% to -0.4%), intra-abdominal fat (-8.6 g/cm²; 95% CI, -17.8 to 0.9 g/cm²), and subcutaneous abdominal fat (-28.8 g/cm²; 95% CI, -47.5 to -10.0 g/cm²). A significant dose response for greater body fat loss was observed with increasing duration of exercise.

Conclusions Regular exercise such as brisk walking results in reduced body weight and body fat among overweight and obese postmenopausal women.

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pausal women.¹⁰ The analyses described in this article examine the effects of this exercise intervention on total and intra-abdominal body fat and evaluate the exercise effect among subgroups specified by age, baseline adiposity, and adherence to the exercise intervention.

METHODS

Details of the aims and design of the study have been published previ-

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ously.^{10,11} The study, conducted from 1997 to 2001, was a randomized controlled trial comparing the effect of a year-long exercise vs control group on body fat and sex hormone concentrations measured 3 and 12 months after randomization. The intervention included a 3-month exercise program intensively monitored by an exercise physiologist at a facility (University of Washington, Seattle, and a commercial gym) followed by a 9-month program primarily occurring at participants' homes. The study and protocol were approved by the Fred Hutchinson Cancer Research Center Institutional Review Board. Written informed consent was also obtained in

accordance with the requirements of the Fred Hutchinson Cancer Research Center Institutional Review Board.

Participants

We selected the study population to maximize the possible effects of exercise on endogenous sex hormones and to avoid other factors known to affect sex hormones. Participants were postmenopausal women from the greater Seattle area who were aged 50 to 75 years, were sedentary at baseline (<60 min/wk of moderate- and vigorous-intensity recreational activity and maximal oxygen consumption <25.0 mL/kg per minute), had a body mass index (BMI; calculated as weight in kilo-

grams divided by the square of height in meters) of more than 25.0 (or a BMI of 24.0-25.0 and body fat >33.0%), were not taking hormone replacement therapy, had no clinical diagnosis of diabetes and had fasting blood glucose levels of less than 140 mg/dL (7.8 mmol/L),¹² and were nonsmokers.

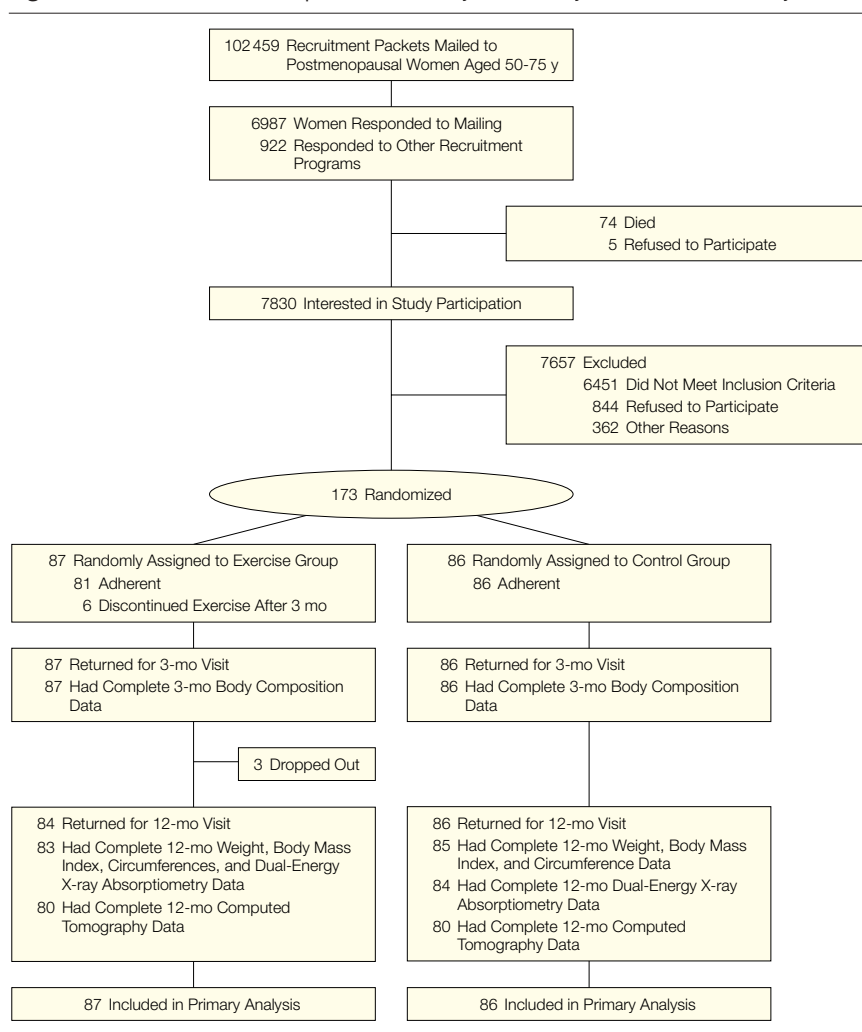
We recruited women through a combination of mass mailings and media placements. Details on recruitment have been published elsewhere.¹¹ After a telephone call to potential participants to determine interest in the study, eligible women were scheduled for 3 baseline clinic visits (a physical examination, a cardiorespiratory fitness assessment, and dual-energy x-ray absorptiometry [DXA] and computed tomography [CT] scans). After further determining eligibility and study interest, we randomly assigned 173 women to either the exercise intervention (n=87) or the control group (n=86) (FIGURE 1). Randomization was performed by random number generation and group assignment was placed in a sealed envelope, which was opened by the study coordinator at the time of randomization. Randomization was stratified by BMI (<27.5 vs ≥27.5) to ensure equal numbers of heavier and lighter women in each study group.

