Effect of Addition of Exercise to Therapeutic Lifestyle Changes Diet in Enabling Women and Men With Coronary Heart Disease to Reach Adult Treatment Panel III Low-Density Lipoprotein Cholesterol Goal Without Lowering High-Density Lipoprotein Cholesterol

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To reduce the risk for coronary heart disease, the Adult Treatment Panel III of the National Cholesterol Education Program has recommended a multifaceted lifestyle approach. The Therapeutic Lifestyle Changes (TLC) Diet has replaced the former Step 1 and Step 2 diets and consists of <7% saturated fat and <200 mg cholesterol for all subjects. The Adult Treatment Panel III guidelines recommend that if low-density lipoprotein (LDL) cholesterol is 100 to 129 mg/dl in subjects with coronary heart disease, drug treatment is optional, or if patients are already on drugs, no change in dose is necessary.1 To determine the additive effect of exercise to a TLC diet, we conducted a structured exercise and stress reduction program in subjects with coronary heart disease who were already following a TLC diet. Our hypotheses were: (1) that exercise and weight loss would result in significant reductions in LDL cholesterol and thus obviate the need to add or increase lipid-lowering medications; (2) that exercise and weight loss would result in reductions in triglyceride levels and thus prevent lowering of high-density lipoprotein (HDL) cholesterol in response to the TLC diet in women and men; and (3) that stress reduction and weight loss would have a beneficial effect on blood pressure.

All subjects had coronary heart disease documented as follows: (1) myocardial infarction with creatine kinase-MB more than twice the upper limit of normal; (2) positive exercise tolerance test, thallium scan, or coronary angiography with ≥1 narrowing of ≥50% in diameter <2 years from entry; (3) post-coronary artery bypass grafting <2 years but >4 weeks; and/or (4) percutaneous transluminal coronary artery angioplasty <2 years but >6 months. The Institutional Review Board approved the study, and the subjects gave informed consent.

Dietary recommendations were for <7% saturated fat and <200 mg of cholesterol per day. On the basis of exercise treadmill test results, each study subject received an exercise prescription for 30 to 60 minutes of aerobic exercise, 3 to 6 times per week at a minimum of 50% to 75% of age-predicted maximum or target heart rate. Study subjects underwent 3-hour sessions for 20 weeks; each session included 1 hour of therapeutic aerobic exercise, including upper extremity free weights, followed by yoga, meditation, and/or quiet reflection (relaxation response). Exercise was followed by a dinner with spouses or significant others. Cooking demonstrations taught preparation of low fat, heart-healthy meals, and recipes were distributed. Dinner was followed by a 1-hour educational lecture and discussions that provided information on nutrition and exercise in the prevention of coronary heart disease and skills necessary for behavioral and lifestyle changes.

At baseline and 6 months, the following were recorded: weight, body mass index, waist-hip ratio, heart rate at rest, systolic and diastolic blood pressure in duplicate, fasting lipid profile, grams of fat in the diet, 5-day food records, number of anginal episodes, minutes of exercise, relaxation response, and yoga per week. METs were determined during a graded exercise treadmill test using the Bruce protocol. Plasma levels of lipids were measured by enzymatic procedures as previously described.2 The coefficient of variation ranged from 2% to 5% within and between runs, respectively. Results are expressed as mean ± SD. Continuous variables were compared with 2-tailed paired t tests. Triglyceride values were log transformed to attain a normal distribution. Spearman correlation coefficients were determined. A p value <0.05 was considered significant.

Of 27 subjects (21 men, 6 women), 16 (59%) were receiving lipid-lowering drugs; however, no change in dose occurred during the 6-month period. At baseline, mean saturated fat intake constituted 6.9% of total calories (consistent with a TLC diet) and decreased to 3.9% at 6 months. Table 1 shows changes in diet, exercise, and angina. Exercise duration measured by supervised treadmill testing increased 18.2% (p = 0.02), and METs increased 13.1% (p = 0.03). The number of minutes of exercise per week increased 119.9% (p <.0001) and averaged 30 minutes daily.
The number of anginal episodes per week decreased from a mean of 7.0 ± 1.5 at baseline to 3.0 ± 0.5 at 6 months (p = 0.02).

