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The efficacy of moderate-intensity exercise as an aid for smoking cessation in women: A randomized controlled trial

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Evidence suggests that vigorous-intensity exercise interventions may be effective for smoking cessation among women; however, few studies have examined the efficacy of a moderate-intensity exercise program. The present study examined the efficacy of moderate-intensity exercise for smoking cessation among female smokers. Healthy, sedentary female smokers ($N=217$) were randomly assigned to an 8-week cognitive–behavioral smoking cessation program plus moderate-intensity exercise (CBT+EX) or to the same cessation program plus equal contact (CBT). A subsample received nicotine replacement therapy. Results indicated that the CBT+EX and CBT groups were equally likely to attain smoking cessation at the end of treatment, as measured by cotinine-verified 7-day point-prevalence abstinence (20.2% for CBT+EX vs. 18.5% for CBT). The CBT+EX group was more likely to report smoking cessation, as measured by 7-day point prevalence at the 3-month follow-up (11.9% vs. 4.6%, $p<.05$), compared with the CBT group. No group differences were found at 12 months by either 7-day point prevalence (7.3% for CBT+EX vs. 8.3% for CBT) or continuous abstinence (0.9% for CBT+EX vs. 0.9% for CBT). Additionally, among participants in the CBT+EX group, those with higher adherence to the exercise prescription were significantly more likely to achieve smoking cessation at the end of treatment than were participants reporting lower adherence to exercise. Our findings indicate that the empirical support for moderate-intensity exercise as an adjunctive treatment to CBT for smoking cessation may be limited. Perhaps future studies could compare moderate- vs. vigorous-intensity physical activity to test their relative efficacy.

Introduction

Despite the health risks, nearly one-quarter (22%) of American women smoke cigarettes (U.S. Department of Health and Human Services [USDHHS], 2001). Women who smoke are at increased risk of coronary heart disease, several types of cancer, emphysema, bronchitis, and other lung diseases (USDHHS, 2001). Lung cancer and heart disease, illnesses directly linked to smoking, are now the leading causes of death among women (USDHHS, 2001). Beliefs that smoking can control weight and negative mood are strong factors for both initiating smoking among adolescent girls and sustaining smoking throughout adulthood (USDHHS, 2001). Concerns about postcessation weight gain (Brady, 1999), depressive symptoms, and psychological stress prevent many women from initiating treatment (Ginsburg et al., 1997; Weekley, Klesges, & Reylea, 1992).

Weight gain is a hallmark of smoking cessation and is considered among ex-smokers to be a normative part of the nicotine withdrawal syndrome (Hughes, Higgins, & Bickel, 1994). The average weight gain following cessation is 10–13 pounds (Ginsburg et al., 1997; McBride, French, Pirie, & Jeffery, 1996; Pirie et al., 1992); approximately 25%

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of women who quit gain in excess of 15 pounds, many exceeding 30 pounds (Hudmon, Gritz, Clayton, & Nisenbaum, 1999; Nides et al., 1994; Williamson et al., 1991). In addition to weight gain, depressive symptoms, stress, and craving cigarettes increase the likelihood of relapse to smoking (Doherty, Kinnunen, Militello, & Garvey, 1995; Niaura et al., 2001; Swan, Ward, & Jack, 1996; Shiffman, Gnys, Richards, & Paty, 1996). Therefore, smoking cessation interventions are needed that effectively address these concerns among female smokers.

Given that regular exercise can address weight concerns, depressed mood, stress, and cravings associated with smoking cessation, several studies have examined the efficacy of vigorous-intensity exercise interventions for smoking cessation (Ussher, Taylor, West, & McEwen, 2000). Some studies have found vigorous-intensity exercise to be efficacious (Marcus, Albrecht, Niaura, Abrams, & Thompson, 1991; Marcus et al., 1995, 1999), whereas others have not (J. S. Hill, 1985; Russell, Epstein, Johnston, Block, & Blair, 1988; Taylor, Houston-Miller, Haskell, & DeBusk, 1988). Limitations of the studies not finding efficacy include small sample sizes (J. S. Hill, 1985; Russell et al., 1988; Taylor et al., 1988), failure to demonstrate an increase in fitness level among subjects assigned to the exercise group (Russell et al., 1988), no formal smoking cessation treatment (Taylor et al., 1988), very brief programs (J. S. Hill, 1985), lack of pharmacotherapy (J. S. Hill, 1985; Russell et al., 1988; Taylor et al., 1988), and an absence of a comparison group to control for contact time (J. S. Hill, 1985).