Baseline and Follow-up Measures

We collected demographic and medical history information at baseline and at 3- and 12-month visits. We measured total energy intake at baseline, 3 months, and 12 months via a 120-item self-administered food frequency questionnaire.¹³

We assessed current (past 3 months) physical activity at baseline, 3 months, and 12 months among exercisers and controls. In a self-administered adaptation of the Minnesota Physical Activity Questionnaire,¹⁴ women reported whether they did any of the 38 recreational or household activities listed during the past 3 months. For the activities performed, the women recorded the number of days per week and minutes per session.

Figure 1. Recruitment of Participants Into the Physical Activity for Total Health Study



We assessed maximal oxygen consumption at baseline and 12 months. Participants completed a maximal-graded treadmill test, with heart rate and oxygen uptake monitored by an automated metabolic cart (Medgraphics, St Paul, Minn). The test began at 3.0 mph and 0% grade. The speed or grade (2% increments) of the treadmill increased every 2 minutes (eg, stage 2: 3.5 mph, 0% grade; stage 3: 3.5 mph, 2% grade; stage 4: 3.5 mph, 4% grade) until the participant reached volitional fatigue or experienced angina, lightheadedness, a drop in systolic blood pressure, an excessive rise in systolic blood pressure to more than 250 mm Hg or in diastolic blood pressure to more than 120 mm Hg, or more than 4-mm down-sloping ST depression in any lead.¹⁵ No treadmill tests in participants were terminated for reasons other than volitional fatigue.

We measured baseline, 3-month, and 12-month weight and height to the nearest 0.1 kg and 0.1 cm, respectively, by using a balance-beam scale and stadiometer. Both measurements were taken in duplicate and averaged. Coefficients of variation of replicate measures of weight and height, measured by the same technician, were 0.05% and 0.2%, respectively. Waist and hip circumferences were measured at baseline, 3 months, and 12 months to the nearest 0.1 cm using an anthropometric fiberglass tape measure. Both measurements were taken in duplicate using specified landmarks and then averaged. Coefficients of variation of replicate readings of waist and hip circumferences, measured by the same technician, were 0.3% and 0.2%, respectively.

We assessed total body fat and body fat percentage using a DXA whole-body scanner (Hologic QDR 1500, Hologic Inc, Waltham, Mass). A whole-body scan takes approximately 30 minutes to complete. With the participant lying on the examination table in the supine position, a scan of the entire body was performed. All DXA scans were performed by a technician blinded to the participants' group randomization.

We measured intra-abdominal and subcutaneous fat with CT (General Electric model CT 9800 scanner, Waukesha, Wis) at baseline and 12 months. One scan was performed using a lateral-view radiograph of the skeleton (abdominal area) to establish the position of the L4-L5 space within 1.0 mm. A second scan was then performed at the L4-L5 space (at 125 kV and with a slice thickness of 8 mm). One technician measured subcutaneous and intra-abdominal fat areas using a software application (Image Analysis, Waukesha, Wis) that identifies and measures each of the areas of interest by tracing lines around them and computing the circumscribed areas. Coefficients of variation of replicate measures of subcutaneous and intra-abdominal body fat, measured by the same technician, were 1.2% and 1.5%, respectively.

Exercise Intervention

The exercise intervention consisted of at least 45 minutes of moderate-intensity exercise 5 d/wk for 12 months. During months 1 through 3, participants were required to attend 3 sessions per week at one of the study facilities and to exercise 2 d/wk at home. For months 4 through 12, participants were required to attend at least 1 session per week at the facility and to exercise the remaining days on their own for a total of 5 d/wk (participants were allowed to exercise additional days at the facility if they chose). The training program began with a target of 40% of maximal heart rate for 16 minutes per session and gradually increased to 60% to 75% of maximal heart rate for 45 minutes per session by week 8, at which point it was maintained for the duration of the study. Participants wore heart rate monitors (Polar Electro Inc, Woodbury, NY) during their exercise sessions.

