Differential Effect of Resistance Training on the Body Composition and Lipoprotein-Lipid Profile in Older Men and Women

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The effects of a 12-week resistance exercise training (RT) program on body composition and serum lipid concentrations were assessed in weight-stable, moderately overweight older men (n = 18) and women (n = 17) aged 54 to 71 years with a body mass index (BMI) of 26 to 36 kg/m^2. Following RT, the men had a significant increase in fat-free mass (FFM) and a decrease in percent body fat (%BF) and fat mass (FM), whereas the women demonstrated no change, resulting in significant time-by-sex interactions for FFM ($P = .002$), %BF ($P = .006$), and FM ($P = .005$). There were no changes in total cholesterol (Chol), low-density lipoprotein cholesterol (LDL-C), or triacylglycerol (Tg) due to RT. However, following RT, high-density lipoprotein cholesterol (HDL-C) increased (0.06 ± 0.02 mmol/L) in the men and decreased (0.09 ± 0.03 mmol/L) in the women (time-by-sex interaction, $P = .0004$). The Chol/HDL-C ratio decreased (0.36 ± 0.11) in the men and increased (0.29 ± 0.10) in the women (time-by-sex interaction, $P = .0001$). For all subjects combined, the changes in HDL-C and the Chol/HDL-C ratio were not related to any changes in body fat stores (ie, %BF or FM), suggesting that RT may potentially alter the lipoprotein-lipid profile in older weight-stable men and women. In conclusion, although the changes in the lipoprotein-lipid profile were small, the men had a significantly increased HDL-C level and decreased Chol/HDL-C ratio, while the women demonstrated opposite changes.

THE RISK for the development of cardiovascular disease is reduced in physically active people compared with their sedentary counterparts, in part due to their more favorable lipoprotein-lipid profile. Aerobic exercise training improves the lipoprotein-lipid profile in previously untrained men and women by increasing high-density lipoprotein cholesterol (HDL-C) and decreasing total cholesterol (Chol), low-density lipoprotein cholesterol (LDL-C), or triacylglycerol (Tg).[1-10] The majority of studies show that the improved lipoprotein-lipid profile with aerobic training is primarily due to an accompanying loss of body weight (primarily body fat mass [FM]).[1-6,9] However, the aerobic training–induced improvement in the lipoprotein-lipid profile without weight loss has been equivocal, with some studies demonstrating the importance of the accompanying weight loss during exercise[1-6,9] and others documenting that exercise training without a change in body weight or body fat stores can alter the lipid profile.[7,8]

The effect of resistance exercise training (RT) on the lipoprotein-lipid profile is not as well documented, nor are the results as consistent as those for aerobic training. Some investigators observed increases in HDL-C and/or decreases in Chol and LDL-C,[11,12] while others reported no change[13-15] in these risk factors for cardiovascular disease. The effect of RT on the lipoprotein-lipid profile in older men and women has rarely been studied. RT has been demonstrated to produce a reduction in total and relative body fat stores in elderly men and women. If the effects of exercise on lipoproteins are manifested through changes in body composition RT might be expected to have positive effects.

There have been no direct comparisons of the effects of RT in older men and women. Therefore, the purpose of this study was to compare the effects of a RT program on the lipoprotein status and body composition of a group of older, moderately overweight men and women consuming an ad libitum diet. We hypothesized that any beneficial effect of RT on the lipoprotein-lipid profile would only be found with a reduction in body fat stores.

SUBJECTS AND METHODS

Subjects

Eighteen men and 17 women (age, 54 to 71 years; body mass index [BMI], 26 to 36 kg/m^2) who were not actively involved in any physical training volunteered to participate in this 13-week study. A medical history questionnaire, resting and RT electrocardiogram, routine blood and urine analyses, 75-g dextrose oral glucose tolerance test, and physician-administered physical examination were completed to exclude individuals with type 2 diabetes and any metabolic or cardiac abnormalities before admission to the study. Smokers and women on estrogen therapy were excluded from the study. After enrollment in the study, each subject signed an informed-consent form in accordance with The Pennsylvania State University Institutional Review Board and the General Clinical Research Center (GCRC) Advisory Committee.