More recently, studies have examined the efficacy of moderate-intensity exercise for smoking cessation (R. D. Hill, Rigdon, & Johnson, 1993; Martin et al., 1997; Ussher, West, McEwen, Taylor, & Steptoe, 2003). Moderate-intensity exercise has significant advantages over vigorous intensity for the following reasons: (a) Individuals are more likely to adhere to moderate- than vigorous-intensity exercise (Blair & Connelly, 1996); (b) it can be achieved by walking, which is the most frequently reported type of exercise (Manson et al., 1999; Stofan, DiPietro, Davis, Kohl, & Blair, 1998); (c) moderate-intensity activities require little medical supervision; and (4) moderate-intensity exercise is less likely than vigorous-intensity exercise to lead to injury (American College of Sports Medicine, 1995). Moreover, moderate-intensity exercise has been shown to reduce cigarette cravings and withdrawal symptoms among abstinent smokers (Ussher, Nunziata, Cropley, & West, 2001). R. D. Hill and colleagues (1993) conducted an exercise and smoking cessation intervention among men and women aged 50 years or older. On completion of treatment, participants in the four groups (i.e., behavioral treatment alone, behavioral treatment plus nicotine gum, behavioral treatment plus moderate-intensity exercise, and moderate-intensity exercise only) were equally likely to report smoking cessation. At 12 months after the end of treatment, only the behavioral training group achieved a higher rate of cessation than the exercise-only condition. Martin and colleagues (1997) conducted a similar study among recovering alcoholic patients. Behavioral counseling plus moderate-intensity exercise was more effective than behavioral counseling plus nicotine gum or the standard treatment. However, group differences were not significant at 6 or 12 months. Both of these studies targeted specific populations (e.g., older adults, alcoholic patients); therefore, the results may not be generalizable to the general population of smokers. More recently, Ussher and colleagues (2003) conducted a study in which male and female smokers were randomly assigned to a 7-week individualized smoking cessation program including nicotine replacement therapy plus either exercise counseling or health education advice. There were no differences between these groups regarding smoking abstinence; however, the CBT+EX group reported less anxiety and stress during the first week of smoking abstinence, less irritability during 2 weeks of abstinence, and less restlessness during 3 weeks of abstinence. The Ussher et al. (2003) study was limited in that the exercise intervention relied solely on an exercise consultation and it was not clear whether the participants received the required dose of exercise.

Given the advantages of moderate-intensity activity and the limitations of the moderate-intensity trial conducted by Ussher et al. (2003), a need existed for a trial examining the efficacy of moderate-intensity exercise for smoking cessation. The present study, named Commit to Quit II (CTQII), was a randomized controlled trial designed to examine the efficacy of moderate-intensity exercise for smoking cessation. The intervention in the present study was based on a cognitive–behavioral smoking cessation treatment plus vigorous-intensity exercise program that had been shown to be effective among female smokers relative to a contact control group (Marcus et al., 1999). This intervention combined home-based and supervised exercise.

Method

Research design

Participants in CTQII were randomly assigned to a cognitive–behavioral smoking cessation treatment designed for women plus supervised group and home-based moderate-intensity exercise (CBT+EX) or to CBT plus equal contact time with staff (CBT).

The exercise program was a supervised moderate-intensity class and home-based program of sufficient frequency, intensity, and duration to produce cardiovascular adaptations (King, Haskell, Taylor, Kraemer, & DeBusk, 1991). We chose a home-based method because moderate-intensity exercise can be easily integrated into one's lifestyle, and therefore, participants may be more likely to continue to be physically active following the trial (King, Taylor, & Haskell, 1993). The outcome variables were 7-day point-prevalence abstinence and continuous abstinence, which were assessed at the end of treatment (8 weeks) and at the 3- and 12-month follow-ups. We also assessed exercise capacity at baseline and the end of treatment. More details regarding the study design are described elsewhere (Marcus, Lewis et al., 2003). The study was conducted at group treatment and exercise facilities at The Miriam Hospital in Providence, Rhode Island.