Facility sessions consisted of treadmill walking and stationary bicycling. Strength training, consisting of 2 sets of 10 repetitions of leg extension, leg curls, leg press, chest press, and seated dumbbell row, was recommended but

not required to decrease risk of injury and maintain joint stability. A variety of home exercises were suggested and encouraged, including walking, aerobics, and bicycling. Participants were encouraged to wear their heart rate monitors when exercising at home.

Women randomly assigned to the control group attended weekly 45-minute stretching sessions for 1 year and were asked not to change other exercise habits during the study. Exercise and control participants were asked to maintain their usual diet.

Measure of Exercise Adherence

The exercise intervention participants kept daily activity logs of all sports or recreational activities they performed. They recorded type of exercise, peak heart rate, rating of perceived exertion (scale, 6-20),¹⁶ and duration of exercise. Each week, exercise trainers reviewed the logs for completeness and clarity.

We used data from the daily activity logs as the primary measurement of adherence. We included only activities that were sports or recreational activities of at least 3 metabolic equivalents (METs) (based on the Compendium of Physical Activities¹⁷), such as brisk walking (a 3.8-MET level) and stationary bicycling (a 5.5-MET level). We defined good adherence as meeting 80% of the exercise prescription (ie, 80% of 225 minutes per week of moderate-intensity sports/recreational exercise).

Intervention Strategies

We used several techniques for promoting adherence, including individualized attention in facility classes; group exercise behavior-change education classes; weekly telephone calls to promote adherence; individual meetings at baseline and every 3 months to outline goals and provide feedback on progress; incentives; quarterly newsletters; and group activities such as hikes.

Statistical Analysis

We calculated duration (minutes per week of exercise) and change in cardiorespiratory fitness level at 12

Table 1. Baseline Characteristics of Randomized Participants in the Physical Activity for Total Health Study*

	Exercisers (n = 87)	Controls (n = 86)
Age, mean (95% CI), y	61.0 (59.6-62.5)	60.6 (59.1-62.1)
Full-time employment, No. (%)	25 (29)	25 (29)
Education, No. (%)		
High school graduate	10 (12)	9 (10)
Some college	36 (41)	35 (41)
College graduate	5 (6)	10 (12)
Graduate degrees	36 (41)	32 (37)
Race/ethnicity, No. (%)		
Non-Hispanic white	75 (86)	75 (87)
African American	4 (5)	2 (3)
Asian/Pacific Islander	6 (7)	3 (4)
Hispanic/Latino	0	2 (2)
American Indian	0	2 (2)
Other	2 (2)	2 (2)
Body measurements, mean (95% CI)		
Weight, kg	81.6 (78.4-84.7)	81.7 (79.1-84.3)
Body mass index†	30.5 (29.6-31.4)	30.6 (29.8-31.4)
Waist circumference, cm	93.1 (90.6-95.6)	93.5 (91.3-95.8)
Hip circumference, cm	111.1 (109.1-113.1)	111.3 (109.5-113.0)
Total body fat, % (DXA)	47.6 (46.5-48.6)	47.4 (46.4-48.4)
Total body fat, kg (DXA)	38.5 (36.4-40.6)	38.4 (36.6-40.2)
Intra-abdominal body fat, g/cm ² (CT)	147.6 (134.3-161.0)	147.6 (135.4-159.8)
Subcutaneous abdominal body fat, g/cm ² (CT)	389.1 (362.8-371.1)	371.1 (343.6-398.5)
Total energy intake, mean (95% CI), kcal/d‡	1645 (1467-1822)	1724 (1578-1870)
Maximal oxygen consumption, mean (95% CI), mL/kg per min	20.1 (19.3-20.9)	20.4 (19.8-21.1)

Abbreviations: CI, confidence interval; CT, computed tomography; DXA, dual-energy x-ray absorptiometry.

*None of the comparisons between baseline characteristics of intervention and control participants were statistically significant.

†Body mass index is calculated as weight in kilograms divided by the square of height in meters.

‡Calculated from food frequency questionnaire.

months. All analyses were based on assigned treatment at the time of randomization, regardless of adherence or compliance status (ie, intent-to-treat). A small number of 12-month body composition data were not available. No change from the baseline values was assumed for these missing values in the intent-to-treat analysis.