Experimental Design

The study period was 13 weeks. All baseline testing was completed during study week 1. This was followed by a 12-week period in which the men and women performed supervised RT. All tests and evaluations were repeated at study week 13.

RT Protocol

The RT program consisted of 12 weeks of progressive RT twice weekly with a minimum of 2 days' rest between training sessions. The following five exercises were performed using Keiser pneumatic variable-resistance machines (Keiser Sports Health Equipment, Fresno,

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CA): (1) unilateral knee extension, (2) unilateral knee flexion for men and bilateral knee flexion for women, (3) double leg press, (4) seated chest press, and (5) seated arm pull. The first two sets consisted of eight repetitions at 80% of the one-repetition maximum (1RM), and the third set was continued until voluntary muscular fatigue or until 12 repetitions were completed. If 12 repetitions were completed for a given exercise, the resistance was increased by 5% for the next RT session. RT sessions were preceded and concluded by 10 minutes of easy cycling (heart rate < 100 bpm) and 10 minutes of stretching. Seventeen men completed 23 RT sessions (100% compliance) and one man completed 22 RT sessions. All of the women completed 23 RT sessions (100% compliance).

Each subject's maximal strength was measured for each exercise on Keiser pneumatic-resistance equipment as the maximal amount of resistance that could be moved through the full range of motion one time only (1RM). Baseline maximal strength for each exercise was set as the greater of two 1RMs obtained during the first two RT sessions. Each subject's 1RM was reassessed every 2 weeks and the training load was adjusted accordingly. Final 1RM assessments were repeated at the end of study week 13. Total body strength is reported as the sum of 1RM measurements for the unilateral knee extension, double leg press, seated chest press, and seated arm pull.

Diet

To standardize the diets prior to lipid and lipoprotein assessments, all subjects consumed foods and beverages (except water) prepared and provided by the Metabolic Research Kitchen at the GCRC for 5 days during study weeks 1 and 13 of the intervention. They were asked to refrain from drinking any alcoholic beverages during weeks 1 and 13. The controlled diet consisted of 2-day rotating menus. Both menus were designed to provide 13%, 57%, and 30% of total energy as protein, carbohydrate, and fat, respectively.[16] Each subject's total energy intake was estimated to be 1.5 times the basal energy need as predicted from the sex-specific Harris-Benedict equation.[17] Total energy intake was calculated using Nutritionist IV software (Version 4.0; N-Squared Computing, First Data Bank, San Bruno, CA) assuming a metabolizable energy value for protein, carbohydrate, and fat of 16.7, 16.7, and 37.7 kJ/g, respectively. During the other weeks of the study, the subjects consumed their self-prepared habitual diet.

Serum Lipids

Fasting serum samples were collected from the subjects in the postabsorptive state after an overnight 12-hour fast. At study week 13, serum samples were collected 72 hours after the last exercise session. Serum Chol, HDL-C, and Tg concentrations were measured by autoanalyzer techniques at a clinical medical laboratory (American Medical Laboratory, Chantilly, VA). Serum Tg and Chol levels were measured enzymatically, and HDL-C was determined after precipitation with dextran sulfate.[18] The LDL-C fraction was computed using the standard formula, LDL-C = Chol − (HDL-C + Tg/5).[19] The intraassay and interassay variability in the clinical medical laboratory during the period when these samples were analyzed was 0.87% and 1.34% for Tg, 0.68% and 1.33% for Chol, and 0.90% and 4.68% for HDL-C.

Body Composition

All body composition measurements were performed in the postabsorptive state after a 12-hour overnight fast. The subjects were encouraged to maintain their initial baseline weight for the duration of the intervention period, since the objective of the study was to assess the effects of RT on lipid and lipoprotein concentrations independently of changes in body weight. Fasting body weight was measured each weekday during study weeks 1 and 13 and twice weekly during the other study weeks (model 2181; Toledo Scale, Toledo, OH). Weight was measured to the nearest 0.1 kg with the subjects wearing underwear, socks, a T-shirt, and gym shorts. Nude body weight was calculated as total body weight minus the weight of the socks, T-shirt, and gym shorts. Body height without shoes was measured to the nearest 0.1 cm with a wall-mounted stadiometer on one morning during week 1, and was assumed to remain constant throughout the study.

