Reported Exercise Patterns and Their Relationship to Lipid Levels Among Healthy Older Adults

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There have been few studies concerning the relationship between exercise habits and lipid levels of older adults. This study examines this relationship using data from 117 healthy older adults who volunteered to participate in a health promotion project. Responses to a seven-day activity recall questionnaire, percentage of body fat as measured by bioelectric impedance, age, and gender were used to predict total cholesterol, HDL, LDL, and triglyceride levels. Only the model predicting HDL was significant (R^2=.15, p = .002). Subsequent regression analyses predicting HDL levels were limited to persons who participated in one or more exercise sessions in the previous week. For these active women, the model's ability to predict HDL improved (R^2 = .37, p = .005), with exercise level having the greatest effect. For the active men, the model's predictive ability was not significant. The findings suggest that for active women, level of physical activity does modestly influence HDL levels.

Although the impact physical activity has on lipid levels has received considerable research attention, findings of these studies have been inconsistent (Butler and Goldberg 1989). Several cross-sectional studies report that individuals who are more active tend to have higher high-density lipoprotein cholesterol (HDL) and lower triglyceride

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levels (Haskell et al. 1980; Haskell 1984; Owens et al. 1990; Sallis et al. 1988; Wood et al. 1976). Haskell (1984) found that men who reported being moderately or highly active had significantly higher HDL levels than those who were inactive. Similarly, Owens et al. found that premenopausal women reporting weekly energy expenditures of 2,000 calories or greater had lower total cholesterol, lower triglycerides, and higher HDL than premenopausal women reporting less activity. A recent study of 863 Dutch men ages 65 to 84 reported a significant correlation between quartiles of total weekly energy expenditure and HDL levels (Caspersen et al. 1991). Other studies have failed to find a relationship. For example, the Framingham study found no association between activity levels and total cholesterol (Superko 1991).

Nevertheless, there are indications that activity does influence lipid levels and that relative levels of intensity and duration may be significant factors in the relationship between activity and lipid levels. Tucker and Friedman (1990) found that walking for exercise was associated with lower total cholesterol/HDL ratios only for individuals walking at least three to four hours per week. This investigation did not, however, attempt to quantify the intensity level of walking or total caloric expenditures. Other investigations that have shown a significant impact of exercise on lipids involved subjects reporting high levels of exercise intensity and weekly duration (e.g., trained competitive athletes) (Martin, Haskell, and Wood 1977; Wood et al. 1976; Rotkis et al. 1984; Marti et al. 1990).

A review of several studies that employed both cross-sectional and intervention designs suggests that a minimum of 10 miles per week of moderate-intensity jogging (or its equivalent) is necessary to increase HDL levels (Williams et al. 1982; Superko 1991). However, Cook et al. (1986) reported that the number of miles walked per week was correlated with HDL levels. The authors concluded that low-intensity, long-duration activity may have a positive influence on HDL levels. On the other hand, they also found that total weekly caloric expendi-

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ture was not significantly related to any lipid indices. Duncan, Gordon, and Scott (1991) had similar results in a study of sedentary women aged 20 to 40 who were divided into three intervention groups and a control group. The intervention groups walked the same number of miles per week but at varying levels of intensity. Surprisingly, both the highest- and lowest-intensity walkers showed a significant increase in HDL levels following the 24-week intervention. The moderate-intensity group showed no significant change.

A potential confounding effect in lipid studies is body composition (Marti et al. 1989; Marti et al. 1990; Wood et al. 1988). A meta-analysis of 95 exercise intervention studies conducted between 1955 and 1983 indicated that when the percentage of body fat remained constant, LDL levels fell an average of 7.3 mg/dl. (Tran and Weltman 1985). However, activity levels were assessed by a variety of methods, making overall conclusions difficult.