For both the exercise intervention and control groups, we computed the mean change from baseline in body composition at 3 and 12 months after randomization. Differences between intervention and control trends in body composition changes from baseline through 3 and 12 months were assessed. To account for the longitudinal nature of the data, we used a generalized estimating equation modification of the linear regression model in making inferences.¹⁸

We also conducted stratified analyses to explore between-group differences in body composition changes stratified by baseline age (<60, 60-69, or ≥70 years) and BMI (<27.6, 27.6-29.9, or ≥29.9). As a secondary analysis, we compared the mean changes at 12 months across tertiles of measures of adherence. All statistical tests were 2-sided. Statistical analyses were performed using SAS software, version 8.2 (SAS Institute Inc, Cary, NC).

RESULTS

Complete body weight, BMI, and circumference data were available for all 173 participants at 3 months and for 168 women at 12 months (3 dropped out and 2 refused 12-month measures). Complete DXA and CT data were available for 167 women and 160 women at 12 months, respectively.

Baseline demographic and body composition data in the intervention and control groups were similar (TABLE 1). Participants were a mean age of 61 years and were highly educated. Less than a third worked full time; 86% were non-Hispanic white, 4% were African American, and 6% were Asian American.

Eighty-three percent of the 4524 expected activity logs were completed (about 43 weeks of activity data per exerciser). A total of 24320 activities were recorded in the logs, reflecting 38 different activities (TABLE 2). Heart rate was available for 68% of the activities; mean (SD) heart rate was 81% (9%) of maximal heart rate. The exercisers participated in moderate-intensity sports/recreational activity for a mean (SD) of 3.5 (1.2) d/wk for 176 (91) min/wk. Six exercisers (8%) dropped out of the exercise intervention (all after 3 months); however, 3 of the 6 returned for the 12-month clinic visit and are used in the analyses. Among the control group, 6 participants (7%) reported an increase of at least 225 min/wk of moderate-intensity sports/recreational activity from baseline on the 12-month physical activity questionnaire.

Mean 3- and 12-month changes from baseline in body composition for both groups are shown in TABLE 3. After 12 months, exercisers lost an average of 1.3 kg compared with a 0.1-kg weight gain in controls ($P=.01$). The exercise group lost an average of 8.5 g/cm² of intra-abdominal body fat compared with a slight gain (0.1 g/cm²) among the control group ($P=.045$). Statistically significant between-group differences in body weight ($P=.05$), BMI ($P=.04$), and hip circumference ($P=.01$) occurred over time ($P<.05$ for trend), with greater between-group differences observed at 12 months than at 3 months.

The mean change in body composition at 12 months among exercise and control participants, stratified by age and BMI at baseline, is shown in TABLE 4. Between-group differences in the changes in body weight and body fat at 12 months did not vary by age or BMI.

Changes in total body fat percentage, measured by DXA at 12 months

and stratified by tertiles of duration and changes in cardiorespiratory fitness level, are shown in FIGURE 2. Women who exercised for more than 195 min/wk (highly active) lost 4.2% of total body fat compared with losses of 2.4% among intermediate-activity exercisers (136-195 min/wk), 0.6% among low-activity exercisers (≤ 135 min/wk), and 0.4% among the control group between baseline and 12 months. A similar trend of greater body-fat loss with increasing cardiorespiratory fitness level was also observed.

The percentage change in intra-abdominal fat, measured by CT at 12 months and stratified by duration and change in cardiorespiratory fitness level, is shown in FIGURE 3. Women who exercised for more than 195 min/wk (highly active) lost 6.9% of intra-abdominal body fat compared with a loss of 5.9% among intermediate-activity exercisers (136-195 min/wk), a loss of 3.4% among low-activity exercisers (≤ 135 min/wk), and a gain of 0.1% among the control group between baseline and 12 months. A similar trend of greater intra-abdominal body fat loss with increasing cardiorespiratory fitness

level was also observed. No injuries were reported as a result of the exercise intervention.

COMMENT

This year-long moderate-intensity exercise program among overweight,

Table 2. Types of Physical Activity Recorded Among Exercisers (n = 87) in Daily Activity Logs

Activity Type	Observations, No. (%)	Maximum Heart Rate %, Mean (SD) [Range]*
At the Facility		
Treadmill walking	5892 (51.8)	83 (8) [51-113]
Stationary bicycling	5066 (44.5)	82 (9) [49-126]
Recumbent stepper with hand cranks	193 (1.7)	76 (11) [46-108]
Elliptical stair climber	188 (1.6)	82 (9) [58-99]
Strength training†	45 (0.4)	80 (1) [79-81]
Total	11 384	83 (9) [46-126]
At Home		
Walking	9544 (73.7)	80 (9) [47-116]
Bicycling	950 (7.3)	81 (9) [54-121]
Strength training	756 (5.8)	79 (7) [49-103]
Aerobics	431 (3.3)	79 (9) [61-115]
Calisthenics‡	276 (2.1)	80 (12) [58-105]
Stair climber	179 (1.4)	77 (8) [52-91]
Water aerobics	172 (1.3)	78 (5) [65-88]
Swimming	120 (0.9)	74 (8) [58-103]
Volleyball	70 (0.5)	81 (4) [74-84]
Tennis	66 (0.5)	79 (6) [65-87]
Stationary rowing	62 (0.5)	87 (5) [72-91]
Elliptical stair climber	60 (0.5)	83 (8) [62-95]
Total§	12 946	80 (9) [47-121]

*Maximum heart rate percentage = (maximum heart rate max from graded exercise test - exercise heart rate) / maximum heart rate $\times 100$.