Body density was determined in the fasting state using hydrostatic weighing,[20] with residual volume measured in the hydrostatic-weighing tank by the nitrogen dilution technique.[21] Percent body fat (%BF), fat mass (FM), and fat-free mass (FFM) were estimated from body density using the two-compartment model of Siri.[22]

The waist circumference was obtained by placing a Gulick tape around the waist at the umbilicus, and the hip circumference was obtained by placing the tape around the hips at the greatest protrusion of the buttocks. All circumferences were measured by the same technician.

Statistical Methods

Values are reported as the mean ± SEM. The difference between men (n = 18) and women (n = 17) for each independent variable was determined at baseline using Student's unpaired t test (two-tailed). The main effects of RT and sex and the interactions between these independent variables on each of the dependent variables were determined using repeated-measures ANOVA. Pearson product-moment correlation analyses were performed to search for any relationships between the changes in body composition and the indices of lipids and lipoproteins. All data processing and calculations were performed using JMP Statistical Discovery Software (SAS Institute, Cary, NC). Statistical significance was set at a P value less than .05.

RESULTS

Group Characteristics and Body Composition

At baseline, the men were taller and heavier and had a higher absolute FFM, a lower absolute FM, and a lower %BF than the women. With RT, the men had a significantly increased FFM (2.2 ± 0.5 kg) and decreased FM (−2.1 ± 0.7 kg) and %BF (−2.1% ± 0.6%), whereas the women experienced no significant change in FFM (0.0 ± 0.3 kg), FM (0.3 ± 0.4 kg), and %BF (0.1% ± 0.5%) (Table 1). These absolute differences in the response for these weight-stable men and women resulted in a significant time-by-sex interaction for FFM (P = .002), FM (P = .005), and %BF (P = .0006). Figure 1 shows the significant time-by-sex interaction for the relative change in FFM, FM, and %BF. The weight, BMI, waist circumference, and waist to hip ratio remained stable throughout the intervention period in both men and women.

Strength Indices

As expected, the men had greater total body strength than the women at baseline (352 ± 13 *v* 213 ± 9 kg, $P < .001$). RT-induced gains in absolute total strength were greater in men versus women (65 ± 7 *v* 46 ± 6 kg, P = .036). However, there was no difference in the gain in relative total strength between men and women (19% ± 2% *v* 23% ± 3%, P = .332).

Serum Lipid and Lipoprotein Response

At baseline, the women had higher HDL-C, a lower Chol/HDL-C ratio, and lower Tg than the men. Following RT, the

Table 1. Body Composition Measures for the Group of Older Men and Women

Measure	Men (n = 18) Baseline	Men (n = 18) Post-RT	Women (n = 17) Baseline	Women (n = 17) Post-RT
Age (yr)	62 ± 4 (56-69)		62 ± 5 (54-71)	
Height (cm)	175.9 ± 6.4		163.4 ± 4.8	
Weight (kg)	93.2 ± 2.6	93.3 ± 2.4	76.9 ± 1.9	77.3 ± 2.0
BMI (kg/m²)	30.2 ± 0.7	30.2 ± 0.6	28.8 ± 0.6	28.9 ± 0.6
%BF	34.5 ± 1.2	32.4 ± 1.0*†	45.6 ± 0.7	45.7 ± 0.9†
FM (kg)	32.3 ± 1.7	30.3 ± 1.3*†	35.1 ± 1.2	35.5 ± 1.4†
FFM (kg)	60.9 ± 1.7	63.0 ± 1.7*†	41.8 ± 1.0	41.9 ± 0.9†
Waist circumference (cm²)	99.9 ± 1.7	100.8 ± 1.7	103.9 ± 1.8	104.5 ± 1.6
Waist to hip ratio	0.95 ± 0.01	0.95 ± 0.01	0.94 ± 0.01	0.95 ± 0.01

NOTE. Values are the mean ± SEM.

