Prescribing Exercise at Varied Levels of Intensity and Frequency

A Randomized Trial

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Background: Regular physical activity produces beneficial effects on health, but the exercise prescription needed to improve cardiovascular disease risk factors in free-living sedentary individuals remains unclear.

Methods: Sedentary adults (N = 492, 64.0% women) were randomized to 1 of 4 exercise-counseling conditions or to a physician advice comparison group. The duration (30 minutes) and type (walking) of exercise were held constant, while exercise intensity and frequency were manipulated to form 4 exercise prescriptions: moderate intensity–low frequency, moderate intensity–high frequency (HiF), hard intensity (HardI)–low frequency, and HardI–HiF. Comparison group participants received physician advice and written materials regarding recommended levels of exercise for health. Outcomes included 6- and 24-month changes in cardiorespiratory fitness (maximum oxygen consumption), high-density lipoprotein cholesterol (HDL-C) level, and the total cholesterol–HDL-C ratio.

Results: At 6 months, the HardI–HiF, HardI–low-frequency, and moderate-intensity–HiF conditions demonstrated significant increases in maximum oxygen consumption (P < .01 for all), but only the HardI–HiF condition showed significant improvements in HDL-C level (P < .03), total cholesterol–HDL-C ratio (P < .04), and maximum oxygen consumption (P < .01) compared with physician advice. At 24 months, the increases in maximum oxygen consumption remained significantly higher than baseline in the HardI–HiF, HardI–low-frequency, and moderate-intensity–HiF conditions and in the HardI–HiF group compared with physician advice (P < .01 for all), but no significant effects on HDL-C level (P = .57) or total cholesterol–HDL-C ratio (P = .64) were observed.

Conclusions: Exercise counseling with a prescription for walking at either a HardI or a HiF produced significant long-term improvements in cardiorespiratory fitness. More exercise or the combination of HardI plus HiF exercise may provide additional benefits, including larger fitness changes and improved lipid profiles.

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The health benefits of engaging in regular physical activity have been well established.1-5 However, most US adults are not sufficiently active regularly, and 26% are not active at all.6 Guidelines recommended by the American Heart Association,7 the Centers for Disease Control and Prevention/American College of Sports Medicine,8 and the US Surgeon General9 suggest that the accumulation of 30 minutes of moderate-intensity (ModI) physical activity on most days of the week will produce significant health benefits. The reports supporting these guidelines also describe a dose-response relationship between physical activity and health outcomes. Moderate-intensity (45%-60% of heart rate reserve [HRres]) activities completed on as few as 3 d/wk may produce observable changes in disease risk factors, and greater benefits generally accrue from engaging in exercise of greater intensity or volume.7,9 Indeed, recent analyses10,11 of the dose-response issue affirm an inverse and generally linear relationship between physical activity and cardiovascular disease (CVD)–related morbidity and mortality. However, because of the large variability in adherence that occurs when individuals are advised to perform unsupervised exercise in their natural environments, the exercise prescription required to produce beneficial changes in CVD risk factors among free-living sedentary adults requires further research.12

See also pages 2324 and 2355
The present study examines the effects of 4 exercise-counseling prescriptions, varied in intensity (“moderate” [45%-55% HRres] vs “hard” [65%-75% HRres]) and frequency (“low” [3-4 d/wk] vs “high” [5-7 d/wk]), on selected CVD risk factors compared with a control group that received exercise advice from a physician without programmatic counseling. Our primary objective was to test the hypothesis that exercise counseling with a prescription for hard-intensity (HardI) and/or high-frequency (HiF) exercise would produce significantly greater improvements in maximum oxygen consumption (VO2max), high-density lipoprotein cholesterol (HDL-C) level, and total cholesterol (TC)–HDL-C ratio, when compared with the physician advice (PA) group.