†Strength training included leg press, leg extension, leg curls, bench press, and seated dumbbell row.

‡Calisthenics included conditioning and floor exercises.

§Other activities were performed at a frequency of less than 0.1%.

Table 3. Change in Body Composition Measures at 3 and 12 Months in Exercise Intervention and Control Participants

	Mean (95% Confidence Interval)						P Value for Difference From Baseline	P Value for Trend*
	Baseline vs 3 mo			Baseline vs 12 mo				
	Exercisers	Controls	Difference	Exercisers	Controls	Difference		
Weight, kg	-0.5 (-1.0 to 0.1)	0.0 (-0.6 to 0.5)	-0.5 (-1.2 to 0.3)	-1.3 (-2.0 to -0.5)	0.1 (-0.6 to 0.8)	-1.4 (-2.5 to -0.3)	.01	.05
Body mass index†	-0.2 (-0.4 to 0.0)	0.0 (-0.2 to 0.2)	-0.2 (-0.5 to 0.1)	-0.3 (-0.6 to -0.1)	0.3 (0.0 to 0.6)	-0.6 (-1.0 to -0.2)	.004	.04
Waist circumference, cm	-0.5 (-1.2 to 0.2)	-0.1 (-0.8 to 0.6)	-0.4 (-1.4 to 0.6)	-1.0 (-1.8 to -0.1)	0.1 (-0.8 to 0.9)	-1.1 (-2.2 to 0.2)	.049	.30
Hip circumference, cm	-0.1 (-0.6 to 0.6)	0.2 (-0.4 to 0.9)	-0.3 (-1.2 to 0.7)	-1.5 (-2.3 to -0.7)	0.1 (-0.6 to 0.9)	-1.6 (-2.7 to -0.6)	.003	.01
Total body fat, % (DXA)	NA	NA	NA	-1.2 (-1.6 to -0.8)	-0.2 (-0.6 to 0.2)	-1.0 (-1.6 to -0.4)	.001	NA
Total body fat, kg (DXA)	NA	NA	NA	-1.4 (-2.0 to -0.8)	-0.1 (-0.6 to 0.6)	-1.3 (-2.2 to -0.6)	.001	NA
Intra-abdominal fat, g/cm ² (CT)	NA	NA	NA	-8.5 (-15.1 to -2.0)	0.1 (-6.7 to 6.6)	-8.6 (-17.8 to 0.9)	.045	NA
Subcutaneous abdominal fat, g/cm ² (CT)	NA	NA	NA	-21.2 (-34.4 to -7.9)	7.6 (-5.8 to 20.9)	-28.8 (-47.5 to -10.0)	.003	NA
Maximal oxygen consumption, % change	NA	NA	NA	11.7 (8.8 to 14.6)	0.7 (-2.2 to 3.6)	11.0 (6.9 to 15.1)	<.001	NA
Total energy intake, kcal/d‡	-155 (-250 to -60)	-151 (-246 to -55)	-4 (-139 to 131)	-37 (-152 to 79)	-116 (-232 to 0)	79 (-85 to 244)	.34	.24

Abbreviations: CT, computed tomography; DXA, dual-energy x-ray absorptiometry; NA, not applicable.

*Test for trend in between-group differences over time (ie, baseline vs 3 and 12 months).

†Body mass index is calculated as weight in kilograms divided by the square of height in meters.

‡Calculated from food frequency questionnaire.

postmenopausal, previously sedentary women led to significant decreases in body weight, total body fat, and intra-abdominal and subcutaneous abdominal fat. Our finding of statistically significant between-group differences in body weight changes over time indicates that long-term adher-

ence to a facility- and home-based exercise program is possible and results in prolonged and increasing benefits.

