The Efficacy of Exercise as an Aid for Smoking Cessation in Women
A Randomized Controlled Trial

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Background: Smoking prevalence rates among women are declining at a slower rate than among men.

Objective: To determine if exercise, a healthful alternative to smoking, enhances the achievement and maintenance of smoking cessation.

Methods: Two hundred eighty-one healthy, sedentary female smokers were randomly assigned to either a cognitive-behavioral smoking cessation program with vigorous exercise (exercise) or to the same program with equal staff contact time (control). Subjects participated in a 12-session, group-based smoking cessation program. Additionally, exercise subjects were required to attend 3 supervised exercise sessions per week and control subjects were required to participate in 3 supervised health education lectures per week. Abstinence from smoking was based on self-report, was verified by saliva cotinine level, and was measured at 1 week after quit day (week 5), end of treatment (week 12), and 3 and 12 months later (20 and 60 weeks after quit day, respectively).

Results: Compared with control subjects (n = 147), exercise subjects (n = 134) achieved significantly higher levels of continuous abstinence at the end of treatment (19.4% vs 10.2%, P = .03) and 3 months (16.4% vs 8.2%, P = .03) and 12 months (11.9% vs 5.4%, P = .05) following treatment. Exercise subjects had significantly increased functional capacity (estimated V̇O₂ peak, 25 ± 6 to 28 ± 6, P < .01) and had gained less weight by the end of treatment (3.05 vs 5.40 kg, P = .03).

Conclusions: Vigorous exercise facilitates short- and longer-term smoking cessation in women when combined with a cognitive-behavioral smoking cessation program. Vigorous exercise improves exercise capacity and delays weight gain following smoking cessation.

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Despite reductions in smoking prevalence over the last 25 years, tobacco use remains a leading preventable cause of such chronic diseases as coronary heart disease, cancer, emphysema, bronchitis, and respiratory infections in both men and women. However, smoking prevalence rates among women are declining at a slower rate than among men. Men and women have similar rates of attempting to quit smoking, but men are able to refrain from tobacco use for longer periods. This has prompted requests for smoking cessation programs designed specifically for women. Sex-specific variables, such as concerns about weight gain, the belief that smoking reduces stress, and the need for social support, have been identified as particularly relevant to smoking cessation programs for women.

Participation in regular, vigorous physical exercise is an alternative to smoking that may aid cessation efforts among female smokers. Exercise may address psychosocial and physiological needs that cannot be achieved with nicotine replacement therapy alone. For example, exercise may help to attenuate depressed affect and to reduce tension in the group of women smokers characterized as “negative-affect” smokers. Regular exercise also increases energy expenditure, thereby helping to offset the transient increase in energy intake and decrease in metabolic rate that is reported during smoking cessation. For these reasons, exercise may reduce the fear of weight gain, a motivator for continued smoking and relapse. This concern is more prevalent in female than male smokers. Direct treatment of the fear of weight gain and...
METHODS

SUBJECTS AND RANDOMIZATION

This randomized controlled trial compared the efficacy of a 12-week program of vigorous aerobic exercise with a contact control in promoting smoking cessation and reducing weight gain among female smokers enrolled in a 12-week cognitive-behavioral smoking cessation program. Continuous abstinence, 7-day point prevalence abstinence (PPA) (defined as total abstinence for 7 days \( V(O_2) \)), and weight were measured at the end of treatment and 3 and 12 months after the end of treatment. Exercise capacity was assessed before and after the treatment program.

Healthy sedentary women aged 18 to 65 years who had regularly smoked 10 or more cigarettes a day for at least 3 years and who had exercised less than twice a week for at least 6 months were recruited into the study through newspaper advertisements. Exclusion criteria included current or planned use of nicotine replacement therapy, medical problems, or use of medications that would make compliance with the study protocol difficult or dangerous. Women with a current psychiatric illness, alcohol abuse, or another substance abuse problem were also excluded. Subjects obtained written consent from their physicians to participate in both maximal exercise testing and regular physical activity and then were randomly assigned to either of the 2 investigational conditions. The randomization code for group assignment was generated by a computer program. The study was approved by the institutional review board of The Miriam Hospital, Providence, RI, and subjects provided written consent to participate in the research procedures. A detailed description of the rationale for the Commit to Quit study and its design, including recruitment information, is presented elsewhere.