**METHODS**

**STUDY POPULATION**

This single-center randomized trial, approved by the Institutional Review Board of the University of Florida, was conducted from May 1, 1998, to April 30, 2003. Participants were 492 healthy but sedentary women (n=313) and men (n=177), recruited primarily through advertisements. Eligibility requirements included age (30-69 years), sedentary lifestyle (<1 h/wk of ModI or greater leisure time physical activity during the prior year), body mass index (calculated as weight in kilograms divided by the square of height in meters) (19-45), and normal resting blood pressure (<140/90 mm Hg, with or without medication). Following telephone screening, potentially eligible persons attended an informational meeting during which informed consent was obtained. Potential participants completed a medical history, exercise testing, and laboratory measures of endocrine, hematological, and metabolic function. Individuals with abnormal findings were excluded from participation. Five cohorts of approximately 100 participants were recruited and randomized at 3- to 4-month intervals.

**STUDY MEASURES**

The primary outcome measures were VO2max, HDL-C level, and TC/HDL-C ratio. These variables were selected because increases in cardiorespiratory fitness and improved blood lipid profile, particularly increases in HDL-C level, likely contribute to the protective effects of physical activity against CVDs.13,14

Study measurements were taken at 3 assessment periods (baseline, 6 months, and 24 months). Participants performed a graded treadmill exercise test to volitional fatigue, according to the Bruce protocol.15 Participants were required to meet 2 of 3 standard criteria for having achieved VO2max (ie, HR, age-predicted maximum HR or greater; respiratory exchange ratio ≥1.10; or rating of perceived exertion ≥19). Pulmonary gas exchange variables were measured continuously using a metabolic cart (TrueMax 2400; ParvoMedics, Inc, Sandy, Utah). Pulmonary ventilation (calculated in liters per minute) was measured by a pneumotachygraph that was calibrated daily and fractions of oxygen and carbon dioxide via analyzers that were calibrated with gases of known concentration before each test. The HR was measured by a continuous 12-lead electrocardiogram. The maximal HR was taken as the highest value recorded during or immediately following exercise, and VO2max was defined as the average of two 30-second values measured during the last minute of exercise. Resting HR was taken as the average of 3 seated measurements, performed and averaged over 2 different days. The HRres was calculated as the difference between maximal HR and resting HR. At each assessment period, a fasting blood sample was collected on 2 separate days, and average values were used in data analyses. Lipid and lipoprotein profiles were analyzed at the University of Florida’s Clinical Chemistry Laboratory, using methods recommended by the National Cholesterol Education Program. The coefficients of variation for TC in this laboratory, which is accredited by the College of American Pathologists, are less than 3%. More specifically, at a control level of 133 mg/dL (3.44 mmol/L), the coefficient of variation was 1.04%, and at a control level of 242 mg/dL (6.26 mmol/L), the coefficient of variation was 1.12%.

**EXPERIMENTAL DESIGN**

Following stratification by age and sex, participants were randomly assigned to the PA comparison group or to 1 of the 4 exercise-counseling conditions: ModI–low frequency (LowF), ModI–HiF, hard intensity (HardI)–LowF, or HardI–HiF. The computerized randomization was performed using SAS statistical software (PROC PLAN).16

**EXERCISE COUNSELING**

**Exercise Prescriptions**

Participants in the counseling conditions were provided individualized training HR zones (THRZs) using specific percentages of HRres derived from their baseline graded treadmill exercise test performances. The THRZs corresponded to 45% to 55% HRres in the ModI conditions and 65% to 75% HRres in the HardI conditions. Participants in the LowF conditions were asked to walk 3 to 4 d/wk, while those in the HiF conditions were asked to walk 5 to 7 d/wk. Each participant was provided a HR monitor (Polar Beat; Polar, Inc, Port Washington, NY), and was instructed to wear the monitor during each exercise session and to record the most frequently observed HR in a log. Participants were instructed to adjust their pace of walking to intensity levels consistent with their prescribed THRZs for 30 min/d for the prescribed number of days per week. The walking could occur at home, at a work site, or at other walking-friendly sites in sessions of 10 minutes or longer.

**Counseling Sessions**

Participants followed a standard exercise intervention program based on a modified version of the protocol used by Dunn et al.12 The intervention was delivered in 2 phases: an exercise adoption phase that included 11 group sessions over 6 months and an exercise maintenance phase that included 6 quarterly group sessions over the remaining 18 months. The intervention included goal setting, self-monitoring, problem solving, cognitive reframing (ie, substituting positive self-statements for negative ones), and didactic presentations on topics such as proper techniques for warm-ups and cooldowns and the avoidance of exercise-related injuries.