*Significant change *v* baseline for each sex, $P < .05$.

†Significant time-by-sex interaction between changes in men and women, $P < .05$.

men had an increase in HDL-C of 0.06 ± 0.02 mmol/L (2.0 ± 0.8 mg/dL, $P = .03$) and the women had a decrease of 0.09 ± 0.03 mmol/L (3.4 ± 1.1 mg/dL, $P = .04$). There were no significant changes in Chol, LDL-C, and Tg for either men or women. As a result of the change in HDL-C and lack of change in Chol, the men had a decrease of 0.36 ± 0.11 in the Chol/HDL-C ratio ($P = .007$) and the women had an increase of 0.29 ± 0.10 ($P = .006$) (Table 2).The absolute difference in the response between men and women resulted in a significant time-by-sex interaction for HDL-C ($P = .0004$) and the Chol/HDL-C ratio ($P = .0001$). Figure 2 shows the relative difference between the changes in HDL-C and the Chol/HDL-C ratio and indicates the significant time-by-sex interactions.

Correlations

Correlation analyses were performed to assess the relationships between changes in the measures of body composition and changes in the lipoprotein-lipid profile (Table 3). For all 35 subjects combined, there was a negative correlation between the change in FFM and the change in the Chol/HDL-C ratio ($r = -.354$, $P = .037$), whereas the correlation between the change in %BF and the change in the Chol/HDL-C ratio showed a positive trend ($r = .299$, $P = .08$). Since the men and women showed different changes in body composition variables, correlation statistics were also used to examine the separate group responses. No significant correlation was observed between changes in the HDL-C and Chol/HDL-C ratio and changes in %BF, FM, and FFM for either men or women.

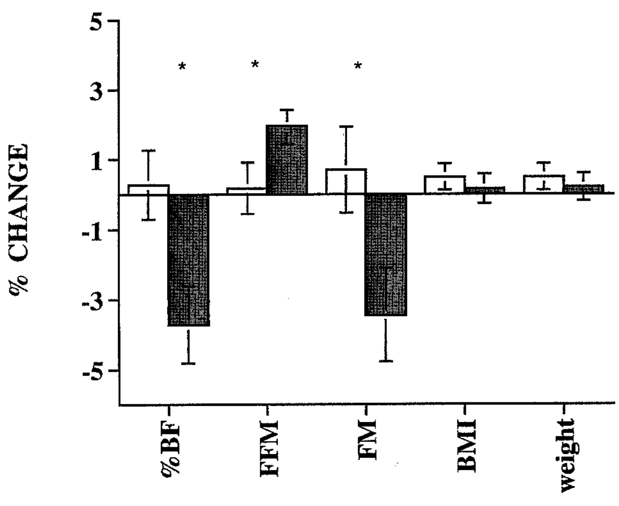

Fig 1. Comparison of relative change in body composition measures after 12 weeks of RT. (□) Women; (■) men. *Significant time-by-sex interaction, $P < .05$.

DISCUSSION

The results of this study demonstrate a gender-related difference in the response to RT in older individuals. The same relative intensity and duration of exercise produced a positive change in the body composition and lipoprotein-lipid profile in men, whereas there was a slight deterioration in the lipoprotein-lipid profile in women and no change in the body composition. Other investigators have reported the effect of RT on the body composition and lipoprotein-lipid profile in young or middle-aged men or women separately.[3,6-9,11-15,19,23] However, no study has compared the sex-specific response of these variables to RT.