Another limitation of the existing research is that the populations studied often involve young or middle-aged Caucasian men. The Minnesota Heart Survey included individuals up to age 74 but did not report specifically on how activity patterns of the older age groups related to lipid levels (Folsom et al. 1985). A recent study of the Stanford Five-City Project included men and women aged 18 to 74. This study found that increases in physical activity levels were associated with increases in HDL levels for both sexes younger than 50 years old (Young et al. 1993). There was no significant relationship between activity level and total cholesterol. The Lipid Research Clinics Prevalence Study found higher HDL levels for both sexes aged 50 to 69 who reported engaging in vigorous activity at least three times per week, but the differences were not statistically significant (Haskell et al. 1980).

RESEARCH QUESTIONS

There have been few studies concerning the relationship between exercise habits and lipid levels of older adults, and even fewer for women and minorities. The issue of the weekly duration and intensity of exercise necessary to have a meaningful impact on lipid profiles is especially important for older adults, because this group generally exercises at lower intensity levels. This study addresses these gaps in the literature by examining the exercise habits and lipid profiles of a group of healthy older adults (aged 50-80 years) that includes a substantial number of women and African Americans.

The following specific research questions were addressed:

1. What is the relationship between self-reported exercise patterns and lipid levels in this group?
2. Are self-reported exercise patterns, gender, age, and body composition predictive of lipid levels?

Materials and Method

STUDY POPULATION

A sample of 117 healthy older adults (50-80 years old) who participated in a health promotion screening and intervention project served as subjects for this study. Volunteers were recruited through four inner-city churches and from advertisements placed in two local newspapers. Individuals who responded were screened to determine if they met a set of standard health status criteria necessary for participation in the project. The following self-reported chronic or debilitating medical conditions resulted in exclusion from enrollment in the project: severe hypertension or diabetes mellitus requiring treatment with medications, history of liver or kidney failure, frequent bleeding, severe anemia or sickle cell disease, history of angina pectoris, previous myocardial infarction, or a cancer diagnosis within the past year. Individuals were also excluded if they experienced chest or leg pain when walking fast or climbing stairs, had inadequate vision for reading a newspaper, or had inadequate hearing for use of a radio or telephone.

Finally, project participants who smoked or were taking estrogen or other hormonal medication were excluded from this analysis because smoking and these medications affect lipid levels. Thirty-nine participants were excluded on these criteria. Another 30 participants were excluded because they failed to complete a treadmill test (25 were excluded for either medical reasons or were unable to finish due to fatigue or leg pain, and 5 chose not to take the test).

EXERCISE HABIT MEASUREMENT

Data on exercise activity were collected through an interview at the screening site. A modification of Paffenbarger's Physical Activity Index Questionnaire (Paffenbarger, Wing, and Hyde 1978; Paffenbarger et al. 1984) was used to determine cardiovascular exercise activity (e.g., swimming, aerobics classes, walking, jogging, and cycling) for the past seven days. In addition to the type of exercise performed, participants were asked to estimate the duration of each activity and the number of times it was performed during the previous week. The modification involved inclusion of an intensity component for walking, jogging, and cycling. Individuals engaged in these activities were asked to estimate the distance covered during the exercise session.

Based on the self-reported exercise habits, a dichotomous classification was used to distinguish active and nonactive participants. Individuals who participated in one or more exercise sessions in the previous week were classified as "active," while individuals who had not exercised in the previous week were classified as "not active."

For active participants, the relative intensity at which cardiovascular activities were performed was estimated and expressed in metabolic equivalent (MET) levels according to published tables (Taylor et al. 1984; Wilson et al. 1986). For walking, jogging, and cycling, MET levels were based according to miles per hour. For activities where intensity levels are more difficult to determine (e.g., swimming), MET levels at the lower end of the published reference values were assigned on the assumption that older people are more likely to exercise at a lower intensity. In addition, because only a few individuals were involved in informal cardiovascular activities (e.g., gardening and housework) and because of the difficulty in quantifying the exercise intensity of these activities, informal cardiovascular activities were not included in these analyses.