ASSESSMENT

Subjects completed a graded maximal exercise test performed on a stationary bicycle prior to randomization. This test was used to screen participants, to determine fitness level at baseline, and to calculate an exercise prescription. Electrocardiograms were obtained at the end of every minute during exercise, at peak exercise, and at 1, 3, 5, and 10 minutes of recovery. The testing protocol consisted of 2-minute stages beginning with a zero-load warm-up and increasing by 25-W increments until the subject was unable to maintain a pedaling rate of 50 rpm. Blood pressure was measured during seated rest, at the end of each stage, at peak, immediately after exercise, and at 3 and 10 minutes of recovery. Ratings of perceived exertion were obtained at the end of each stage and at peak exercise. Subjects were given a 2-minute active recovery interval, during which they pedaled at zero load. This was followed by sitting at rest until their heart rates were within 15% of baseline or until 10 minutes had elapsed. The graded maximal exercise test was repeated after 12 weeks of treatment. Functional capacity, expressed as estimated peak oxygen consumption per unit time \( V(O_2) \), was used to determine if participation in the exercise condition produced a training effect.

Body weight and height were measured at the beginning, middle, and end of the program and at each follow-up using a calibrated scale; subjects were clothed in examination gowns. Percentage of body fat was estimated from skinfold thickness measured on the right side at the triceps, suprailiac crest, and thigh using a Lange caliper. Waist measurement was obtained at the smallest circumference of the torso. Hip circumference was determined at the widest level of the buttocks. Psychosocial questionnaires were administered before and after treatment and at each follow-up.

TREATMENT

Smoking Cessation Program

All subjects participated in a group-based smoking cessation program consisting of a 12-session, cognitive-behavioral program designed for women. Traditional cognitive-behavioral topics (eg, self-monitoring, stimulus control, coping with cravings and high-risk situations, stress management, and relaxation techniques) were included along with topics of particular importance to women (eg, healthy eating, weight management, mood management, and managing work and family). To ensure standard administration of the program, written manuals for both therapists and subjects were used and followed at all times.

Exercise Condition

An exercise prescription was calculated for subjects in the exercise condition using the peak heart rate achieved on the

RESULTS

SUBJECTS

A total of 1647 women were screened by telephone to determine initial eligibility. Of these, 757 were deemed ineligible (385 had health conditions, 165 were regular exercisers, 43 had psychiatric conditions, and 164 had a variety of other problems that precluded participation). Six hundred nine were eligible but chose not to participate (236 had schedule conflicts and 373 were not interested). The remaining 281 were randomized. The trial was conducted in 9 cohorts of approximately 30 subjects, half in the contact control condition and half in the exercise condition. Table 1 shows the demographic data and smok-
baseline exercise test. The target heart rate range for training the exercise subjects was resting heart rate plus 60% to 85% of heart rate reserve. Subjects were instructed to exercise in a perceived exertion range of somewhat hard to hard, which corresponds to a training intensity of 60% to 85% of functional capacity. Exercise subjects began the 12-week exercise program 3 weeks before the quit date of the smoking cessation program and were required to attend 3 exercise sessions per week. The exercise sessions consisted of a 5-minute warm-up, 30 to 40 minutes of aerobic activity, and a 3-minute cool-down period with stretching. The sessions were supervised by an exercise specialist, who documented the subjects’ heart rates and perceived exertion levels during each exercise session.

**Contact Control Condition**

Subjects in the contact control condition began the 12-week wellness program 3 weeks before the quit date of the smoking cessation program. Control subjects were required to participate in three 45- to 60-minute supervised sessions per week. Lectures, handouts, films, and discussions addressed a variety of women’s health and lifestyle issues, such as healthy eating and prevention of cancer and cardiovascular disease. Control subjects were instructed not to adopt a program of regular, vigorous exercise until the treatment portion of the study was completed. This protocol was previously pilot-tested to ensure its acceptability.