While the body weight lost at 12 months among the exercisers was modest, the amount of intra-abdominal fat lost was considerable (8.5 g/cm²) and was dose-dependent. Only 2 random-

ized trials have been conducted previously that examined the effect of exercise on intra-abdominal body fat, used imaging techniques (eg, CT), and studied women.^{19,20} One trial randomized 4 women with type 2 diabetes into an 8-week exercise intervention,¹⁹ and the other trial randomized 8 women into

Table 4. Change in Body Composition Measures at 12 Months in Exercise Intervention Participants Stratified by Age and Body Mass Index at Baseline

	Mean (95% Confidence Interval)					P Value for Exercisers vs Controls
	Baseline		Baseline vs 12 mo			
	Exercisers	Controls	Exercisers	Controls	Difference	
Age at Baseline, y*						
Weight, kg						
50-59	85.6 (81.1 to 90.2)	82.9 (79.2 to 86.5)	-0.5 (-1.4 to 0.4)	0.7 (-0.2 to 1.7)	-1.3 (-2.6 to 0)	.05
60-69	78.6 (73.1 to 84.1)	83.1 (78.1 to 88.0)	-2.2 (-3.6 to -0.9)	-0.6 (-1.9 to 0.7)	-1.6 (-3.5 to 0.2)	.09
70-75	74.4 (69.3 to 79.6)	74.1 (68.8 to 79.3)	-1.7 (-3.8 to 0.4)	-0.5 (-2.8 to 1.7)	-1.1 (-4.2 to 1.9)	.45
Total body fat, % (DXA)						
50-59	47.6 (45.9 to 49.4)	47.3 (46.1 to 48.5)	-0.7 (-1.2 to -0.2)	0.4 (-0.2 to 0.9)	-1.1 (-1.8 to -0.4)	.003
60-69	47.6 (46.1 to 49.1)	48.4 (46.5 to 50.3)	-1.8 (-2.4 to -1.2)	-0.7 (-1.3 to -0.1)	-1.1 (-2.0 to -0.3)	.009
70-75	47.4 (45.4 to 49.4)	45.1 (41.7 to 48.5)	-1.4 (-3.2 to 0.4)	-1.0 (-2.9 to 0.8)	-0.4 (-2.9 to 2.2)	.77
Intra-abdominal fat, g/cm ² (CT)						
50-59	140.7 (121.9 to 159.6)	142.4 (123.8 to 161.0)	-2.5 (-10.5 to 5.5)	-2.1 (-10.3 to 6.1)	-0.4 (-11.8 to 11.1)	.95
60-69	157.8 (133.3 to 182.2)	161.9 (142.6 to 181.3)	-19.0 (-31.1 to -6.9)	4.5 (-7.2 to 16.2)	-23.5 (-40.3 to -6.7)	.007
70-75	149.6 (112.8 to 186.4)	132.3 (102.1 to 162.5)	-8.8 (-32.1 to 14.6)	-3.5 (-27.8 to 20.8)	-5.3 (-39.0 to 28.4)	.75
Subcutaneous abdominal fat, g/cm ² (CT)						
50-59	401.4 (359.1 to 443.7)	366.3 (335.6 to 397.1)	-12.3 (-26.3 to 1.7)	10.0 (-4.3 to 24.2)	-22.2 (-42.2 to -2.3)	.03
60-69	380.5 (338.8 to 422.1)	398.6 (336.0 to 461.2)	-33.3 (-64.4 to -2.3)	6.1 (-23.9 to 36.0)	-39.4 (-82.5 to 3.8)	.05
70-75	366.8 (312.1 to 421.5)	321.9 (257.7 to 386.1)	-28.0 (-66.1 to 10.0)	2.3 (-37.3 to 42.0)	-30.4 (-85.3 to 24.6)	.26
Body Mass Index at Baseline†						
Weight, kg						
24.1-27.5	70.3 (67.4 to 73.2)	68.4 (65.6 to 71.1)	-0.1 (-1.1 to 0.8)	0.3 (-0.7 to 1.3)	-0.4 (-1.8 to 0.9)	.65
27.6-29.9	75.6 (72.3 to 79.0)	78.3 (75.4 to 81.3)	-2.3 (-4.2 to -0.4)	0.8 (-0.9 to 2.5)	-3.1 (-5.6 to -0.6)	.02
30.0-42.0	90.7 (86.3 to 95.1)	89.9 (86.7 to 93.2)	-1.4 (-2.4 to -0.4)	-0.4 (-1.4 to 0.6)	-1.0 (-2.4 to 0.4)	.17
Total body fat, % (DXA)						
24.1-27.5	43.8 (42.2 to 45.5)	43.6 (41.8 to 45.4)	-1.1 (-2.0 to -0.3)	-0.3 (-1.2 to 0.6)	-0.8 (-2.1 to 0.4)	.18
27.6-29.9	46.0 (44.3 to 47.6)	46.2 (44.6 to 47.8)	-1.9 (-3.0 to -0.8)	0.2 (-0.7 to 1.2)	-2.2 (-3.6 to -0.7)	.004
30.0-42.0	50.4 (49.2 to 51.7)	49.9 (48.6 to 51.1)	-0.8 (-1.4 to -0.3)	-0.4 (-0.9 to 0.1)	-0.4 (-1.1 to 0.3)	.26
Intra-abdominal fat, g/cm ² (CT)						
24.1-27.5	116.3 (91.4 to 141.3)	111.2 (95.9 to 126.5)	-7.5 (-15.6 to 0.6)	7.3 (-1.8 to 16.3)	-14.8 (-26.9 to -2.6)	.02
27.6-29.9	117.5 (100.1 to 134.8)	135.4 (114.7 to 156.2)	-5.9 (-19.0 to 7.1)	1.6 (-10.1 to 13.3)	-7.6 (-25.1 to 10.0)	.39
30.0-42.0	179.1 (160.9 to 197.3)	171.9 (152.5 to 190.3)	-10.4 (-21.6 to 0.8)	-4.5 (-15.9 to 6.8)	-5.9 (-21.8 to 10.0)	.46
Subcutaneous abdominal fat, g/cm ² (CT)						
24.1-27.5	300.9 (266.3 to 335.4)	278.4 (237.1 to 319.8)	-16.6 (-31.9 to -1.3)	4.0 (-13.3 to 21.2)	-20.6 (-43.6 to 2.5)	.049
27.6-29.9	347.1 (304.4 to 389.8)	339.4 (311.0 to 367.7)	-30.7 (-54.8 to -6.6)	9.0 (-12.7 to 30.6)	-39.7 (-72.1 to -7.3)	.02
30.0-42.0	456.5 (421.0 to 492.0)	433.3 (389.5 to 477.1)	-19.0 (-42.5 to -4.5)	8.3 (-15.4 to 32.1)	-27.3 (-60.7 to 6.1)	.11