Using the data from the seven-day activity recall, an exercise index (EI) score was calculated for each participant by multiplying each activity's frequency (number of days/week) times the duration (minutes/exercise session) times the exercise intensity level (MET). For example, an individual who reported walking five days per week for 60 minutes at four miles per hour (4.5 METS) would be assigned an EI score of 1,350 (i.e., $5 \times 60 \times 4.5 = 1{,}350$). For individuals participating in two or more exercise activities, the EI score was calculated by summing the scores of each activity.

To determine the representativeness of the previous week's activity, participants were asked, "How many days per week do you usually engage in planned exercise?" The correlation between the response to this question and the EI score was .70 ($p < .05$) for all participants and .58 ($p < .05$) for active participants, suggesting that reported activities were representative of usual exercise patterns.

LIPID MEASUREMENTS

Blood lipid levels of study participants were measured in the mornings following an at least eight-hour overnight fast. Enzymatic determination of total cholesterol and HDL was completed using Sigma Diagnostic Kit, Procedure #351. Triglyceride levels were determined using Sigma Diagnostic Kit, Procedure #336. LDL levels were calculated using the above measurements. All assays were performed with standards and controls; all reagents were from the Sigma Chemical Company. Cholesterol and triglyceride samples were read at 500 nm on a Beckman DU-8 Spectrophotometer (Beckman Instruments, Inc., Arlington Heights, IL). Assays were completed by a trained lab technician.

Based on measured total cholesterol/HDL ratios, participants were also categorized as either high or low risk for cardiovascular disease. Total cholesterol/HDL ratios greater than 4.5 were considered high risk; ratios equal to or less than 4.5 were considered low risk (Grundy et al. 1987).

BODY COMPOSITION ASSESSMENT

The body fat percentage of study participants was estimated by measurement of bioelectric impedance using a tetrapolar impedance plethysmograph (RJL Systems, Detroit). Previous studies have reported a high reliability and validity of this methodology to assess human body composition when compared to hydrodensitometry in groups of subjects aged 18 to 83 with a wide range of body fat percentages (Lukaski et al. 1985; Lukaski et al. 1986; Deurenberg et al. 1990). For the purposes of this study, body fat percentages less than 25% and 32% for men and women, respectively, were considered healthy (Nieman, 1990).

STATISTICAL METHODS

Independent *t* tests were performed to determine differences by gender, ethnicity, and active/nonactive status for total cholesterol, HDL, LDL, and triglycerides levels. Differences in the cholesterol levels of the three age decades were determined by one-way analysis of variance. A significance level of $p = .05$ was chosen to determine differences.

Regression analysis was used to examine the relationships of each lipid value to the measures of EI score, percentage of body fat, age, and gender. The lipid measures were used as the dependent variable, and the independent variables were EI score, percentage of body fat, age, and gender. Gender was used as a dummy variable (male = 0, female = 1). The standardized βs for the independent variables are provided in the results; "these coefficients are independent of the scales of measurement of the independent variables and may offer a comparison of the magnitude of the effects of the variables" (Freund, Littell, and Spector 1986: 26).

A second series of regression analyses also was completed. Because the literature suggested that relative levels of activity intensity and duration may play a significant role in influencing lipid levels, the above regression models were run using only active individuals.

Results

DEMOGRAPHICS

Demographics of the 117 participants are provided in Table 1. Most participants were active, and almost half had an unhealthy body fat percentage. In addition, the majority (68%) were married, more than half (55%) held baccalaureate or graduate degrees, and 75% had an annual household income of $25,000 or greater. There was a wide range in the duration and intensity of the exercise activities of the active participants. The mean and standard deviation of the EI scores

TABLE 1
Demographics

	Participants
n	117
Women (%)	56
African American (%)	36
Mean age (mean ± sd)	62 ± 7
Active[a] (%)	60
Healthy body fat[b] (%)	46

a. Active individuals have an EI score greater than 0.
b. For women, the percentage of body fat < 32. For men, the percentage of body fat < 25.

were 979.13 ± 937.35. The most frequent type of exercise reported was walking (41%), followed by calisthenics (21%), biking (15%), swimming (8%), jogging (7%), and racquet sports (7%).