**MEASURES OF OUTCOME**

Self-report of the number of cigarettes smoked daily was collected weekly during the 12-week program and 3 and 12 months after treatment. Carbon monoxide in end-expiratory air after breath was held for 15 to 20 seconds was measured with a carbon monoxide analyzer weekly during treatment, at the end of the treatment phase (12 weeks), and at the follow-up visits. The main outcome analyses and power calculations were based on achievement of 7-day PPA. Quit status was verified with carbon monoxide (cutoff, 8 ppm) and saliva cotinine (cutoff, 57 nmol/L [10 ng/mL]) levels, which were measured 1 week after the quit day (week 5), at the end of treatment, and 3 and 12 months after treatment. To be considered abstinent, subjects needed to have a carbon monoxide level less than 8 ppm and a cotinine level less than 57 nmol/L. Continuous abstinence from quit day (week 4) to end of treatment (8 weeks later) and 3 and 12 months after treatment (20 and 60 weeks after quit day, respectively) was evaluated to examine sustained cessation. Continuous abstinence relates more directly to health outcomes than 7-day PPA, however, since none of the studies on smoking and exercise reported continuous abstinence rates, it was not possible to estimate the sample size needed. Thus, while continuous abstinence is of primary importance, it is here considered as a secondary analysis. Smoking relapse rates (days of abstinence from quit day to first cigarette) were also analyzed. Weight gain was defined as change in weight from baseline to the assessment period. For the analyses on weight change, continuous abstinence rather than 7-day PPA was used as the marker for quit status, since 7-day PPA has been shown to underestimate actual weight gain as a result of smoking cessation.

**STATISTICAL ANALYSIS**

The trial was designed to randomize 125 subjects to each intervention group to have 75 in each group at the end of 12 months of follow-up. A total sample size of 150 at 12 months was projected to provide a power of 80% (α = 0.05) and to detect a 21% net difference in smoking rates between the 2 groups. Analyses were conducted by intent to treat, with participants analyzed according to the initial randomized assignments. All tests of hypotheses and reported P values are 2-sided. Analysis of variance (ANOVA) and the χ² test were used to test for differences in baseline characteristics and to analyze 7-day PPA and continuous outcomes by treatment group. Logistic regression was used to model relapse rates by treatment condition. Weight gain by treatment assignment and continual quit status was assessed using ANOVA. For smoking outcomes, subjects were considered to be smokers if they did not provide information at a given assessment session. However, data for the analyses on weight change were limited to actual observations at each of the assessment points. We used ANOVA to analyze change in functional capacity by treatment group. Functional capacity was measured at the baseline and 12-week end-of-treatment assessments. We used χ² tests to determine whether there was differential dropout between treatment groups at the end of treatment and after 3 and 12 months of follow-up.

**ADHERENCE**

Control subjects attended an average of 72.2% of the smoking cessation sessions and 69.0% of the contact sessions. Exercise subjects attended an average of 69.6% of the smoking cessation sessions and 67.3% of the exercise training sessions. There was no differential loss to follow-up. Of those randomized, 64.6% of control subjects and 68.7% of exercise subjects returned at end of treatment (P = .47). At the 3-month follow-up, 46.9% of control subjects and 58.2% of exercise subjects returned (P = .06); at the 12-month follow-up, 50.3% of control subjects and 56.0% of exercise subjects returned (P = .35).

**EXERCISE PERFORMANCE**

The training heart rate in the exercise subjects averaged 63.7% (SD, 14.3%) of their mean heart rate reserve (83% of maximum heart rate). Among those attending the posttreatment exercise assessment (n = 146), the estimated V̇O₂ peak increased significantly with training in the exercise subjects (25 ± 6 mL/kg per minute at baseline, 28 ± 6 mL/kg per minute at end of treatment; P < .01; n = 75) but was unchanged in the control subjects (25 ± 4 mL/kg per minute at baseline, 25 ± 5 mL/kg per minute at end of treatment; P = .62; n = 71).
SMOKING OUTCOME

Following the 12 weeks of treatment (8 weeks after quit day), 30.6% of exercise subjects had 7-day PPA, compared with 21.8% of control subjects (P = .09). For the 3-month follow-up (20 weeks after quit day), 24.6% of exercise subjects had 7-day PPA, as opposed to 13.6% of control subjects (P = .02). At the 12-month follow-up (60 weeks after quit day), 19.4% of exercise subjects had 7-day PPA, compared with 13.6% in control subjects (P = .19) (Table 2).