Participants and randomization

We recruited sedentary female smokers between the ages of 18 and 65 years who regularly smoked 5 cigarettes/day or more for at least 1 year. Sedentary was defined as participating in 90 min/week or less of exercise that was at least of moderate intensity, which is consistent with previous studies (e.g., King, Haskell, Young, Oka, & Stefanick, 1995). Potential participants were recruited from the Rhode Island/Southern Massachusetts area using newspaper advertisements and flyers. Potential participants called the telephone number listed in the newspaper advertisement and completed a telephone screening interview to determine eligibility. Eligible participants were scheduled for an exercise test appointment. Exclusion criteria included medical problems or medications that might impair exercise performance or tolerance; current treatment for a psychiatric disorder, substance abuse, hypertension, or respiratory or lung problems; using prescription medication for less than 3 months; and using smoking cessation medication. Group assignment was based on a randomization code generated by a computer software program and was stratified based on participant's patch usage decision. The institutional review board from The Miriam Hospital in Providence, Rhode Island, approved the study, and participants completed written consent forms prior to participating in the research program.

Assessment

Participants underwent symptom-limited maximal treadmill exercise testing at baseline and at the completion of the 8-week treatment following the Balke protocol. Thus the exercise test was used to calculate the exercise prescription, determine study eligibility, and determine baseline fitness level (Balke, 1970). To determine if participants received a training effect, exercise tests were repeated at week 8. Functional capacity expressed as estimated peak oxygen consumption (VO_2) was used. We used a calibrated scale to assess height and weight at baseline, weekly during the intervention, at the end of treatment, and at the follow-up assessment sessions.

Treatment

Smoking cessation program. Participants in both conditions participated in an 8-week cognitive–behavioral group-based smoking cessation intervention, which was an abbreviated version of the previous 12-week intervention study examining the efficacy of vigorous-intensity exercise for smoking cessation (Marcus et al., 1999; Marcus, King, Albrecht, Parisi, & Abrams, 1997). The cognitive–behavioral intervention lasted 1 hr and included traditional topics such as stimulus control. Topics relevant to women were included such as weight management and balancing family and work. Manuals for the therapists and written materials for the participants were used to ensure standard delivery of the intervention. The counselors were masters- and Ph.D.-level individuals who had been thoroughly trained on the treatment protocol. All treatment sessions were tape-recorded, and a subsample of the sessions were listened to by Ph.D.-level therapists who provided feedback to the counselors.

A treatment length of 8 weeks was chosen after considering the following factors: (a) This was the minimum number of sessions needed to deliver the cognitive–behavioral treatment and to assist participants in total withdrawal from nicotine, (b) a briefer intervention would be more generalizable and, if effective, would reduce costs compared with longer interventions, and (c) this was the minimum number of weeks needed to show a training effect of aerobic exercise.

In accordance with the Public Health Service (PHS) tobacco cessation guideline (Fiore et al., 1996), the option of using the nicotine patch (free of charge) was available for both study arms beginning with the fifth cohort of participants (there were 13 cohorts, with an average of 17 participants per cohort). The patch was not offered to cohorts 1–4 because these cohorts were conducted prior to the 1996 guidelines recommending use of the patch. The patch protocol for the present study was based on the recommendations from the PHS Guideline (Fiore et al., 1996), which states that 6–8 weeks of patch treatment is sufficient for managing withdrawal symptoms and learning strategies for staying

abstinent from nicotine. The patch was optional rather than standard because offering behavioral strategies as potential alternatives to using the patch was appealing to participants not seeking nicotine replacement therapy, and therefore, requiring use of the patch might have limited the generalizability of our findings. Participants were asked each week if they used the patch and, if so, what dose they used. Participants were instructed not to purchase the patch over the counter after week 7; however, given that some participants may not have followed this instruction, participants also were asked about patch use after week 7.

Participants choosing to use the patch began using it on "quit day" (day 8, week 2) and gradually reduced the dose during the intervention until they were no longer using the patch during the last week of treatment. Participants received one patch per day and were started on a 21-mg patch on quit day, tapered to a 14-mg patch at day 22 (week 4), and tapered to the 7-mg patch on day 36 (week 6). Participants who smoked fewer than 10 cigarettes/day or who weighed less than 100 pounds began treatment with a 14-mg patch at quit day and tapered to the 7-mg patch on day 29 (week 5). On day 50 (week 7), all participants discontinued use of the patch.