GENDER COMPARISONS

Table 2 provides the lipid values for men and women. The only difference between men and women was in HDL values, with men having a lower average (46.5) than women (55.0). More men were active than women (75% vs. 48%), and men were more likely to have an acceptable percentage of body fat (67% vs. 30%). Although there was not a statistically significant difference by gender, 79% of the women and only 61% of the men were categorized as low risk for total cholesterol/HDL ratio.

ETHNIC COMPARISONS

No significant differences were found between African Americans and Caucasians for total cholesterol and LDL (see Table 2). African Americans had higher HDL levels and lower triglyceride levels than Caucasians. No difference was found between the groups for the total cholesterol/HDL ratio risk.

AGE DECADES COMPARISONS

No significant differences were found in the lipid values of the three age decades (see Table 2). The analysis also found no significant

TABLE 2
Mean Lipid Values

Participants	n	*Total Cholesterol* (Mean ± SD)	*HDL* (*Mean* ± SD)	*LDL* (*Mean* ± SD)	*Triglycerides* (*Mean* ± SD)
Total	112	188.5 ± 38.3	51.3 ± 15.6	115.1 ± 34.1	110.4 ± 67.6
Women	63	190.6 ± 38.6	55.0 ± 16.6*	114.2 ± 33.7	103.8 ± 70.7
Men	49	185.8 ± 38.1	46.5 ± 12.8	116.1 ± 34.9	118.9 ± 63.0
African American	41	188.7 ± 37.1	54.4 ± 16.9**	113.9 ± 35.3	91.26 ± 32.2**
Caucasian	67	188.9 ± 40.0	48.5 ± 13.0	115.6 ± 34.2	123.2 ± 81.3
Aged 50 to 59	45	187.4 ± 39.2	49.6 ± 12.0	114.9 ± 35.1	109.9 ± 62.7
Aged 60 to 69	54	189.6 ± 40.0	54.1 ± 18.5	114.1 ± 34.6	113.2 ± 77.1
Aged 70 to 80	13	187.4 ± 29.0	46.0 ± 10.8	119.8 ± 30.2	100.7 ± 37.3
Active	68	187.6 ± 37.4	50.8 ± 14.0	114.2 ± 33.5	113.4 ± 46.6
Nonactive	44	189.8 ± 40.0	52.1 ± 17.9	116.4 ± 35.3	105.8 ± 91.5

*Significant difference between women and men, $p \leq .05$.

**Significant difference between African Americans and Caucasians, $p \pm .05$.

differences in the activity status, body fat percentage category, or cholesterol ratio risk category by age decade.

ACTIVITY CLASSIFICATION COMPARISONS

No significant differences were found for the lipid levels (see Table 2) and the body fat percentage categories of the active and nonactive participants. Similarly, activity status had no impact on total cholesterol/HDL risk ratios.

REGRESSION ANALYSIS

Regression models were built for each of the four lipid values. In these models the EI score, the percentage of body fat, age, and gender were used as independent variables to predict each lipid value. Only one model proved to be significant, the model predicting HDL. Pearson correlation coefficients for HDL values and the EI score, percentage of body fat, age, and gender are provided in Table 3. A negative correlation was found between the percentage of body fat and the EI score (i.e., as EI scores increased, the percentage of body fat decreased). Gender was significantly correlated with HDL, the EI score,

TABLE 3
Correlations Between the Measures of High-Density Lipoprotein Cholesterol (HDL), Exercise Index Score, Percentage of Body Fat, Age, and Gender (n = 117)

	Pearson Correlation Coefficients			
	HDL	*Exercise Index Score*	*Body Fat (%)*	*Age*
Exercise index score	.11			
Body fat (%)	.05	–.31*		
Age	–.01	–.13	–.11	
Gender[a]	.27*	–.28*	.70*	.10

a. Male = 0, female = 1.
*$p \leq .05$.

