How Exercise Affects Lipid Profiles in Women

What to Recommend for Patients

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IN BRIEF: After menopause, women have less favorable lipid profiles than before menopause. While regular exercise improves lipid metabolism in men, the specifics for doing so in pre- and postmenopausal women are not fully understood. Literature review suggests that higher-volume aerobic exercise programs increase high-density lipoprotein cholesterol (HDL-C) levels in both pre- and postmenopausal women. Although longitudinal studies of resistance training did not reveal increases in HDL-C levels in women, other favorable benefits observed included decreases in low-density lipoprotein-cholesterol, total cholesterol, and body fat. Cross-sectional studies, however, seem to favor high-volume exercise for increasing HDL-C levels.

Coronary heart disease (CHD) is the leading cause of death and disability in both men and women. In those under age 65, death rates from CHD are substantially higher for men than for women. After age 65, death rates for both genders become similar.[1] After the onset of menopause, women have increased levels of total cholesterol, triglycerides, low-density lipoprotein cholesterol (LDL-C), as well as decreased levels of high-density lipoprotein cholesterol (HDL-C), compared with their premenopausal counterparts. Research indicates that HDL-C levels are strong predictors of cardiovascular disease after menopause.[2] Exercise training has been shown to improve lipid metabolism (manifested by increased HDL-C levels) and decrease total cholesterol, LDL-C, and triglycerides in men.[3] However, the volume of physical activity required to enhance lipid profiles in women is not well defined.

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Lipids and Coronary Heart Disease

Epidemiologic studies have shown a relationship between elevated cholesterol and coronary artery dis-

continued

TABLE 1. Cross-Sectional Studies of Lipids and Aerobic Training in Women

Study	Subjects	No.	Age (yr)	Training	HDL-C	LDL-C
Durstine et al[15]; mixed OC	Elite (E) Good (G) Recreational (R) Controls (C)	16 14 14 14	25 28 26 27	467 min/wk 320 min/wk 158 min/wk None	E, G, R>C	No difference between groups
Moore et al[16]; no OC	Runners (R) Joggers (J) Controls (C)	45 49 47	39 39 39	41.8 km/wk 9.7 km/wk 1.6 km/wk	R>C, R>J, J>C	No difference between groups
Hartung et al[17]; OC status not reported	Runners (R) Controls (C)	18 18	41 39	34 mi/wk None	R>C	C>R

HDL-C = high-density lipoprotein cholesterol; LDL-C = low-density lipoprotein cholesterol; OC = oral contraceptives

ease (CAD).[1] However, the lipoproteins (especially HDL-C and LDL-C) have been found to be strong predictors of CAD. HDL-C retards the development of atherosclerosis by acting as a reverse cholesterol transfer system, whereas LDL-C and its subfractions are the principal cholesterol carriers. More recently, a subfraction of LDL, lipoprotein (a) [Lp(a)], has been found to be an independent risk factor for CHD events and is considerably higher in male and female African Americans.[4] Some have proposed that the cholesterol associated with Lp(a) can be deposited with accumulations on the arterial wall (atherosclerotic plaque) and also inhibit fibrinolytic processes resulting in thrombosis. Thus, the distribution of cholesterol among the various types of lipoproteins seems to be a more powerful predictor of CHD than simply total quantity of plasma lipids.

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Serum Lipid Profiles in Women

Previous studies have shown fluctuations in plasma lipid/lipoprotein levels associated with menstrual status. In addition, oral contraceptive use or hormone replacement therapy (HRT) also influences plasma lipid concentrations.

Postmenopause. After the onset of menopause, women undergo changes in several cardiovascular disease (CVD) risk factors, including blood lipid/lipoprotein levels and blood clotting characteristics such as fibrinogen levels. Their plasma levels of total cholesterol, LDL-C, triglycerides, and fibrinogen are increased, and HDL-C levels are decreased.[5] The hypoestrogenemic status of natural or surgical menopause leads to these changes.