**Training Logs**

Participants were instructed in the use of daily training logs for self-monitoring of the duration, intensity, and frequency of exercise. To corroborate self-reported HR values recorded during exercise sessions, each participant was asked to complete a 30-minute walk on 3 separate occasions while wearing a recordable HR monitor. The stored data were later down-
loaded, and the percentage of time that the participant’s exercise HR was within the prescribed THRZ was calculated. In the ModI conditions, 88% of the exercise sessions showed mean HRs within the prescribed THRZ, 2% were below prescription, and 10% exceeded the prescription. In the HardI conditions, 71% of the sessions had mean HRs within the prescribed THRZ, 6% exceeded the prescribed intensity, and 23% were below prescription, as previously reported.18

PHYSICIAN ADVICE

Participants assigned to the PA condition received one 90-minute group session of advice from a physician member of the investigative team (M.C.L.) who described the benefits and risks of physical activity, presented detailed recommendations for exercise, and distributed copies of an American Heart Association booklet.19 The participants were instructed on how to measure HR, and they were advised to accumulate 30 minutes of ModI exercise on 5 d/wk or more. The group did not receive HR monitors or activity logs. The participants met as a group quarterly, with the same physician (M.C.L.) who conducted an informal 3-minute question-and-answer session regarding exercise and encouraged adherence to the American Heart Association recommendations. A guest speaker then presented a 45-minute lecture on a health topic unrelated to CVD or exercise.

STATISTICAL ANALYSES

The data were evaluated with analysis of variance procedures using SAS statistical software (PROC GLM).10 The effects of conditions during the exercise adoption phase were examined using an analysis that included only those participants with baseline and 6-month data. The long-term effects of the treatment conditions were examined using an intent-to-treat procedure, substituting baseline values for missing 24-month data. Best-case analyses were given as mean±SD unless otherwise indicated.

RESULTS

BASELINE CHARACTERISTICS

A total of 2165 people made telephone inquiries about the study, and 877 underwent screening for eligibility. The criteria for participation were met by 553 individuals, and 492 accepted randomization into the study. The sample included 315 women and 177 men. The ethnic/racial makeup was 76.4% white (not of Hispanic origin), 15.9% African American (not of Hispanic origin), 4.1% Hispanic, 2.6% Asian American or Pacific Islander, and 1.0% American Indian or Alaskan native. The age of the sample was 48.4±8.7 years, and the years of education were 15.1±3.3. Of the participants, 75.0% were in the lowest quartile of fitness based on age- and sex-adjusted norms. The baseline characteristics (Table 1) were similar for all conditions (P>.05 for all); however, among women, the between-group difference in body mass index approached significance (P<.06).

ATTENDANCE AND ADHERENCE

The overall rates of attendance (71.4%±21.2%) at counseling sessions were equivalent across conditions. At 6 months, 411 participants (83.3% of those randomized) returned for repeated measurement, and at 24 months, 342 participants (69.5%) returned for final assessments. The rates of return were equivalent across conditions. Data from the daily training logs were used to examine adherence to the exercise prescriptions during the exercise adoption phase of the study. As expected, the HiF prescriptions resulted in more exercise completed over 6 months than the LowF prescriptions (95±65 min/wk for ModI-HiF and 88±55 min/wk for HardI-HiF vs 63±33 min/wk for ModI-LowF and 51±35 min/wk for HardI-LowF; P<.001 for each). When viewed as percentages of prescribed exercise completed, similar levels of adherence were observed for exercise prescribed at a low or HiF (62.7% vs 60.9%), but the ModI prescriptions produced greater adherence than did the HardI prescriptions (65.8% vs 57.8%; P<.03). Most exercise sessions (83.9%) were completed in sessions that were 20 minutes or longer, and there were no significant between-group differences in the use of shorter sessions (P>.10 for all).