The men had an increase in FFM and a decrease in %BF and FM, while the women showed no significant changes in any of these body composition variables. The reasons for the difference in the response for FM and %BF between the men and women are not readily apparent. The men may have exhibited a more favorable change in %BF and FM because lipolysis in fat cells is more sensitive to changes in energy expenditure in men versus women.[24,25] Kohrt et al[26] and Meijer et al[27] evaluated body composition and fat distribution in older men and women and observed that the absolute FM loss was larger in men after exposure to the same relative intensity and duration of aerobic training. Although the mode of exercise was different from the present study, the adaptations to the training regimens were similar. Therefore, irrespective of the type of training, women seem to have a more conservative response to mobilizing energy stores than men. To observe similar changes in FFM and FM in men and women with respect to RT, women may have to train for longer periods than men. In fact, a 1-year training study by Nelson et al[28] demonstrated that postmenopausal women respond to high-intensity RT by increasing FFM and decreasing FM.

The increase in FFM in men and not in women in this study may be attributed to the higher concentration of circulating

Table 2. Serum Lipid and Lipoprotein Concentrations in the Group of Older Men and Women

Variable	Men (n = 18)		Women (n = 17)	
	Baseline	Post-RT	Baseline	Post-RT
Chol				
mmol/L	4.97 + 0.16	4.94 + 0.18	5.53 + 0.28	5.55 + 0.28
mg/dL	192.1 ± 6.1	191.2 ± 6.9	213.7 ± 10.7	214.7 ± 10.7
HDL-C				
mmmol/L	0.92 + 0.04	0.98 + 0.04*†	1.38 + 0.07	1.29 + 0.08*†
mg/dL	35.6 ± 1.4	37.6 ± 1.6	53.2 ± 2.8	49.9 ± 2.6
LDL-C				
mmol/L	3.15 + 0.16	3.13 + 0.18	3.51 + 0.26	3.58 + 0.25
mg/dL	121.9 ± 6.1	121.2 ± 6.8	135.8 ± 10.2	138.6 ± 9.8
Tg				
mmol/L	4.47 + 0.49	4.20 + 0.43	3.18 + 0.32	3.39 + 0.36
mg/dL	172.9 ± 18.9	162.3 ± 16.5	122.9 ± 12.4	131.2 ± 13.80
Chol/HDL-C ratio	5.6 ± 0.3	5.2 ± 0.3*†	4.2 ± 0.3	4.5 ± 0.4*†

NOTE. Values are the mean ± SEM.

*Significant change *v* baseline for each sex, $P < .05$.

†Significant time-by-sex interaction between changes in men and women, $P < .05$.

anabolic hormones in men. Although we did not assess hormonal status in the present study, the lower concentration of testosterone normally observed in women and the consistent absence of an increase following RT may suggest why women typically do not achieve the same response as men.[29-32] However, the data for the RT-induced increase in circulating concentrations of anabolic hormones in men are equivocal.[29-35] Therefore, one cannot rule out the possibility that some physiologic process other than the concentration of circulating hormones is responsible for the different response between men and women exposed to the same relative intensity of exercise.

The present data also demonstrate that older men and women have distinctly different responses in the lipoprotein-lipid profile following a high-intensity RT protocol. Men showed a 5.7% increase in HDL-C that resulted in a 6.5% decrease in the Chol/HDL-C ratio, whereas women showed a 5.6% decrease in

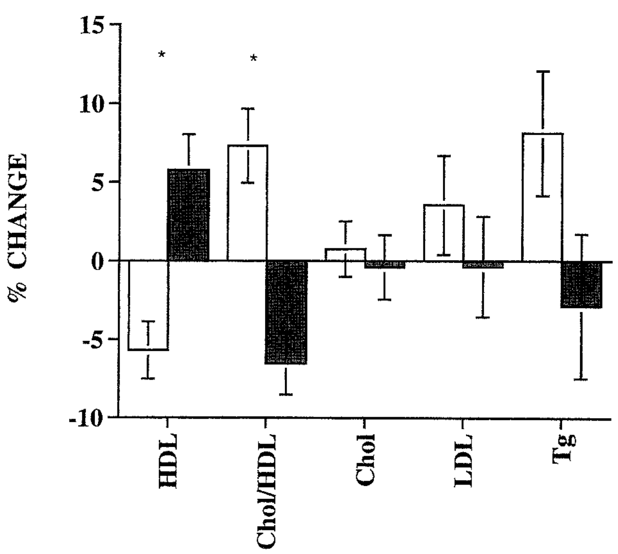

Fig 2. Comparison of relative change in serum lipids and lipoproteins after 12 weeks of RT. (□) Women; (■) men. *Significant time-by-sex interaction, $P < .05$.