Hormone replacement therapy. Epidemiologic data indicate that postmenopausal women who take hormone replacement therapy (HRT), whether unopposed estrogen or a combination of estrogen and progestogen, have a 40% to 60% reduction in CAD risk.[6] The estrogen component exerts primarily a favorable effect on lipid and fibrinogen levels. The use of unopposed estrogen replacement lowers LDL-C and Lp(a) levels and raises HDL-C levels.[7] In addition, lower fibrinogen and plasma viscosity has been documented.[8]

The effect of added progestogens to estrogen replacement is less clear. It appears that the addition of

Total Cholesterol	Triglycerides	Body Fat
No difference between groups	No difference between groups	R, C>E, G
R>C	No difference between groups	C>R, C>J, R>J
No difference between groups	No difference between groups	C>R

progestogens may have a damping effect on the rise of HDL-C levels associated with estrogen therapy alone.[9] However, Lp(a), fibrinogen, and plasma viscosity are still significantly lower with combined therapy than nonusers of HRT.[9] Several studies have found that newer generations of progesterone and lower doses have few, if any, negative effect on HDL-C.[7,10] To date, research suggests that clinical evaluation of an individual may influence the choice of progestin type, dose, and administration. What is important is that the use of unopposed estrogen or the addition of progestogen does reduce the risk of CHD morbidity and mortality in postmenopausal women.[11] In addition, the Postmenopausal Estrogen/Progestin Interventions Trial supports the premise that lowering Lp(a) is one of the mechanisms through which HRT may convey health benefits in postmenopausal women.[12]

Benefits of Physical Activity

Exercise plays a role in preventing cardiovascular disease as well as other serious health problems. Exercise-trained and physically active individuals generally exhibit lower plasma concentrations of triglycerides and higher levels of HDL-C than their untrained, sedentary counterparts. Some of the potential mechanism by which exercise modifies plasma and lipoprotein profile are related to increases in lipoprotein lipase (LPL) and lecithin cholesterol acid transferase (LCAT) activity.[13] HDL contains LCAT, and the enzyme catalyzes a reaction that gathers free cholesterol and returns it to the liver. LPL decreases HDL_2 breakdown and increases the use of triglycerides (HDL_2 is a major class of HDL). In addition, exercise lowers triglycerides by increasing insulin receptor activity and reduces abdominal body fat.[14] Abdominal fat, commonly seen postmenopausally, is associated with decreased liver LPL activity, impairing the breakdown of triglycerides.[12,13] Therefore, the therapeutic effects of physical exercise have become a widely used strategy to reduce the risk of CVD.

Aerobic Exercise and Lipid Profiles

Numerous studies have examined the effects of aerobic exercise training on lipid profiles in both pre- and postmenopausal women.

Premenopausal women. Several prospective studies have suggested a significant positive correlation between exercise volume and HDL-C level, as well as a strong inverse relationship between body weight and HDL-C levels in premenopausal women (table 1).[15-17] Durstine et al[15] observed significantly higher HDL-C levels in elite, good, and recreational women runners compared with those in inactive women. Significant positive correlations were found between minutes run per week and HDL-C and HDL-C_2. There was also an inverse relationship between body weight and HDL-C. In a similar, but larger study, Moore et al[16] reported significantly higher HDL-C levels and lower percentages of body fat among female runners who increased their running volume compared with sedentary women. They also reported a negative correlation between percent body fat and HDL-C levels. Hartung et al[17] reported the same findings in their large-scale study.

Cross-sectional comparisons seem to substantiate that HDL-C is related to volume of aerobic activity and lower percent body fat in both pre- and postmenopausal women.[16-18] The difference was about 10 mg/dL. HDL-C levels averaged about 55 mg/dL for sedentary women versus about 65 mg/dL for active women.

Longitudinal studies employing exercise training intervention also suggest that HDL-C is generally directly related to the volume of exercise performed by women who engage in aerobic exercise (table 2).[19-29]

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TABLE 2. Longitudinal Studies of Lipids and Aerobic Training in Women