CBT+EX (cognitive–behavioral treatment for smoking cessation plus exercise). Participants in the exercise condition received an exercise intervention in addition to the smoking cessation treatment. Participants were required to exercise at our gym for a minimum of one session per week lasting approximately 1 hr, which occurred on the same night as the smoking cessation intervention. The first exercise session occurred immediately following the first CBT session. Therefore, participants began exercising 1 week before quit day. For the remainder of the week, participants had the option of exercising either at our gym or at home. They were instructed to participate in 4 days of exercise of at least 30 min per occasion in addition to the 45-min exercise session (the overall session lasted 1 hr to include 15 min of stretching) that occurred following the smoking cessation session. We chose this schedule because research indicates that individuals are more likely to adhere to a home-based exercise program than a group-based program (King et al., 1993). Participants received a telephone call if they missed the weekly in-person exercise session, but additional prompts for the home-based exercise were not implemented.

Exercise prescriptions were based on peak heart rate obtained during the baseline exercise test. Specifically, the prescription was participating in exercise that produced 45%–59% of heart rate reserve or 50%–69% of maximum heart rate (e.g., walking; 4 metabolic equivalents, or METS) 5 days/week for a total of 165 min each week (USDHHS, 1996). We instructed participants to engage in exercise at the moderate-intensity range (11–12 on the Borg scale of 6–20; Borg, 1982). Participants completed a 5-min warm-up, 45 min of exercise, and a 5-min cool-down with stretching during the supervised exercise session. The exercise specialist documented the participants' perceived exertion levels and heart rates. Participants were instructed to engage in additional days of exercise either at our supervised open gym or on their own. To record home-based physical activity, participants completed logs, which were reviewed by the exercise specialist each week. Accuracy of home logs was verified with data from an objective monitor of physical activity (i.e., the Actigraph, Manufacturing Technology Inc., MTI, Fort Walton Beach, Florida). The goal was 165 min/week of moderate-intensity exercise because this amount approximates the Centers for Disease Control and Prevention and the American College of Sports Medicine's recommendation of expending 1,000 kcal/week (Fletcher, 1997; Pate et al., 1995; USDHHS, 1996).

CBT (cognitive–behavioral treatment for smoking cessation with contact control). Participants in the CBT group attended an 8-week wellness program (films, lectures, discussions, and handouts on lifestyle and health issues) lasting 1 hr/week, in addition to the smoking cessation program (Marcus et al., 1999). This protocol has been used successfully in previous studies (Marcus et al., 1995, 1999). The purpose of this group was to control for contact time with the study staff and to reduce the risk of differential attrition between groups.

Outcome measures

The main outcome measure for the study was 7-day point-prevalence abstinence in the absence of patch use (participants were instructed to discontinue patch use by week 7). Therefore, participants still using the patch at the end of treatment were not considered quit, given that they were still receiving nicotine through the patch. Quit status was assessed weekly during the intervention, at the end of treatment (i.e., week 8), and at the 3- and 12-month follow-ups. We used expired carbon monoxide (using the Bedfont carbon monoxide analyzer) and salivary cotinine levels to verify quit status. Criteria for 7-day point-prevalence abstinence was a cotinine level less than 57 nmol/l (10 ng/ml; Etzel, 1990) and a carbon monoxide level less than 8 ppm (Ossip-Klein et al., 1986). We also examined continuous abstinence from quit day (day 8) through the end of treatment (i.e., week 8), 3-month follow-up, and 12-month follow-up.

Data analyses

Objectives and design considerations. The objective of the study was to compare smoking cessation rates between the CBT+EX and CBT groups. Specifically, we predicted that the CBT+EX group would exhibit higher rates of 7-day point-prevalence abstinence and continuous abstinence than the CBT group at the end of treatment (i.e., week 8) and at the 3- and 12-month follow-ups. Our measure of effect was difference in cessation rates. The study was designed to have 80% power to detect an 18.3% net difference on 7-day point-prevalence abstinence between the two study arms, with a 5% Type I error rate (alpha, one-sided), which calls for randomizing 86 participants to each group (172 total). The end-of-treatment and follow-up analyses were powered utilizing a one-tailed alpha of .05; therefore, a one-sided test was used for the current analyses. The effect size was derived from data on our previous trial examining vigorous-intensity physical activity (i.e., Commit to Quit I; CTQI). We checked for obvious violations of balance in the randomization by comparing key baseline variables using either *t* tests or chi-square tests. The primary outcomes were analyzed using the intent-to-treat principle (Lachin, 2000), with the objective of comparing the effect of randomizing to CBT+EX and CBT. Another objective was to compare results from the current moderate-intensity trial to those of a previous study examining the efficacy of vigorous-intensity physical activity (i.e., CTQI). The data analyses were conducted using SAS.