Abbreviations: CT, computed tomography; DXA, dual-energy x-ray absorptiometry.

*Sample sizes for ages 50 to 59 years, 60 to 69 years, and 70 to 75 years, respectively: exercisers = 47, 27, and 13; controls = 45, 29, and 12.

†Body mass index is calculated as weight in kilograms divided by the square of height in meters. Sample sizes for body mass indexes of 24.1 to 27.5, 27.6 to 29.9, and 30.0 to 42.0, respectively: exercisers = 24, 21, and 42; controls = 19, 26, and 41.

a 4-month exercise intervention.²⁰ Because of the small sample sizes, the results were inconclusive.

Whether the effect of a diet-plus-exercise intervention would result in greater loss of intra-abdominal fat among women is unknown. More studies using imaging techniques such as CT to examine the effect of diet and/or exercise on intra-abdominal fat are needed.

Intra-abdominal obesity is associated with insulin resistance, insulin-like growth factors, type 2 diabetes, hypertension, dyslipidemia, and cardiovascular disease.²¹⁻²⁵ Exercise may counteract the aberrant metabolic profile associated with intra-abdominal obesity, both directly and as a consequence of body-fat loss. Numerous adaptive responses take place with exercise training, including development of a more efficient system for transfer of oxygen to muscle. With this more efficient system, muscles can increase their use of lipid stores rather than relying primarily on carbohydrate reserves.²⁶ In addition, exercise helps counteract the weight regain often observed after diet-induced weight loss.²⁷

According to meta-analyses conducted by Dattilo and Kris-Etherton²⁸ and MacMahon et al,²⁹ a weight loss of 1 kg decreases serum cholesterol by 1% or 2.3 mg/dL (0.06 mmol/L), triglycerides by 1.9% or 1.5 mg/dL (0.02 mmol/L), and fasting plasma glucose by 3.6 mg/dL (0.2 mmol/L). Thus, a 5-kg weight loss would decrease average fasting plasma glucose values by 18 mg/dL (1.0 mmol/L). This improvement is in the range provided by many of the oral hypoglycemic agents that are currently used, although the benefits of these medications usually decrease with time. Furthermore, the Diabetes Prevention Program Research Group³⁰ recently showed that a weight loss goal of 7% and at least 150 min/wk of physical activity significantly reduced incidence of type 2 diabetes by 58% in overweight adults. Thus, consistent with the recommendation of the National Heart, Lung, and Blood Institute and the American College of Sports Medicine, an initial weight-loss goal should be to

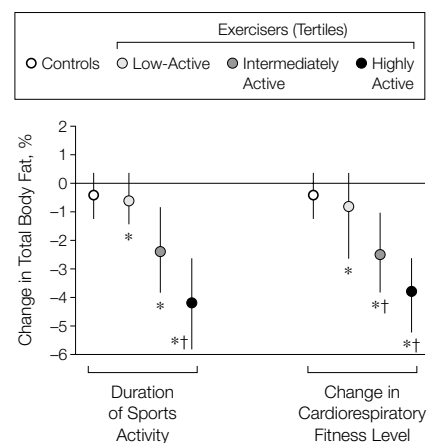
decrease body weight by 5% to 10% and to sustain this loss over the long term.³¹