Study	Age (yr)	Subjects (No.)	Regimen	HDL-C	LDL-C
Hill et al[19]; OC status not reported	22-45*	Women (W=9) Men (M=8)	Walk/jog, 70% MPHR, 4 sessions/wk for 10 wk	↑ W No change M	Not reported
Duncan et al[20]; mixed OC	20-40*	Aerobic walk (AW=16) Brisk walk (BW=12) Stroll (S=18) Controls (C=13)	4.8 km/day, 5 sessions/wk for 24 wk	↑ AW, S No change BW, C	↓ BW No change AW, S, C
Rotkis et al[21]	20-37*	Premenopausal runners (19), 24 km/wk	Increase distance to 100 km/wk over 15 mo	↑	Not reported
Goodyear et al[22]; no OC	Avg, 24	Premenopausal runners (5), 48 km/wk	Increase run to 100 km/wk over 8 wk	↑	No change
Wynne et al[23]; OC	19-30*	Women (W=13) Controls (6)	30 min bicycle, 3 sessions/wk at 70% HRR for 10 wk	No change	No change
Frey et al[24]; no OC	19-29*	Interval-train (10) Continuous-train (6)	5 min exercise, 2 min rest (30 min), 5 min exercise, 10 sec rest (30 min), 3 sessions/wk, at 70% HRR for 10 wk	No change	No change
Brownell and Stunkard[25]; no ERT	20-57*	Women (W=37) Men (M=24)	15-20 min aerobic exercise, 3 sessions/wk at 70% MPHR for 10 wk	↑ M No change F	↓ M No change F
Cauley et al[26]; no ERT	Avg, 57.7	Exercise (100) Controls (104)	Walking, ≈11 km/wk for 2 yr	No change	Not measured
Binder et al[27]; HRT	60-72*	Exercise (Ex=23) Exercise + HRT (E/HRT=16) HRT only (15)	Aerobic exercise 45 min, 3 times/wk, 70% MPHR for 6 mo	↑ E/HRT ↑ HRT	↓ E/HRT ↓ HRT
Lindheim et al[28]; ERT	42-59*	Exercise (Ex=25) Exercise + ERT (E/ERT=28) ERT only (ERT=15)	Aerobic exercise 30 min, 3 times/wk at 70% MPHR for 6 mo	↑ E/ERT ↑ ERT	↓ Ex ↓ E/ERT ↓ ERT
Klebanoff et al[29]; ERT	45-61*	Postmenopause, ERT (8) Postmenopause, no ERT (10)	Aerobic exercise, 30-50 min, 3 times/wk, 75%-85% $\dot{V}O_2$ max for 12 wks	No change	No change

*Sedentary at onset of study.
HDL-C = high-density lipoprotein cholesterol; LDL-C = low-density lipoprotein cholesterol; OC = oral contraceptives; MPHR = maximum predicted heart rate; HRR = heart rate reserve; ERT = estrogen replacement therapy; HRT = hormone replacement therapy

Total Cholesterol	Triglycerides	Body Fat
No change W ↓ M	Not reported	No change both sexes
No change in all	No change in all	↓ S No change AW, BW, C
No change	Not reported	↓
No change	No change	↓
No change	No change	↓ W
No change	No change	↓ both
↓ both	↓ M ↑F	↓ both
No change	No change	Not measured
↓ E/HRT ↓ HRT	↓ HRT	↓ E/HRT ↓ Ex
↓ Ex ↓ E/ERT ↓ ERT	↓ Ex ↓ E/ERT ↓ ERT	No change
No change	No change	No change

The relationship with body composition varied. For example, Hill et al[19] observed an increased HDL-C concentration in women participating in 10 weeks of walking-jogging (4 times/wk at 70% MPHR). Duncan et al[20] reported similar HDL-C levels in women who walked a given distance each day for 24 weeks, whether the pace was slow, medium, or fast. Neither of the studies observed changes in body composition. Additionally, two studies[21,22] reported an increase in HDL-C levels and a decrease in percentage of body fat in premenopausal women who increased their running distance from either 24 or 48 km/wk to 100 km/wk. These findings suggest high-volume exercise may have a greater influence on HDL-C and percentage body fat than had previously been thought.

Studies of women participating in lower-volume exercise protocols have reported a lack of change in lipid profiles. For example, Wynne et al[23] observed no change in HDL-C, LDL-C, total cholesterol, and triglyceride levels in premenopausal women (users of oral contraceptives) participating in 10 weeks of cycling (70% $\dot{V}O_2$max for 30 minutes, 3 times/wk). Two other studies[24,25] involving similar exercise volumes (70% heart rate reserve, about 30 minutes, 3 times/wk) reported the same observations in women who did not use oral contraceptives or HRT. Even though the low-volume exercise protocol studies reported significant improvements in oxygen consumption ($\dot{V}O_2$max), they revealed no changes in lipid profiles. They did, however, report significant reductions in percentage of body fat with low-volume exercise. The lack of changes in lipid levels could have been the result of the shorter study period (10 weeks versus 24 to 48 weeks).

Postmenopausal women. Two studies in postmenopausal women (not on HRT) suggest no relationship between the volume of physical activity and HDL-C when the studies were controlled for body composition. In one study, Cauley et al[30] evaluated HDL-C levels after physical activity based on the Paffenbarger Activity Survey in 75 women (non–HRT users). There were no changes in lipid profile after controlling for degree of obesity. A second, larger study,[26] reported similar observations. Both studies involved observations of women who engage in brisk walking for approximately 11 km/wk for 2 years.