Exercise subjects were significantly more likely than control subjects to be continuously abstinent during the 8 weeks of treatment following quit day (19.4% vs 10.2%, P = .03) (Figure 1 and Table 2). In addition, exercise subjects were significantly more likely than control subjects to achieve 20 and 60 weeks of continuous abstinence following quit day (20 weeks: 16.4% vs 8.2%, P = .03; 60 weeks: 11.9% vs 5.4%, P = .05). Exercise subjects achieved significantly more days of continuous abstinence than control subjects at the end of treatment (mean ± SD, 30.1 ± 26.4 vs 17.3 ± 22.4 days, P < .01), at 3 months after treatment (65.9 ± 69.4 vs 36.0 ± 56.6 days, P < .01), and at 12 months after treatment (127.1 ± 164.1 vs 69.6 ± 130.9 days, P < .01).

Multiple logistic regression analyses were conducted to determine the efficacy of treatment condition while adjusting for program attendance. Odds ratios derived from the analyses revealed that the exercise subjects were 35% less likely to have relapsed at the end of treatment (8 weeks after quit day) (95% confidence interval [CI], 16%-75%; P < .01), 34% less likely to have relapsed 3 months after treatment (95% CI, 15%-78%; P = .01), and 36% less likely to have relapsed 12 months after treatment (95% CI, 14%-91%; P = .03). Additionally, the number of smoking cessation sessions attended was negatively correlated with and highly predictive of smoking relapse at the end of treatment and 3 and 12 months following treatment (−0.33, −0.30, and −0.27, respectively). The greater the number of smoking cessation sessions attended, the less likely that a relapse would occur (P < .01). The Hosmer-Lemeshow statistics for the end-of-treatment, 3-month, and 12-month models indicate that the models are a good fit to the data.
This study demonstrates that vigorous exercise, as part of a comprehensive cognitive-behavioral treatment of cigarette smoking, leads to improved rates of continuous abstinence from smoking in young to middle-aged female smokers who averaged more than a pack of cigarettes per day for more than 20 years. The differences between those who exercised and their controls were evident 8 weeks after their assigned quit date, and the differential was maintained after 3 and 12 months.

Additionally, there was significantly less weight gain for exercise subjects who had been continuously abstinent at the end of treatment. This is consistent with the findings of other studies that increased participation in physical activity attenuates weight gain after smoking cessation. Concern about weight gain after quitting is prevalent among women and may act as a barrier to cessation attempts. Weight control interventions during smoking cessation have been unsuccessful in preventing weight gain and have also been associated with a greater risk of smoking relapse. This has led experts in smoking cessation to test treatments that help ex-smokers accept rather than fight weight gain. Thus, an intervention effective for smoking cessation that also minimizes weight gain would offer a major advantage. Exercise seems to have that potential, even though the differences observed were moderate and the effect seems to be limited to the period subjects participate in the exercise intervention.

The effect of a longer treatment period on weight gain and the effect seems to be limited to the period subjects participate in the exercise intervention. This is consistent with the findings of other studies that increased participation in physical activity during the follow-up period of the study.

**WEIGHT GAIN**

**Figure 2** shows the average amount of weight gained by treatment condition and by quit status in relation to target quit date. All available data were used for analyses at each time point. No imputation of weight data was performed for missing data. Quitters gained significantly more weight than nonquitters after 2, 8, 20, and 60 weeks (P < .01 for each) of continuous abstinence. Among quitters, exercise subjects had gained significantly less weight than control subjects at the end of treatment (3.05 ± 3.43 vs 5.40 ± 6.94 kg, P = .03) (Figure 2). This treatment effect did not hold for the 2 follow-up periods (Table 3).