VOLUME OF EXERCISE

The volume (metabolic equivalent hours per week) of exercise completed by participants in the exercise-counseling conditions was calculated as follows: [mean weekly hours of exercise × assigned intensity (using the lower end of the target HRres zone, ie, 45% for ModI and 65% for HardI)) × VO2max (expressed as milliliters per kilogram per minute)]/3.5. The metabolic equivalent hours per week of exercise per condition were 6.77±1.76 for HardI-HiF, 5.02±1.09 for ModI-HiF, 4.00±0.92 for HardI-LowF, and 3.64±0.81 for ModI-LowF. All 4 conditions differed significantly from each other with respect to volume of exercise completed (P<.05 for all).

CARDIORESPIRATORY FITNESS

Table 2 contains the 6-month changes in fitness expressed in absolute values (liters per minute). The analysis of variance conducted on the percentage change from baseline (Figure) indicated a significant treatment effect (P<.001). Significant increases in VO2max were observed in the HardI-HiF, HardI-LowF, and ModI-HiF conditions (P<.01 for each). In addition, the HardI-HiF condition produced a significantly greater change in VO2max compared with the ModI-LowF and PA groups (P<.01). Planned contrasts showed significantly greater improvements for the HardI plus HiF prescriptions vs PA (P<.01 for each) and for the combination of HardI plus HiF vs PA (P<.001).
The analysis of variance conducted on the percentage change from baseline to 24 months (Figure) also showed a significant treatment effect (P<.01). Significant improvements from baseline were observed in the HardI-HiF, HardI-LowF, and ModI-HiF conditions (P<.01 for each), and the HardI-HiF condition demonstrated a significantly greater increase in VO₂max compared with the ModI-LowF and HardI-LowF conditions (Table 2). Planned contrasts showed that only the HardI-HiF condition improved significantly compared with the PA group for percentage change from baseline to 6 months in HDL-C level (3.88±1.20 mg/dL [0.10±0.03 mmol/L] vs 0.99±1.07 mg/dL [0.03±0.03 mmol/L], respectively; P<.03) and TC/HDL-C ratio (−3.32±0.92 vs 0.78±1.15, respectively; P<.04). There were no significant treatment effects on percentage change from baseline to 24 months for any of the lipid or lipoprotein variables (P>.20 for all), and all planned comparisons failed to show significant effects (P>.20 for all) (Table 3). In addition, the exercise conditions did not show significant changes in body weight (P=.78), blood pressure (P=.26), diastolic blood pressure (P=.21), or blood glucose levels (P=.44).

**Table 1. Select Baseline Characteristics of Men and Women in the Study Sample**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>HardI-HiF</th>
<th>ModI-HiF</th>
<th>HardI-LowF</th>
<th>ModI-LowF</th>
<th>PA</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of subjects</td>
<td>38</td>
<td>38</td>
<td>30</td>
<td>37</td>
<td>34</td>
</tr>
<tr>
<td>Age, y</td>
<td>51.5±9.8</td>
<td>49.0±8.2</td>
<td>52.3±10.1</td>
<td>49.1±8.0</td>
<td>51.1±10.7</td>
</tr>
<tr>
<td>BMI</td>
<td>28.9±5.2</td>
<td>28.6±4.3</td>
<td>28.2±4.1</td>
<td>28.5±4.1</td>
<td>27.6±4.6</td>
</tr>
<tr>
<td>VO₂max, mL/kg/min</td>
<td>29.6±6.5</td>
<td>29.2±5.0</td>
<td>29.6±7.2</td>
<td>29.7±4.3</td>
<td>30.0±5.5</td>
</tr>
<tr>
<td>TC, mg/dL</td>
<td>188.8±30.3</td>
<td>196.7±23.5</td>
<td>197.2±27.3</td>
<td>199.1±25.3</td>
<td>194.9±25.1</td>
</tr>
<tr>
<td>LDL-C, mg/dL</td>
<td>116.8±23.1</td>
<td>123.4±20.7</td>
<td>124.3±24.9</td>
<td>126.9±22.6</td>
<td>120.4±21.9</td>
</tr>
<tr>
<td>HDL-C, mg/dL</td>
<td>45.2±9.8</td>
<td>43.3±7.4</td>
<td>46.6±8.4</td>
<td>44.2±10.8</td>
<td>48.3±11.0</td>
</tr>
<tr>
<td>TG, mg/dL</td>
<td>130.3±78.6</td>
<td>150.9±64.1</td>
<td>131.6±59.6</td>
<td>142.8±80.6</td>
<td>130.7±73.7</td>
</tr>
<tr>
<td>FBG, mg/dL</td>
<td>88.4±7.1</td>
<td>88.8±8.2</td>
<td>88.3±6.3</td>
<td>90.8±8.5</td>
<td>87.4±6.3</td>
</tr>
<tr>
<td>SBP, mm Hg</td>
<td>118.7±10.1</td>
<td>118.9±11.5</td>
<td>116.4±10.7</td>
<td>120.5±11.1</td>
<td>118.7±11.8</td>
</tr>
<tr>
<td>DBP, mm Hg</td>
<td>76.9±7.6</td>
<td>77.2±7.0</td>
<td>76.2±6.4</td>
<td>79.2±6.9</td>
<td>75.8±7.4</td>
</tr>
</tbody>
</table>