Limited research has examined the effects of com-

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TABLE 3. Cross-Sectional Studies of Lipids and Resistance Training in Women

Study	Subjects	No.	Age (yr)	Training	HDL-C	LDL-C	Total Cholesterol	Triglycerides	Body Fat
Elliot et al[31]; mixed OC	Body-builders	15	28	≈90 min/day, 4-6 sessions/wk	No difference between groups	Not reported	No difference between groups	Not reported	No difference between groups
	Runners	14	34	50-70 mi/wk					
Morgan et al[32]; mixed OC	Resistance training (RT)	9	36	≈108 min/day, 3 sessions/wk,	R>RT, C	Not reported	No difference among groups	Not reported	C>R, RT
	Runners (R)	9	27	38 mi/wk					
	Control (C)	9	34	None					

HDL-C = high-density lipoprotein cholesterol; LDL-C = low-density lipoprotein cholesterol; OC = oral contraceptives

bined HRT and exercise on lipid profiles in postmenopausal women. In a recent study, Binder et al[27] reported a significant reduction in LDL, total cholesterol, and triglyceride levels and an 8.3% increase in HDL-C in the HRT-only and exercise-plus-HRT groups compared with the exercise-only group. In addition, the exercise-only and exercise-plus-HRT groups had a decrease in percentage of body fat. The 11-month study consisted of vigorous exercise (65% to 85% maximum heart rate [HR_{max}]), 45 min/day for 3 days a week. The results were similar to a 6-month study (70% HR_{max}, 30 minute sessions, 3 times/wk) by Lindheim et al[28]; however, these researchers also observed decreases in LDL-C, total cholesterol and triglycerides in the exercise-plus-ERT, ERT-only, and exercise-only groups, with no changes in percent body fat in any of the groups. On the other hand, Klebanoff et al[29] reported no significant differences in lipid profile and percent body fat in a high-intensity (75% to 85% $\dot{V}O_2$ max) 12-week aerobic exercise program between estrogen-therapy and exercise-only groups. However, researchers divided women into heavier (body mass index >27) and lighter (body mass index <27) groups and observed a trend toward significance for all the blood lipid variables in the lighter women.

In sum, research suggests that higher-volume exercise regimens may be an effective stimulus to increase HDL-C levels and decrease LDL-C, total cholesterol, and triglyceride concentrations in both pre- and postmenopausal women. However, this stimulus may be influenced by decreases in percentage of body fat. In addition, none of the studies adjusted blood variables for fluctuations in plasma volume over time, and few mentioned controlling for body weight.

Resistance Exercise and Lipid Profiles

Only limited research has studied the effects of chronic resistance training on serum lipid profiles in women. Two cross-sectional studies examined lipoprotein profiles among female strength-trained athletes (table 3).[31,32] In one study, Elliot et al[31] reported that HDL-C levels in steroid-free, competitive bodybuilders were comparable to those of female runners (55 mg/dL vs 65 mg/dL). Another study,[31] however, found significantly lower HDL-C levels in female weight lifters compared with female endurance runners (56 mg/dL vs 72 mg/dL). In both studies, all women had comparable percentages of body fat (about 15%).

TABLE 4. Longitudinal Studies of Lipids and Resistance Training

Study	Group*	No.	Age (yr)	Regimen	HDL-C	LDL-C	Total Cholesterol	Triglycerides	Body Fat
Goldberg et al[33]	Resistance (W)	8	27	1 hr/day, 3 sessions/wk, 84% 1-RM, 16 wk	No change	↓ W	↓ W	↓ W	No change
	Resistance (M)	6	33		No change	↓ M	No change	No change	No change
Prabhakaran et al[34]	Resistance (R)	12	28	50 min/day, 3 sessions/wk, 85% 1-RM, 14 wk	No change	↓ R	↓ R	No change	↓ R
	Control	12	26						
Boyden et al[35]	Resistance (R)	46	34	1 hr/day, 3 sessions/wk, 70% 1-RM, 20 mo	No change	↓ R	↓ R	No change	↓ R
	Control	42	34						

* Sedentary at outset.
HDL-C = high-density lipoprotein cholesterol; LDL-C = low-density lipoprotein cholesterol; RM = repetition maximum; W = women; M = men

Longitudinal intervention studies (table 4)[33-35] have suggested favorable effects of resistance training on lipid metabolism in premenopausal women. Goldberg et al[33] observed decreased LDL-C, total cholesterol, and triglyceride levels after 16 weeks of resistance training (84% of 1-repetition maximum [RM]) in premenopausal women. There were no changes in body weight. More recently, Prabhakaran et al[34] examined the effects of 14 weeks of resistance training (85% of 1-RM) on lipid profiles in premenopausal women compared with sedentary controls and noted a significant decrease in total cholesterol, LDL-C, and percent body fat (1.2%) in the resistance-training group.