HDL-C that resulted in a 7.3% increase in the Chol/HDL-C ratio. These results are in agreement with a study by Brownell et al,[36] who reported that young men and women responded differently to a 10-week exercise program that included cardiopulmonary conditioning, flexibility, and muscular strength and endurance exercises. They reported a 5.1% increase and a 1% decrease in HDL-C for men and women, respectively. Our study, as well as the study by Brownell et al,[36] also shows that when the data for men and women are combined, there is no effect of training on any measure of lipid or lipoprotein concentrations. Therefore, combining the responses for both men and women might obscure a sex-specific response to a particular exercise regimen.

One would suspect that the decrease in %BF and FM in men with the lack of a significant change in women was probably an important determinant of the sex-specific lipoprotein-lipid response in the present study. However, changes in HDL-C and the Chol/HDL-C ratio were not significantly related to any measure of body fat stores such as %BF or FM, although the relationship between the changes in %BF and the Chol/HDL-C

Table 3. Correlation of Changes in HDL-C and the Chol/HDL-C Ratio With Changes in %BF, FM, and FFM for All 35 Subjects Combined and for Men and Women Separately

Parameter	ΔHDL-C *r*	ΔHDL-C *P*	ΔChol/HDL-C Ratio *r*	ΔChol/HDL-C Ratio *P*
Δ%BF				
All subjects	−.17	.33	.30	.08
Men	.18	.47	−.07	.79
Women	.05	.85	.21	.41
ΔFM				
All subjects	−.20	.25	.28	.10
Men	.15	.54	−.15	.55
Women	−.004	.99	.31	.22
ΔFFM				
All subjects	.14	.42	−.35	.04
Men	−.25	.32	−.08	.75
Women	−.17	.52	−.06	.83

Abbreviation: Δ, change.

ratio showed a positive trend. These nonsignificant relationships were surprising given that various studies comparing plasma lipid and lipoprotein changes during weight loss by dieting or exercise concluded that changes in the measures of body composition are more important determinants of the lipoprotein-lipid profile than exercise per se.[1-3,5,9] In further support of the importance of the accompanying body composition changes, Poirier et al[6] and Fonong et al[37] reported that middle-aged men, older men, and postmenopausal women who responded to aerobic training without change in body composition did not show any changes in Chol, LDL-C, and HDL-C concentrations, despite a significant increase in peak O_2 consumption. Similar responses were demonstrated in middle-aged men after completing a RT program that did not result in changes in body fat stores.[13,14]

In contrast to these studies, other investigators concluded that the training-induced improvement in the lipoprotein-lipid profile was achieved without the accompanying change in body fat stores and that exercise per se may beneficially alter lipid metabolism. Hurley et al[12] and Goldberg et al[11] reported increases in HDL-C and decreases in the Chol/HDL-C ratio in young and middle-aged men following RT without any significant changes in body weight or %BF. Thompson et al[7,8] reported that the increase in HDL observed after aerobic training is associated with both the decrease in the fractional catabolic rate of HDL proteins and apolipoprotein A-1 and the increase in the synthetic rate of apolipoprotein A-1. Therefore, the possibility that RT might affect HDL-C metabolism, independently of changes in FM or FFM, by decreasing the catabolic rate of HDL protein and increasing the synthetic rate of HDL apolipoprotein A-1 cannot be completely ruled out.

With respect to the decrease in HDL-C and increase in the Chol/HDL-C ratio observed in the women, other researchers have documented similar changes in postmenopausal women after completion of a RT program.[15] Although Manning et al[15] reported no significant changes over time in an exercise group compared with a nonexercise control group, the data demonstrated a trend for a decrease in HDL-C (59 ± 4 to 54 ± 4 mg/dL) and an increase in the Chol/HDL-C ratio (3.6 ± 0.2 to 3.8 ± 0.3) in the RT-only group. In contrast, Goldberg et al[11] and Boyden et al[23] reported significant reductions in Chol and the Chol/HDL-C ratio in premenopausal women following RT. One factor that may account for the inconsistent results between premenopausal and postmenopausal women could be related to the availability of endogenous sex steroids.[4] In a cross-sectional study, Reaven et al[38] reported that postmenopausal women on estrogen therapy exhibited higher HDL-C concentrations compared with those not using estrogen, irrespective of the activity level.