**Table 3** contains the 24-month changes in fitness expressed in absolute values.

**LIPIDS, LIPOPROTEINS, AND OTHER MEASURES**

Analyses of variance conducted on percentage change from baseline to 6 months indicated a significant treatment effect on TC/HDL-C ratio (P=.05) but no significant effects of treatment on TC (P=.51), LDL-C (P=.68), or HDL-C (P=.13) (Table 2). Planned contrasts showed that only the HardI-HiF condition failed to show significant effects (P>.20 for all). For more detailed information, see the “Baseline Characteristics” subsection of “Results” section.©2005 American Medical Association. All rights reserved.
Table 2. Observed Values for Cardiorespiratory Fitness and for Lipoproteins and Lipids at Baseline and Change From Baseline to 6 Months by Condition

<table>
<thead>
<tr>
<th>Variable</th>
<th>Condition*</th>
<th>Condition*</th>
<th>Condition*</th>
<th>Condition*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HardI-HiF</td>
<td>ModI-HiF</td>
<td>HardI-LowF</td>
<td>ModI-LowF</td>
</tr>
<tr>
<td></td>
<td>(n = 86)</td>
<td>(n = 94)</td>
<td>(n = 80)</td>
<td>(n = 73)</td>
</tr>
<tr>
<td>V˙O₂max, L/min</td>
<td>Baseline</td>
<td>2.09 ± 0.69</td>
<td>2.04 ± 0.59</td>
<td>2.03 ± 0.58</td>
</tr>
<tr>
<td></td>
<td>Change</td>
<td>0.15 ± 0.24</td>
<td>0.08 ± 0.15</td>
<td>0.07 ± 0.18</td>
</tr>
<tr>
<td>TC, mg/dL</td>
<td>Baseline</td>
<td>193.4 ± 37.7</td>
<td>192.5 ± 29.2</td>
<td>189.8 ± 28.6</td>
</tr>
<tr>
<td></td>
<td>Change</td>
<td>−1.3 ± 18.0</td>
<td>0.9 ± 15.9</td>
<td>−0.5 ± 16.3</td>
</tr>
<tr>
<td>LDL-C, mg/dL</td>
<td>Baseline</td>
<td>115.5 ± 28.4</td>
<td>114.3 ± 26.4</td>
<td>114.5 ± 25.9</td>
</tr>
<tr>
<td></td>
<td>Change</td>
<td>−2.2 ± 14.4</td>
<td>1.0 ± 14.3</td>
<td>−0.8 ± 13.8</td>
</tr>
<tr>
<td>HDL-C, mg/dL</td>
<td>Baseline</td>
<td>52.13 ± 12.21</td>
<td>54.49 ± 14.93</td>
<td>53.47 ± 11.49</td>
</tr>
<tr>
<td></td>
<td>Change</td>
<td>1.83 ± 6.11</td>
<td>0.54 ± 6.43</td>
<td>−0.09 ± 5.55</td>
</tr>
<tr>
<td>TC/HDL-C ratio</td>
<td>Baseline</td>
<td>3.89 ± 1.09</td>
<td>3.78 ± 1.09</td>
<td>3.71 ± 0.95</td>
</tr>
<tr>
<td></td>
<td>Change</td>
<td>−0.12 ± 0.33</td>
<td>0.04 ± 0.55</td>
<td>−0.02 ± 0.46</td>
</tr>
<tr>
<td>TG, mg/dL</td>
<td>Baseline</td>
<td>124.8 ± 74.0</td>
<td>119.0 ± 59.4</td>
<td>108.3 ± 52.5</td>
</tr>
<tr>
<td></td>
<td>Change</td>
<td>−6.9 ± 40.7</td>
<td>8.4 ± 46.6</td>
<td>2.4 ± 29.4</td>
</tr>
</tbody>
</table>