Assumptions about dropout and missing data. Following conventions for smoking cessation trials (Lichtenstein & Glasgow, 1992), we categorized participants as smokers if they did not attend an assessment session or if they dropped out of the trial. As a secondary analysis, we compared dropout rates between the two arms using the log-rank test (a version of the rank-sum test, specialized to censored-event time data).

Handling use of the patch. We included an indicator of patch use in our model to make adjustment for its effect on cessation, used two-stage least squares to estimate the model parameters, and computed robust standard errors (e.g., Royall, 1986) to account for nonconstant variance inherent in binary outcomes. After the beginning of our trial, patch use became the standard of care for those trying to quit smoking (Fiore et al., 1996). Although our study was designed to study exercise effects in the absence of patch use, it became necessary to offer women the patch to comply with widely accepted standards of practice. To eliminate the possibility of confounding related to patch use, the patch was offered to women prior to randomization. Once a woman declined use of the patch, she was not offered the patch at any point during the study; however, because the patch is available over the counter, we recorded patch use each week. Statistical adjustments for variability explained by patch use were made using a regression model, by including as a covariate the binary indicator of intention to use the patch.

Results

Participants

A total of 1,065 women were screened by telephone to determine initial eligibility. Of these, 695 were deemed ineligible (289 had health conditions, 180 were regular exercisers, 72 had psychiatric conditions, and 154 had one of our remaining exclusion criteria such as using medication that might impair exercise performance or tolerance). A total of 153 were eligible but chose not to participate. The remaining 217 participated in the study.

The 217 female smokers (mean age=42.8 years) were randomized into the trial (13 cohorts with an average of 17 participants per cohort). We found no significant differences between the participants in the two treatment conditions at baseline on several demographic and psychosocial measures. The sample was 82.5% White, 6.9% Black, 6.0% Hispanic, 3.2% Cape Verdians, and 0.5% Asian (0.9% endorsed "other"). Table 1 summarizes descriptive statistics for the sample. Among the 176 participants offered the use of the nicotine patch, 88.6% chose to use it. We found no difference between the two conditions on use of the nicotine patch (among those who were offered the patch, 87.4% in the CBT+EX group and 89.9% in the CBT group used it).

Table 1. Mean baseline characteristics of study arms.

Characteristic	Exercise group	Control group
Age (years)	42.52 (10.39)	43.02 (10.33)
Education (years)	13.58 (2.40)	13.36 (1.97)
Weight (pounds)	156.43 (33.91)	152.22 (34.99)
Height (inches)	64.52 (2.39)	64.20 (2.41)
Body mass index	26.48 (5.59)	25.96 (5.55)
Waist-to-hip ratio	0.80 (0.08)	0.78 (.08)
Percentage body fat	35.71 (7.06)	35.91 (6.76)
Fagerström Tolerance Questionnaire score	4.98 (2.27)	4.71 (2.39)
Smoking rate (cigarettes/day)	21.04 (9.34)	20.15 (9.38)
Years of smoking	26.49 (10.39)	26.22 (9.77)
Carbon monoxide level (ppm)	19.20 (10.61)	20.21 (10.60)
Estimated VO_2 peak (ml/kg/min)	30.71 (6.12)	30.68 (5.67)

Note. Standard deviations are in parentheses.

Adherence

The CBT+EX group attended 72.1% of the weekly smoking cessation sessions and 70.5% of the weekly onsite supervised exercise sessions. The CBT group attended 71.9% of the weekly smoking cessation sessions and 70.0% of the weekly wellness sessions. We found no differential loss to follow-up between the two groups. For the CBT+EX group, 54.1% attended the end-of-treatment assessment session, 39.4% attended the 3-month follow-up session, and 24.8% attended the 12-month follow-up session. For the CBT group, 58.9% attended the end-of-treatment assessment session, 42.1% attended the 3-month follow-up session, and 31.8% attended the 12-month follow-up session. Among participants in the CBT+EX group, 27.1% exercised an average of 110 min/week or more during the intervention (two-thirds of the prescribed 165 min). Each week during treatment, an average of 15.20% of the participants in the CBT+EX group met or exceeded the prescription of exercising 165 min/week. Participants also reported that about two-thirds (67.84%) of the total exercise minutes during treatment were completed at home. The CBT+EX group exercised an average of 87.00 min/week (SD=67.17) during treatment.