TABLE 4
Results of Multiple Regression to Predict High-Density Lipoprotein Cholesterol (HDL) (n = 112)

Variable	b *Estimate*	*Standardized* β	t	p
Intercept	50.92	.00	3.44	< .01
Exercise index score	.003	.18	1.83	.07
Body fat (%)	–.48	–.28	–2.13	.04
Age	.06	.03	.29	.78
Gender[a]	16.51	.53	4.06	< .01

NOTE: $R^2 = .15$; $p = .002$.
a. Male = 0, female = 1.

and the percentage of body fat. Women tended to have higher HDL values, a higher percentage of body fat, and lower EI scores.

Table 4 presents the results of the regression analysis for the HDL model. The R^2 indicates that the model is not a powerful predictor of HDL values. The t values show that the independent variables of gender and the percentage of body fat are significant and that the EI score is of marginal significance to the model. The standardized βs indicate that gender has the greatest effect, followed by the percentage of body fat.

When the correlation and regression analyses were repeated using only active individuals, again only the HDL model proved to be significant. The results are presented in Tables 5 and 6. This regression model is a better predictor of HDL, $R^2 = .26$. Gender, the percentage of body fat, and the EI score are significant to the model. In this model,

TABLE 5

Correlations Between the Measures of High-Density Lipoprotein Cholesterol (HDL), Exercise Index Score, Percentage of Body Fat, Age, and Gender for Active Participants (n = 70)

	Pearson Correlation Coefficients			
	HDL	*Exercise Index Score*	*Body Fat (%)*	*Age*
Exercise index score	.22			
Body fat (%)	–.02	–.26*		
Age	.08	–.21	–.01	
Gender[a]	.30*	–.21	.66*	.07

a. Male = 0, female = 1.
*$p \leq .05$.

TABLE 6

Results of Multiple Regression to Predict High-Density Lipoprotein Cholesterol (HDL) for Active Participants (n = 68)

Variable	b *Estimate*	*Standardized* β	t	p
Intercept	44.86	.00	2.77	< .01
Exercise index score	.004	.27	2.35	.02
Body fat percentage	–.58	– .38	–2.39	.02
Age	.17	.09	.76	.45
Gender[a]	17.02	.61	3.96	< .01

NOTE: $R^2 = .26$; $p = .001$.
a. Male = 0, female = 1.

TABLE 7

Results of Multiple Regression to Predict High-Density Lipoprotein (HDL) for Active Participants by Gender

Variable	b *Estimate*	*Standardized* β	t	p
Women[a]				
Intercept	19.03	.00	.76	.46
Exercise index score	.01	.48	3.01	< .01
Body fat percentage	–.38	–.20	–1.27	.21
Age	.67	.33	2.08	.05
Men[b]				
Intercept	67.15	.00	3.08	< .01
Exercise index score	.002	.19	1.13	.27
Body fat percentage	–.69	–.31	–1.89	.07
Age	–.12	–.07	–.40	.69

a. $n = 31$; $R^2 = .37$; $p = .005$.
b. $n = 37$; $R^2 = .16$; $p = .130$.

the standardized βs were stronger. As in the previous model, gender was the most important predictor of HDL, followed by the percentage of body fat and the EI score. When this model was run separately for active men and active women, differences emerged (see Table 7). For the women, the model's ability to predict HDL improved ($R^2 = .37$), with EI score having the greatest effect, followed by age and the percentage of body fat. For the men, the model's predictive ability declined ($R^2 = .16$), with the percentage of body fat having the greatest effect, followed by EI score and age.

Discussion

The purpose of this study was to examine the relationship between older adults' exercise habits and lipid profiles. In general, study participants were healthy, well-educated, and economically secure. The majority (60%) had engaged in at least one aerobic exercise session during the preceding week. Women were less likely to be active than the men and more likely to have an unhealthy percentage of body fat. It is especially surprising that women had higher HDL levels than men, despite reporting lower activity levels and having a higher percentage in the unhealthy body fat category. This may reflect the relative importance of gender versus body composition and activity level. Although the total cholesterol averaged 188.5, an alarming number of individuals fell into the total cholesterol/HDL ratio's high-risk category (39% of the men and 21% of the women).