Abbreviations: See Table 1.  
SI conversion factors: See Table 1.  
*Data are given as mean ± SD. The HardI-HiF, HardI-LowF, and ModI-HiF conditions demonstrated significant increases in V˙O₂max (P < .01), but only the HardI-HiF condition showed significant improvements in HDL-C level, TC/HDL-C ratio, and V˙O₂max, compared with the PA and ModI-LowF groups (P < .01 for each). For more details, see the “Cardiorespiratory Fitness” and “Lipids, Lipoproteins, and Other Measures” subsections of the “Results” section.  
†Significant (P < .01) change from baseline.  
‡Significant (P < .01) change compared with the ModI-LowF condition.  
§Significant (P < .01) change compared with the PA condition.

Figure. Mean ± SEM change in maximum oxygen consumption (V˙O₂max) (measured in liters per minute) from baseline to 6 months (A) and from baseline to 24 months (B) according to treatment condition. At the 6- and 24-month evaluations, the HardI-HiF, HardI-LowF, and ModI-HiF conditions demonstrated significant increases in V˙O₂max (P < .01), but only the HardI-HiF condition showed a significant improvement compared with the PA and ModI-LowF groups (P < .01 for each). For more details, see the “Cardiorespiratory Fitness” subsection of the “Results” section. HardI indicates hard intensity; HiF, high frequency; LowF, low frequency; ModI, moderate intensity; PA, physician advice; asterisk, a significant change from baseline (P < .01); dagger, a significant change compared with the ModI-LowF condition (P < .01); and double dagger, a significant change compared with the PA condition (P < .01).
combination of HardI plus HiF exercise was the only prescription that produced proximal changes in lipoprotein profile and long-term changes in fitness.

The effects of exercise prescriptions on cardiorespiratory fitness represent an important clinical research issue because many of the health benefits associated with increased physical activity are related to changes in fitness.4,5,21,22 Efficacy studies, conducted in closely controlled settings, show that supervised training regimens of HardI exercise produce greater improvements in cardiorespiratory fitness than lower-intensity activities.10 However, to our knowledge, the exercise prescription required to improve fitness in free-living sedentary adults has not been established, due in large part to the variability in adherence that occurs when individuals are counseled to perform unsupervised exercise in their natural environment.11 Indeed, the amounts of exercise recorded by our participants, who completed unsupervised walking in their home or work environments, were considerably lower than the levels prescribed. During the exercise adoption phase, participants completed approximately 57% to 70% of the minimum amounts prescribed. Furthermore, the percentage of prescribed exercise completed varied as a function of intensity, with lower adherence in the HardI groups. Thus, taking the observed adherence levels into account, the significant improvements in cardiorespiratory fitness in this sample were accomplished by the addition of approximately 60 to 90 min/wk of brisk walking or 90 min/wk of leisurely paced walking.

Compared with the PA group, significant improvements in fitness and lipoprotein outcomes at 6 months were achieved by prescribing the combination of HardI plus HiF exercise. This prescription also resulted in the highest volume of exercise completed. However, because of the nature of our experimental design, wherein intensity and frequency were manipulated while duration was held constant, we did not have a condition that achieved the same volume as the HardI-HiF group through ModI exercise. Consequently, we cannot determine whether the superior performance of this group was because of the combination of HardI-HiF exercise or the greater volume of exercise completed. In a 24-month study of home-based exercise in older adults, King et al13 controlled for volume and intensity of exercise (but not frequency or duration), and found greater improvement in fitness for high- vs low-intensity exercise.