For the exercise participants, training heart rate averaged 44.3% (SD=19%) of their mean heart rate reserve (74.3% maximum heart rate). Among participants who attended the end-of-treatment assessment, the average absolute estimated percent change from baseline to posttest on VO_2 peak significantly increased from baseline to the end of treatment for the CBT+EX group (+5.51%) but was relatively unchanged in the CBT group (−.60%), $F(1, 117)=3.78$, $p=.054$. For the intent-to-treat sample, the estimated percent change from baseline to posttest on VO_2 peak significantly increased from baseline to the end of treatment for the CBT+EX group (+3.828%) but was relatively unchanged in the CBT group (−.887%), $F(1, 210)=4.338$, $p=.038$.

Weight changes

Among participants in the CBT+EX group, those who were continuously abstinent at the end of treatment gained an average of 3.86 pounds (SD=5.66), and those who were not continuously abstinent gained an average of 2.98 pounds (SD=4.15). Among participants in the CBT group, those who were continuously abstinent at the end of treatment averaged a weight gain of 4.56 pounds (SD=5.05), and those who were not continuously abstinent averaged a weight gain of 2.86 pounds (SD=5.14). These differences were not significant between treatment groups.

Smoking outcome

Group differences. Some 19% (20 of 108) of the women in the CBT group and 20% (22 of 109) of the women in the CBT+EX group achieved 7-day point-prevalence abstinence at the end of treatment, which is a difference of 2% (because of rounding) with a 95% confidence interval of −9% to 13%. Using continuous abstinence as the outcome, cessation rates were 11% and 15%, respectively, corresponding to a difference of 3% with a 95% confidence interval of −6% to 12%. The differences for these and for the 3- and 12-month follow-ups are summarized in Table 2. Results indicate that the CBT+EX and CBT groups were equally likely to achieve 7-day point-prevalence abstinence at the end of treatment. At the 3-month follow-up, the CBT+EX group was significantly more likely to achieve 7-day point-prevalence abstinence than was the CBT group; however, no group differences were found at 12 months. Group differences on continuous abstinence at the end of treatment and at the follow-ups are also summarized in Table 2. No significant differences were observed for continuous abstinence at any of the timepoints. Table 2 also compares our present findings to results from our previous vigorous-intensity smoking cessation trial (CTQI).

Effect of exercise. We examined the direct effect of exercise adherence on smoking cessation among participants in the CBT+EX group. To conduct this analysis, among participants in the CBT+EX group, we compared participants who adhered to the exercise protocol with those who did not adhere. Each participant was coded as either exercising at least 110 min (two-thirds of the recommended 165 min of exercise per week) or not meeting this requirement. The data were obtained from the physical activity logs; therefore, participants who did not complete their physical activity logs were categorized as not meeting the requirement. Next, the number of weeks meeting the requirement of 110 min of exercise was totaled for each participant (range=0–7 weeks). Finally, this exercise variable was entered into a chi-square regression analysis to predict smoking cessation. Specifically, we found that for a 1-week increase in the number of weeks meeting or exceeding 110 min of exercise (per week), the odds of achieving smoking cessation at the end of treatment, as measured by 7-day point-prevalence abstinence, increased by 39.6% ($p<.01$), after controlling for ethnicity, employment status, baseline body mass index, and smoking rate at baseline (Table 3).

Table 2. Comparison of the moderate-intensity trial (CTQII) to the previous vigorous-intensity trial (CTQI).

Study	Follow-up	Exercise group (n=109)	Control group (n=108)	p value
CTQII		7-Day point-prevalence abstinence		
	End of treatment	20.2%	18.5%	.45
	3-Month follow-up*	11.9%	4.6%	.04
	12-Month follow-up	7.3%	8.3%	.49
CTQII		Continual abstinence		
	End of treatment	14.7%	11.1%	.44
	3-Month follow-up	7.3%	3.7%	.19
	12-Month follow-up	0.9%	0.9%	.75
		(n=134)	(n=147)	
CTQI		7-Day point-prevalence abstinence		
	End of treatment	30.6%	21.8%	.09
	3-Month follow-up*	24.6%	13.6%	.02
	12-Month follow-up*	19.4%	13.6%	.19
CTQI		Continual abstinence		
	End of treatment*	19.4%	10.2%	.03
	3-Month follow-up*	16.4%	8.2%	.03
	12-Month follow-up*	11.9%	5.4%	.05

Note: CTQII, Commit to Quit II (current moderate-intensity trial); CTQI, Commit to Quit I (previous vigorous-intensity trial).
*Significant difference between groups at $p<.05$.