There were no differences found between the active and the nonactive participants for total cholesterol, HDL, LDL, and triglycerides. Although a significant correlation (–.31) was found for EI score and the percentage of body fat (i.e., the higher the EI score, the lower the percentage of body fat), only a marginal difference was found for the active and the nonactive groups for percentage of body fat. The wide variation in the frequency, duration, and intensity of the exercise performed by the active individuals may have led to these results. Many of the active individuals reported engaging in relatively short (15-20 minutes) sessions of low-intensity walking. The mean EI score of the active group was inflated due to a small number of extremely active males.

There are inherent methodological problems in assessing physical activity patterns. The seven-day activity recall employed in this study has been frequently used in population studies (Blair et al. 1985; Cauley et al. 1987). Other methodologies include the use of diaries or logs and recalls using longer periods of time (e.g., six months or a year). Although six-month and one-year recalls provide data over a longer period, they are subject to distortions of memory. This might be a major limitation when assessing older adults. In this investigation, a "usual activity" assessment was used in addition to the seven-day recall. The correlation between these two measures indicate that the short-term recall activities of this well-educated sample of volunteers reflect general patterns of activity.

The regression analyses to determine the relationship of self-reported exercise, gender, age, and body composition to the lipid levels proved to be the most informative about the relationship of activity and lipid levels. The regression models using EI score, gender, age, and percentage of body fat proved not to be predictive of total cholesterol, LDL, or triglyceride levels. The model predicting HDL level was significant but not a powerful predictor. However, when the analysis was limited to active individuals, the R^2 improved to .26. The EI score was also a significant predictor of HDL level, although gender and the percentage of body fat were the most important variables in the model. When the model was run separately for men and women, the model's predictive ability improved for the women and declined for the men. Further, in the women's model, EI score was the most important variable in the prediction of HDL level. In the men's model, EI score was second in importance. This suggests that for the active women of this sample, the level of physical activity does modestly influence HDL levels.

In a number of preceding studies, increased activity levels appear to have a beneficial impact on HDL levels. The findings of this study suggest that for healthy older adults, this beneficial impact is limited to women. The results also suggest that activity levels of older adults have little to no impact on the other lipid measures (total cholesterol, LDL, and triglycerides). This also has been generally supported in previous research such as the Framingham study (Superko 1991).

The finding that activity level was a predictor of HDL for active women but not active men was surprising. A number of suppositions could be offered to explain this finding. The study's activity questionnaire may be a more sensitive measure for women than for men; perhaps older women are more accurate when reporting the frequency, duration and intensity of their exercise habits. It may also be that the level of exercise needed to have a measurable impact on HDL levels is different for men and women. A recent report of healthy men aged 30 to 64 years found a "dose-response" relationship between number of miles run per week and HDL levels. Average HDL increased .3 mg/dl for each mile run; however, when compared to a sedentary group a statistically significant difference was found only for those subjects running seven or more miles per week (Kokkinos, Holland, Narayan, Colleran, Dotson and Papademetriou 1995). It may be that women have a lower "threshold" level or no "threshold" level; for women, modest levels of activity may have a positive impact on HDL.

In interpreting these findings, several limitations should be considered. First, study participants were healthy adult volunteers. Second, no adjustments were made for the possible impact of dietary intake on lipid values. Finally, being a cross-sectional study, the impact of changes in body composition or activity level on lipid levels cannot be determined. Despite these limitations, the study does provide information on the relationship between exercise and lipid levels in healthy older adults.

In conclusion, evidence from this and other studies suggests that physical activity is an important factor associated with blood lipids in active older women. From our data, it is not clear whether this relationship is mediational or causal. Future studies aimed at clarifying this relationship appear warranted.

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