The decrease in HDL-C and increase in the Chol/HDL-C ratio in the women is a surprising result. However, this should not be cited as a reason that older women should not perform RT. In fact, RT has been an effective therapeutic device to counter other physical and metabolic abnormalities such as a decrease in muscle mass and bone mineral density and a negative nitrogen balance.[16,39-41] Because fat cells in women are less sensitive to lipolysis than those in men,[24,25] a reduction in body fat stores due to exercise may require a longer duration, frequency, or intensity in postmenopausal women versus men. Aerobic training studies in men with a low HDL-C concentration showed a decreased HDL protein catabolic rate and an increased HDL apolipoprotein A-1 synthetic rate.[7,8] Whether the high baseline concentration of HDL-C observed in this postmenopausal population prevented a similar metabolic response is not known. However, it would be interesting to see if results similar to those in men are observed in women with a low baseline HDL-C concentration.

We realize that because of the small changes in HDL-C (2.0 ± 0.8 mg/dL in men and -3.4 ± 1.1 mg/dL in women) reported in the present study, other confounding variables such as seasonal, biological, and methodological variability[42,43] may minimize the effect of RT on lipoprotein-lipid changes, thereby making it difficult to interpret the true effect of the training stimulus. With regard to analytical error, the intraassay and interassay variability for HDL-C was 0.9% and 4.7%, respectively. The change in HDL-C for the men (5.7%) and women (−5.6%) was slightly higher than the interassay variability, leaving the possibility that methodological variability could account for some of the changes. The starting dates for the subjects were staggered and had a range from June 1995 to July 1996. Therefore, since the study was conducted during different seasons, we assume that the effects of seasonal variability on lipoprotein concentrations would be minimized. Given that the same analytical methods were used for all subjects and given the length of the study period, the fact that 67% of the men had an increase and 76% of the women had a decrease in HDL-C seems to suggest that the training stimulus affected the response. Despite these confounding variables, the changes observed in the present study are similar to previous reports in the literature. A meta-analysis of various exercise training studies reported a 3.3%, or 1.7-mg/dL, increase in the HDL-C concentration in weight-stable subjects (33 studies) and a 4.9%, or 2.3-mg/dL, increase in subjects who had a reduction in body weight while participating in an aerobic training program (19 studies).[44] Another meta-analysis of 27 training studies by Lokey and Tran[5] reported an average increase of 2.6%, or 1.5 mg/dL, in 379 young women (mean age, 29.5 years).

A major limitation of this study is the lack of a control group for either sex to determine whether the change was a result of the training stimulus. As noted by Manning et al,[15] both the RT and control groups had nonsignificant decreases in HDL-C over time, although the decrease was greater in the exercise group (5 *v* 2 mg/dL). However, the reason for the interaction in the present study was that the men had an increase while the women had a decrease in HDL-C concentrations. Therefore, more research is needed to evaluate the sex-specific effect of RT on the serum lipoprotein-lipid profile.

In summary, the results of this study demonstrate that older men and women who performed 12 weeks of RT at the same relative training intensity and duration responded differently in terms of changes in the body composition and lipoprotein-lipid profile. The men had an increase in FFM and a decrease in FM and %BF, while the women exhibited no measurable change in body composition. The men also had an increase in HDL-C and a decrease in the Chol/HDL-C ratio, while the women showed opposite changes. When both groups were combined, changes in the body composition were not significantly associated with the changes in HDL-C and the Chol/HDL-C ratio, underscoring the fact that RT, independently of changes in body fat stores, may alter the lipoprotein-lipid profile in previously sedentary, overweight older men and women.

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