**Table 3. Mean Weight Gain by Quit Status and Group**

<table>
<thead>
<tr>
<th>Time After Quit Day, wk</th>
<th>Control Group</th>
<th>Exercise Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not Quit</td>
<td>Quit</td>
</tr>
<tr>
<td>Treatment phase 2</td>
<td>1.02 ± 1.6 [67]</td>
<td>1.85 ± 2.2 [27]</td>
</tr>
<tr>
<td>8</td>
<td>1.13 ± 2.0 [73]</td>
<td>5.36 ± 6.9 [13]</td>
</tr>
<tr>
<td>60</td>
<td>0.72 ± 4.4 [57]</td>
<td>5.76 ± 12.6 [6]</td>
</tr>
</tbody>
</table>

*Within each week, means with different letters are significantly different in paired comparisons using the Tukey honest significant difference method.*

Exercise participation once the 12 weeks of treatment ended, others did not participate in physical activity at the frequency, duration, and/or intensity necessary to help with weight loss or weight loss maintenance. Self-report of physical activity during the maintenance phase does not appear to be a sufficient measure of actual behavior.

The average weight at baseline was significantly higher in the exercise group than in the control group. Research suggests that women who weigh more are more concerned about their weight and thus may be less motivated to quit smoking, given the known relationship between quitting smoking and gaining weight. In addition, research indicates that the heavier the baseline weight, the greater the weight gain after smoking cessation. Thus, the fact that exercise subjects weighed more than control subjects at baseline may have attenuated the effects of the exercise intervention on cessation rates and weight gain.

In addition to assisting with smoking cessation and delaying weight gain, exercise may also have advantages that complement existing treatments or cannot be provided by other strategies to prevent relapse. Self-confidence may be enhanced, since subjects could attribute their success to their own effort rather than to other agents (eg, pharmacologic agents). Exercise is also effective in modulating depression and is a beneficial strategy for managing stress.

These benefits of exercise may have helped the exercise subjects proceed from 7-day PPA to continuous abstinence more successfully than the control subjects. For example, at the end of treatment there was no significant difference between groups in 7-day PPA, but there was a significant difference in continuous abstinence. Perhaps the smoking cessation treatment combined with the contact provided in the contact control wellness program was sufficient to help participants achieve 7 days of abstinence, but the stress, mood, and weight control aspects of the exercise program were what helped exercise subjects maintain continuous abstinence following their quit day at significantly higher rates.

Adherence to exercise training, like most other adjuncts to smoking cessation treatments, including nicotine replacement therapies, is difficult. The exercise program evaluated in this study was intentionally designed to investigate efficacy under controlled laboratory conditions, so it is unclear if patients would be as successful in supervised exercise programs or in exercise programs that involve less physical exertion. Moreover, only 10% of exercise subjects were able to continue with regular exercise for 12 months following treatment. Future investiga-
tions of how to keep women exercising after treatment are warranted. A program that requires some home exercise during treatment might better prepare subjects for the reality of unsupervised exercise once the program ends. Studies have shown that many individuals prefer home exercise, so this may be a promising avenue to pursue.

The challenges of the generalizability and cost-effectiveness of exercise programs, either in combination with brief cognitive-behavioral and nicotine replacement therapies or as alternatives to nicotine replacement for a specific subgroup of women smokers (eg, those with certain psychological or physiological profiles), have yet to be addressed. The question of whether a less demanding, less intensive exercise regimen with broader appeal in community and primary care settings would be effective also needs to be addressed.

Future research should also examine factors related to adherence. One possible reason for the low adherence rate among study subjects was the intensity of the program. It may be unrealistic to expect that subjects can commit 3 evenings per week for 12 weeks to this type of program. Another possible reason for the low adherence rate was the type of exercise. Research has demonstrated that individuals are more likely to adopt and maintain moderate as opposed to vigorous physical activity. However, it remains to be determined if moderate activity yields the same benefits for smoking cessation and weight management as vigorous activity.

In summary, the findings of this trial show that exercise as a nonpharmaceutical adjunct to a cognitive-behavioral smoking cessation program facilitates smoking cessation, improves exercise capacity, and delays weight gain in women smokers. Physicians and other health professionals should recommend exercise to their patients as part of a treatment program for nicotine dependence.

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