Table 3. The effect of exercise on smoking cessation among participants in the CBT+EX group.

Parameter	Degrees of freedom	Estimate	Standard error	Wald chi-square	p value
Intercept	1	−3.6384	2.0897	3.0315	.0817
Number of weeks met exercise criteria	1	0.3336	0.1262	6.9944	.0082
Ethnicity	1	−0.4226	0.6831	0.3827	.5361
Employment	1	1.1274	0.8750	1.6599	.1976
Body mass index	1	0.0441	0.0487	0.8184	.3657
Smoking rate	1	−0.0047	0.0361	0.0170	.8960

Discussion

Contrary to our hypothesis, participants in the CBT+EX (i.e., cognitive–behavioral smoking treatment plus exercise) and CBT (i.e., cognitive–behavioral smoking treatment plus contact control) groups were equally likely to report smoking cessation at the end of treatment. Because some of the participants did not adhere to the exercise recommendations, we conducted additional analyses to better understand the direct effect of moderate-intensity exercise on smoking cessation. Specifically, we found that among participants in the CBT+EX group, a higher level of exercise participation during the intervention phase was related to a higher likelihood of achieving smoking cessation at the end of treatment. However, one limitation is that this finding is observational, given that participants were not randomly assigned to high versus low adherence to exercise. It is possible that participants who comply with physical activity are more likely to quit for reasons unrelated to engaging in physical activity. Therefore, additional research is needed in which high adherence to moderate-intensity exercise is achieved to further examine the efficacy of moderate -intensity activity. For example, high adherence to exercise could perhaps be achieved through improving social support for exercise, offering community-based programs that are more convenient than those at a research facility (e.g., at the YMCA), and using mail and E-mail exercise prompts.

Moderate- versus vigorous-intensity exercise

As in our present moderate-intensity physical activity study, our previous study examining the efficacy of vigorous-intensity exercise found that female smokers receiving cognitive–behavioral smoking cessation treatment plus vigorous-intensity exercise were significantly more likely to achieve 7-day point-prevalence abstinence at the 3-month follow-up but

not at the end of treatment or at 12 months. However, unlike in our present moderate-intensity exercise trial, participants in the exercise group of the vigorous-intensity trial were more likely to achieve continuous abstinence at all timepoints when compared with the contact control condition. Table 2 compares the outcomes from the current moderate-intensity trial (i.e., CTQII) to the previous vigorous-intensity trial (i.e., CTQI). Given the important differences between these two trials, it is premature to conclude that vigorous-intensity physical activity is more efficacious than moderate-intensity physical activity. To elaborate on this further, differences between these two trials and their possible implications are discussed below.

Fitness changes. The fitness changes (i.e., changes in estimated maximal VO_2 during the stress tests) among the participants from baseline to the end of treatment were half as much in the moderate trial when compared to the vigorous trial. The fitness changes in the present study are similar to those seen in other studies delivering moderate-intensity physical activity (Marcus, Napolitano, & Lewis, 2003). Perhaps the exercise intensity in the present trial was not adequate to produce increased continuous smoking cessation rates. One limitation is that we were not able to assess fitness among the participants who did not attend the posttest assessment (46% of the sample).

Weight changes. The previous trial examining vigorous-intensity exercise indicated that, among participants who quit, participants in the CBT+EX group gained significantly less weight than did participants in the contact control condition. Differences in weight gain were not observed between groups in the present trial. Perhaps the "dose" of exercise was insufficient to produce significant differences in weight gain between the CBT+EX and CBT conditions in the present trial. Additionally, nicotine patch use attenuates weight gain during cessation (A. L. Hill, Roe, Taren, Muramoto, & Leischow, 2002; Jorenby, Hatsukami, Smith, & Fiore, 1996), which may have contributed to the lack of weight gain differences between the two conditions. This possibility is supported by participants in the present trial gaining fewer pounds than participants in the vigorous-intensity trial, although the present study was shorter in duration than was the vigorous-intensity trial (8 weeks vs. 12 weeks).

Protocol differences. Based on participants' responses to a consumer satisfaction survey administered in the vigorous-intensity exercise trial and in the pilot study for the present moderate-intensity exercise trial, we made several changes to the protocol for the present trial. These changes (listed below), as well as the exercise intensity differences, may have contributed to the discrepant results between the two trials. Therefore, until additional studies are conducted, it is premature to definitively conclude that vigorous-intensity exercise is more efficacious than is moderate-intensity exercise for smoking cessation.