Although resistance training did not significantly change HDL-C levels, there was a significant association between percentage change in body fat and percentage change in HDL-C (r= 0.41, P = 0.05). A study[35] employing a 20-week resistance training program (70% of 1-RM) showed similar findings. However, body fat did not correlate with changes in serum lipid levels; body compositions were comparable for both the groups at baseline and post-training.

In summary, although longitudinal intervention studies did not find resistance training effective for increasing HDL-C in women, they did report favorable changes in levels of LDL-C, total cholesterol, and percent body fat. The cross-sectional studies, however, suggest that high-volume resistance exercise may have a favorable effect on body composition and HDL-C. None of the studies observed changes in cardiorespiratory fitness with resistance training.

Recommendations for Exercise Prescription

Aerobic exercise training. The American College of Sports Medicine (ACSM) and the American Heart Association recognize the benefits of both aerobic endurance exercise and resistance training on physical fitness and other health-related factors. Durstine et al[18] recently reported that high-volume exercise training programs designed to expend 1,000 to 1,200 kcal/wk (approximately 7 to 14 miles/wk) may be required for changes in LDL-C, triglyceride, and HDL-C levels in women. For this reason, exercise should be prescribed for women, although further controlled research is needed to examine the relationship between exercise and lipid profile.

The ACSM recommends that aerobic endurance exercise should be performed 3 to 5 days per week, for 20 to 60 minutes (continuously), at 55% to 90% HR_{max}, or between 40% to 85% of heart rate reserve.[36] Very

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sedentary individuals may have to exercise at the lower end of the intensity range for a longer duration than do the physically active. These values may be calculated with the following formulas: (1) HR_{max} = (220-age) $\times$ intensity; and (2) target heart rate = $[(HR_{max} - HR_{rest}) \times \text{intensity}] + HR_{rest}$.

The Centers for Disease Control and Prevention (CDC) recommends that adults should engage in moderate-intensity physical activity expending approximately 200 kcal/day.[37] The CDC also states that these physical activities can be outside of formal exercise programs (eg, gardening, climbing stairs) and intermittent.

Resistance training. The most recently published guidelines for resistance training recommend at least one set of 8 to 15 repetitions, with a minimum of one exercise per major muscle group.[36] Training should be performed 2 to 3 days a week on alternate days.

Warm-up and cooldown. A proper warm-up and cooldown is recommended for all types of exercise sessions. Five to 10 minutes of low-intensity calisthenic-type exercise (eg, light cycling, slow or brisk walking) serves as an ideal warm-up. The cooldown provides a gradual recovery from the endurance phase and should consist of 5 to 10 minutes of lower-intensity activity. Flexibility training should be incorporated into an exercise routine a minimum of 2 to 3 days per week.

Other recommendations. Altering the risk-factor profile of a given individual through lifestyle changes has been shown to reduce the risk of CHD. A low–saturated fat, low-cholesterol, weight-reducing diet with or without exercise has a favorable effect on plasma lipids in both men and women. Abstinence from cigarette smoking and moderate alcohol consumption is also recommended. In addition, medical advances in the detection and treatment of hyperlipidemia, hypertension, and CHD are available to help guide management.

The Emerging Paradigm

Studies of aerobic endurance exercise suggest that high-volume exercise may lower HDL-C, LDL-C, triglycerides, and total cholesterol in both pre- and postmenopausal women. This may be coupled with an inverse relationship between percentage of body fat and HDL-C levels. Limited research has examined the effects of exercise on HDL subfractions in which substantial shifts may be occurring without significant changes in total lipid mass. Thus, well-controlled research on the effects of long-term exercise intervention is needed to examine the interaction between exercise intensity, frequency, and duration in women. Study design should take into consideration menstrual status, menstrual phase, oral contraceptive or hormone replacement use, alcohol consumption, smoking status, and dietary changes. In addition, blood analysis should be done to detect plasma volume changes and examine lipoprotein subfractions. The paucity of long-term studies, however, should not hinder prescribing aerobic endurance exercise and resistance training. PSM

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** A complete reference list will be available at www.physsportsmed.com beginning in October 2001.*