Our findings suggest that various combinations of intensity and frequency may be used to achieve increases in fitness.12,24 However, when counseling sedentary adults to increase their physical activity, the differential between the amount of exercise prescribed and the amount likely to be completed must be taken into account. Counseling adults to perform 30 min/d of ModI exercise on 3 to 4 d/wk is unlikely to produce a volume of exercise sufficient to reach the threshold required for fitness changes. Consistent with the US Surgeon General’s report,9 our findings suggest that when recommending ModI exercise to free-living adults, a prescription for 30 min/d on 5 d/wk or more seems necessary to achieve measurable benefits.

The intensity and frequency of exercise required to produce a favorable response in blood lipids remains unclear. A review14 of 28 randomized studies that used ModI to HardI physical activity in interventions of 12 weeks or longer showed a large variability in lipid response, with significant increases in HDL-C level (mean, 4.6%) observed in approximately 40% of the trials. The HardI-HiF prescription in our study was the only intervention to produce a significant proximal effect on HDL-C level (mean, 3.9%) compared with the PA group. Although adherence was lower in the HardI conditions compared with the ModI conditions, the volume of exercise was significantly greater in the HardI-HiF vs ModI-HiF condition (6.77 vs 5.02 metabolic equivalent h/wk) and in the HardI-LowF vs ModI-LowF condition (4.00 vs 3.64 metabolic equivalent h/wk). Our findings are simi-

<table>
<thead>
<tr>
<th>Variable</th>
<th>Condition*</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>HardI-HiF (n = 102)</td>
</tr>
<tr>
<td>V̇O₂max, L/min</td>
<td>2.03 ± 0.70</td>
</tr>
<tr>
<td>Change</td>
<td>0.10 ± 0.21†‡§</td>
</tr>
<tr>
<td>HDL-C, mg/dL</td>
<td>53.37 ± 12.94</td>
</tr>
<tr>
<td>Change</td>
<td>0.18 ± 6.59</td>
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<tr>
<td>TC/HDL-C ratio</td>
<td>3.79 ± 1.07</td>
</tr>
<tr>
<td>Change</td>
<td>0.05 ± 0.45</td>
</tr>
</tbody>
</table>

Abbreviations: See Table 1.
SI conversion factors: See Table 1.
*Data are given as mean ± SD. The HardI-HiF, HardI-LowF, and ModI-HiF conditions demonstrated significant increases in V̇O₂max (P < .01), but only the HardI-HiF condition showed a significant improvement compared with the PA and ModI-LowF groups (P < .01 for each). For more details, see the ‘Cardiorespiratory Fitness’ and ‘Lipids, Lipoproteins, and Other Measures’ subsections of the ‘Results’ section.
†Significant (P < .01) change from baseline.
‡Significant (P < .01) change compared with the ModI-LowF condition.
§Significant (P < .01) change compared with the PA condition.
lar to those of Kraus et al,25 who observed significant increases in HDL-C level over 8 months for high-intensity–high-volume exercise but not for high-intensity–low-volume or low-intensity–low-volume exercise. Thus, changes in HDL-C level may depend on the intensity, frequency, and volume of exercise and on the individual’s baseline level.14,24,25 The effect of the HardI-HiF prescription on HDL-C level was not observed at 24 months. As exercise adherence diminished during the 2-year course of the study, the volume of physical activity may have decreased below the threshold required for an observable benefit.14,24

In conclusion, this study provides important information about the effects of counseling free-living sedentary adults to exercise at different levels of intensity and frequency. The findings demonstrate that significant improvements in cardiorespiratory fitness can be achieved and maintained over 24 months via exercise counseling with a prescription for walking 30 min/d, either at a ModI (45%-55% HRres) 5 to 7 d/wk or at a HardI (65%-75% HRres) 3 to 4 d/wk. Additional benefits, including larger changes in fitness and increases in HDL-C level, may be achieved by prescribing either more exercise or the combination of HardI plus HiF exercise.

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Author Contributions: Dr Perri had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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