One difference between the two trials is that the present trial included an 8-session intervention protocol and the previous trial included a 12-session intervention protocol. Therefore, participants in the previous trial may have been more likely to achieve smoking cessation, regardless of group, because they received a lengthier smoking cessation intervention than did participants in the present trial. However, this possibility is unlikely given that the CBT groups exhibited similar smoking cessation rates between the two trials at 12-month follow-up (10.2% in the vigorous-intensity trial vs. 11.1% in the moderate-intensity trial). Second, adherence to the exercise prescription was lower in the present trial than in the previous trial. Perhaps if participants had adhered to the exercise prescription, the findings of the present trial would have approximated the findings in the previous trial, especially given that participants in the CBT+EX group who adhered to exercise were more likely to achieve smoking cessation than were participants who did not exercise. Third, participants in the previous trial were instructed to participate in supervised sessions in our gym three times per week and participants in the present trial were required to attend one supervised gym-based session per week and participate in exercise for the remaining days either at our gym or on their own. Even though the gym was available to participants in the moderate-intensity group, very few participants used the gym. Fourth, beginning with cohort 5, participants in the present trial were offered the nicotine replacement patch, whereas participants in the previous trial were not offered nicotine replacement. Therefore, it would be expected that participants in the present trial would be more likely than participants in the previous trial to achieve smoking cessation, regardless of exercise participation. However, the CBT groups in both studies had similar smoking cessation rates. Finally, when compared with the vigorous-intensity trial at baseline, the participants in the present trial weighed more, were older, had a higher percentage of body fat, reported higher levels of trait anxiety, and reported lower self-efficacy to maintain their weight following smoking cessation (Marcus et al., 1999). These differences in cohort composition may have played a role in the different findings observed between the two studies.

Limitations

Several limitations to the present study warrant discussion. First, because fitness was not assessed following the intervention phase, it is unclear whether participants who were physically active during the intervention phase continued their activity after the end of treatment. Furthermore, it is unclear whether individuals who did not adhere to exercise during the intervention adopted exercise following the intervention phase. Second, we began nicotine replacement with cohort 5; therefore, the first four cohorts were not given the opportunity to use nicotine replacement. Given that a majority of the sample who were offered nicotine replacement chose to use it, it is possible that offering it to the first four cohorts would have affected the results. Finally, the study has limited generalizability because participants responded to newspaper advertisements and many participants were excluded because of medical conditions, resulting in a selective sample.

Future directions

One limitation of the present trial is that many of the participants did not receive an adequate dose of exercise because of lack of adherence to moderate-intensity exercise. Therefore, it is premature to conclude that vigorous-intensity exercise is more effective than moderate-intensity exercise for smoking cessation. Because moderate-intensity exercise has the potential to reach a greater number of female smokers than does vigorous-intensity activity, additional research is warranted to further examine the efficacy of moderate-intensity activity. Specifically, to adequately test the efficacy of moderate-intensity activity, randomized controlled trials achieving high adherence to moderate-intensity exercise are needed. After the present trial began, several studies were published that demonstrated the efficacy of theory-based exercise interventions for the promotion of moderate-intensity exercise (e.g., Dunn et al., 1997; Marcus et al., 1999). These interventions include cognitive and behavioral strategies to increase physical activity among sedentary adults. Both face-to-face (i.e., group-based programs) and non-face-to-face (e.g., print-based interventions) strategies have been shown to be efficacious (Dunn et al., 1997; Marcus et al., 1999). Perhaps smokers would benefit from these interventions. Smokers will likely encounter unique barriers associated with exercise, such as stress associated with quitting smoking, which may interfere with adherence to an exercise program. Therefore, smokers may particularly benefit from intensive face-to-face exercise programs. Providing smokers with intensive interventions that have been shown to be efficacious will allow researchers to improve adherence to exercise and, therefore, to adequately test the efficacy of moderate-intensity exercise for smoking cessation.

Contrary to our hypothesis, the CBT+EX and CBT interventions were equally likely to prevent weight gain following smoking cessation. Despite these findings, moderate-intensity exercise may assist in smoking cessation by helping female smokers feel less concerned about weight gain and, therefore, attempt cessation. In other words, it may help them quit smoking even though weight gain may not be attenuated by the moderate-intensity exercise. Because of the poor adherence to exercise in the present trial, additional studies are needed to examine the impact of moderate-intensity exercise on weight gain attenuation before definitive conclusions can be made regarding weight gain and moderate-intensity exercise.

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