A limitation of our study was that the participants did not record the duration for which they exercised at peak heart rate. Thus, we were unable to accurately determine energy expenditure. However, when we used the peak heart rate to examine the effect of energy expenditure per week on body fat, trends and effect sizes similar to duration of exercise were observed. Another limitation was that exercise performed at home was self-reported in the daily activity log compared with exercise performed at the facility, which was both self-reported and observed by the exercise trainer. Nonetheless, moderate-intensity exercise appears to be an effective tool among those who are prepared to make the necessary changes.

A major strength of our study was the excellent adherence to the exercise program and the low dropout rate. We collected daily activity logs from participants for each week of the study. Participants recorded data for each exercise session on type of activity, duration, and peak heart rate (when available). These data allowed us to determine dose-response associations between exercise and body composition. Our results show a statistically significantly greater weight and fat loss with exercise among women with stronger adherence to the exercise intervention. Other strengths of the present study are the large sample size (N=173) compared with other randomized controlled trials on this topic (<25 participants) and the long study duration (1 year vs <6 months).

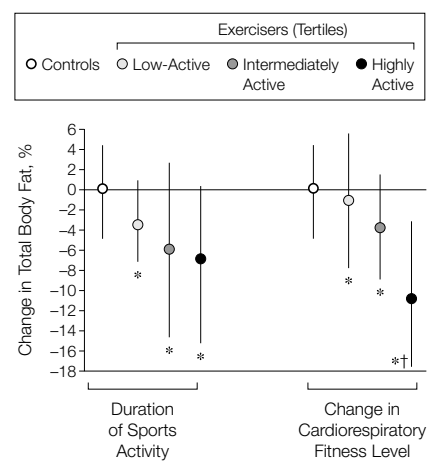
In conclusion, this randomized controlled trial of a moderate-intensity exercise intervention produced significant between-group differences in baseline to 12-month changes in body weight, total body fat, and intra-abdominal and subcutaneous abdominal body fat. Previously sedentary postmenopausal women who exercised for approximately 200 min/wk lost 4.2% of total body fat and 6.9% of intra-abdominal fat while maintaining their energy intake. This amount of exercise is similar to current national

Figure 2. Percentage Change in Total Body Fat at 12 Months by Tertile of Duration and Change in Fitness Level



Body fat was measured by dual-energy x-ray absorptiometry. Error bars indicate 95% confidence intervals; duration, minutes per week spent in moderate-intensity sports activity (low-active, ≤ 135 min/wk; intermediately active, 136-195 min/wk; and highly active, >195 min/wk); change in fitness, low-active, $\leq 5\%$; intermediately active, 5.1%-16%; and highly active, $>16\%$; asterisk, significant difference compared with controls ($P<.05$); and dagger, significant difference compared with low-active group ($P<.05$).

Figure 3. Percentage Change in Intra-abdominal Body Fat at 12 Months by Tertile of Duration and Change in Fitness Level



Intra-abdominal body fat was measured by computed tomography. Error bars indicate 95% confidence intervals; duration, minutes per week spent in moderate-intensity sports activity (low-active, ≤ 135 min/wk; intermediately active, 136-195 min/wk; and highly active, >195 min/wk); change in fitness, low-active, $\leq 5\%$; intermediately active, 5.1%-16%; and highly active, $>16\%$; asterisk, significant difference compared with controls ($P<.05$); and dagger, significant difference compared with low-active group ($P<.05$).

recommendations (ie, 30 minutes of moderate-intensity activity on most days of the week).³² Furthermore, 84% of the exercisers in this study improved their cardiorespiratory fitness. High levels of cardiorespiratory fitness reduce the rate of cardiovascular morbidity and mortality, independent of obesity.³³ Statistically significant between-group differences in body weight and BMI changes occurred over time, even though the structured, intensely monitored aspect of the exercise intervention lessened over time. Overweight women should be encouraged to participate in moderate-

intensity exercise as a method for obesity reduction and chronic disease prevention. Our findings support the important role of exercise in reducing body fat, especially intra-abdominal fat.

Author Contributions: Dr McTiernan, as principal investigator of this study, had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analyses.

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Acquisition of data: Irwin, Ulrich, Rudolph, Schwartz, Yukawa, McTiernan.

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Statistical expertise: Yasui.

Obtained funding: Schwartz, McTiernan.

Administrative, technical, or material support: Irwin, Schwartz, Yukawa, Potter, McTiernan.

Study supervision: Irwin, Bowen, Rudolph, Schwartz, Potter, McTiernan.

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