Compared with baseline, mean LDL cholesterol and triglycerides decreased 9.3% (p = 0.018) and 18.8% (p < 0.05), respectively; mean HDL cholesterol increased 2.6% (p = NS), and mean systolic and diastolic blood pressure decreased 9% (p = 0.001) and 13%, respectively (p < 0.0001) (Table 2). The total cholesterol to HDL cholesterol ratio decreased from 5.2 ± 1.6 to 4.6 ± 1.0 (p = 0.10). Forty-four percent of subjects achieved a LDL cholesterol ≤100 mg/dl, an additional 15% achieved a LDL cholesterol between 101 and 106 mg/dl, and an additional 30% achieved a LDL cholesterol between 106 and 125 mg/dl. Women had a 12.3% reduction in LDL cholesterol and an 11.4% increase in HDL cholesterol compared with a 7.9% reduction in LDL cholesterol and no change in HDL cholesterol in men (Table 3). Blood pressure reductions were similar in women and men (Table 3).

Those who achieved an LDL cholesterol ≤100 mg/dl at 6 months exercised significantly more on a weekly basis at baseline (147 ± 100 vs 58 ± 86 minutes, respectively, p = 0.02), had a significantly longer exercise treadmill time at 6-month follow-up (12.4 ± 1.7 vs 9.8 ± 1.9 minutes, respectively, p = 0.013), and weighed an average of 20 pounds less (187 ± 50 vs 206 ± 60 lbs, respectively, p = 0.03) compared with those whose LDL cholesterol levels remained >100 mg/dl at 6-month follow-up (data not shown).

LDL cholesterol change ranged from a 39% reduction to a 26% increase (Figure 1). HDL cholesterol change ranged from a 39% increase to a 25% reduction. Triglyceride change ranged from a 57% increase to a 46% increase. Systolic blood pressure decreased in all but 3 subjects with a range from a 20% reduction to a 5% increase (Figure 2). Diastolic blood pressure decreased in all subjects with a minimal decrease of 2.4% and maximal decrease of 26%. All but 5 subjects lost weight with a range from a 1.6% increase to a 12% reduction in body weight (Figure 2).

At 6-month follow-up, percent changes in triglyceride and LDL cholesterol levels and diastolic blood pressure were directly correlated with a percent change in weight (p = 0.02, r = 0.501; p = 0.03, r = 0.476; p = 0.03, r = 0.475, respectively). The percent change in minutes of weekly exercise was inversely correlated with percent changes in LDL cholesterol and triglyceride levels (p = 0.02, r = −0.486; p = 0.02, r = −0.456, respectively), diastolic blood pressure (p = 0.02, r = −0.645), and directly correlated with HDL cholesterol level (p = 0.001, r = 0.793), whereas the further reduction in saturated fat was not correlated with lipid level changes. Percent change in systolic blood pressure was inversely correlated with time spent in the relaxation response (p = 0.03, r = −0.551). In multiple linear regression analysis, minutes of weekly exercise were of borderline significance in independently predicting reduction in LDL cholesterol (p = 0.19), whereas the further decrease in saturated fat content was not predictive.

In the present study, the addition of an average of 30 minutes daily exercise to a TLC diet enabled 89% of subjects to reach an acceptable LDL cholesterol (<130 mg/dl) at 6 months, thus obviating the need to add or increase lipid-lowering medications in this group. Many patients with coronary heart disease have LDL cholesterol levels in the range of 100 to 129 mg/dl (mean baseline LDL cholesterol in present study was 118 mg/dl). Our findings provide support for the use of exercise and weight loss in achieving LDL cholesterol goal in this group. Of the 10 patients with a baseline LDL cholesterol >130 mg/dl, 4 decreased their LDL cholesterol to ≤125 mg/dl and 3 patients decreased their levels to ≤100 mg/dl; thus,
this lifestyle program minimized or avoided drugs even in this higher LDL cholesterol group.

Low fat diets are most effective in lowering LDL cholesterol when combined with weight loss. In our study, weight loss was correlated with reductions in LDL cholesterol and triglyceride levels and diastolic blood pressure, whereas the decrease in saturated fat intake from 6.9% to 3.9% was not. Thus, it is important for practitioners to emphasize weight reduction and exercise as goals of dietary counseling to enable patients to achieve optimal changes in lipid levels and blood pressure.

The amount of weekly exercise was extremely important in the present study because it was associated with reductions in levels of LDL cholesterol, triglyceride, and blood pressure and increases in HDL cholesterol levels. In addition, HDL cholesterol was directly correlated with minutes of weekly exercise at 6-month follow-up; therefore, the lack of decrease in HDL cholesterol levels appears to be related to duration of exercise. Our exercise program emphasized moderate exercise (brisk walking, slow jogging, and stationery exercise bicycling) that averaged 30 minutes daily, which can be achieved by most patients with coronary heart disease.

The substitution of polyunsaturated fatty acids

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**TABLE 3** Baseline and Six-Month Values by Gender

<table>
<thead>
<tr>
<th></th>
<th>Women (n = 6)</th>
<th>Men (n = 21)</th>
<th>p Value*</th>
<th>p Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>55.5 ± 7.8</td>
<td>62.4 ± 5.8</td>
<td>0.09</td>
<td>0.02</td>
</tr>
<tr>
<td>Caloric intake (kcal/d)</td>
<td>1415 ± 332</td>
<td>1917 ± 322</td>
<td>0.09</td>
<td>0.04</td>
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<tr>
<td>Total fat (g)</td>
<td>32.6 ± 11.5</td>
<td>49.2 ± 19.5</td>
<td>0.04</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Saturated fat (g)</td>
<td>9.8 ± 3.8</td>
<td>15.4 ± 7.9</td>
<td>0.11</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Body weight (lbs)</td>
<td>174 ± 21</td>
<td>205 ± 61</td>
<td>0.10</td>
<td>0.31</td>
</tr>
<tr>
<td>Body mass index</td>
<td>30.1 ± 4.2</td>
<td>30.3 ± 6.9</td>
<td>0.12</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Treadmill exercise time (min)</td>
<td>7.2 ± 2.1</td>
<td>9.2 ± 2.3</td>
<td>0.70</td>
<td>0.0008</td>
</tr>
<tr>
<td>Mversations (min/ wk)</td>
<td>47 ± 76</td>
<td>112 ± 104</td>
<td>0.07</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>HDL cholesterol (mg/dl)</td>
<td>44 ± 7</td>
<td>36 ± 10</td>
<td>0.12</td>
<td>0.98</td>
</tr>
<tr>
<td>LDL cholesterol (mg/dl)</td>
<td>130 ± 52</td>
<td>114 ± 25</td>
<td>0.29</td>
<td>0.03</td>
</tr>
<tr>
<td>Triglycerides (mg/dl)</td>
<td>205 ± 153</td>
<td>174 ± 109</td>
<td>0.29</td>
<td>0.13</td>
</tr>
<tr>
<td>Systolic blood pressure (mm Hg)</td>
<td>142 ± 11</td>
<td>131 ± 10</td>
<td>0.02</td>
<td>0.0003</td>
</tr>
<tr>
<td>Diastolic blood pressure (mm Hg)</td>
<td>84 ± 6</td>
<td>83 ± 7</td>
<td>0.008</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Data presented as mean ± SD.

*p Value for 6-month values compared with baseline value.

†p Value for 6-month values for men compared with women.

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**FIGURE 1.** Individual variability in LDL cholesterol (LDL-C), HDL cholesterol (HDL-C), and triglyceride concentrations (plotted as percent change) in response to exercise, weight loss, and TLC diet in men and women.

**FIGURE 2.** Individual variability in systolic and diastolic blood pressure and weight (plotted as percent change) in response to exercise, weight loss, and TLC diet in men and women.
or carbohydrates for saturated fat in low fat diets lowers HDL cholesterol, especially when body weight is maintained. After 6 months and 1 year on a Step 2 diet, women had greater HDL cholesterol reductions than men. Because there is an inverse relation between low HDL cholesterol levels and the development of coronary heart disease, the lowering of HDL cholesterol levels on low fat diets has been a major concern. The 11.4% increase in HDL cholesterol in women in the present study suggests that exercise can prevent lowering of HDL cholesterol in women on a low fat diet; thus, this program may be particularly important to women.

The blood pressure reductions in the present study were twofold greater than in the total population in the Diet and Systolic Hypertension study (DASH), in which subjects with high-normal or stage 1 hypertension were randomized to isocaloric diets either rich in fruit, vegetables, and low-fat dairy products with reduced saturated and total fat (treatment diet) or low in fruit, vegetables, and dairy products with a fat content typical of the average US diet (control diet). Subjects in the DASH study did not lose weight or undergo an exercise or stress reduction program; therefore, the greater reductions in blood pressure in the present study may have resulted from exercise, weight loss, and stress management. Additional benefits of our program include a 50% reduction in angina.

In summary, the addition of an average of 30 minutes daily exercise to a TLC diet resulted in 89% of subjects reaching acceptable LDL cholesterol goals, without lowering HDL cholesterol, and obviated the need to add or increase lipid-lowering medications. Our results should encourage practitioners to prescribe exercise and weight loss, in addition to a TLC diet, to achieve LDL cholesterol goals. Our results also provide substantial information about the optimal way to carry out a lifestyle modification program.