

TREATING TOBACCO DEPENDENCE IN WOMEN WITH EXERCISE: REVIEW ON EFFECTIVENESS AND MECHANISMS

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ABSTRACT

Annually, tobacco-related illnesses claim the lives of millions of women worldwide. Women have more difficulty in quitting than men, and smokers in general are more physically inactive than nonsmokers—further contributing to morbidity and mortality. Exercise represents a treatment option that may be particularly suitable for women trying to quit smoking. It may address several known barriers to cessation by promoting emotional well-being and maintenance of healthy body weight and by providing a socially supportive environment. Further, exercise participation is inversely related to other cardiovascular risk factors. Currently, there is a paucity of research testing the effectiveness of exercise as an aid for smoking cessation. Methodological flaws have plagued many of these studies and adherence to exercise interventions has been poor. This paper reviews effectiveness of exercise in treating tobacco dependence in women, including findings from published and ongoing clinical trials. Consequently, several relationships and hypothesized mechanisms between exercise and smoking cessation are discussed. Given the widely established benefits of exercise on women's health, and lack of adequate exercise trials for women smokers, further research is warranted regarding the potential role of exercise as treatment and the harm reduction intervention in the field of tobacco dependence.

Key words: smoking cessation, exercise, nicotine replacement therapy, clinical trials, women's health

Every year, tobacco-related illnesses prematurely claim the lives of nearly one million women worldwide. The majority of these deaths are due to coronary heart disease, stroke, and increasingly to lung cancer (U.S. Department of Health and Human Services [HHS], 2001). Moreover, smoking may increase women's vulnerability to gender-specific

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health consequences (Hellström-Lindahl & Nordberg, 2002; Reynolds et al., 2004). Unfortunately, smoking-related illnesses, especially cardiovascular diseases (CVD), are becoming more prevalent among women (HHS, 2001), and smoking may be a stronger risk factor for women than for men (Bjartveit & Tverdal, 2005; Prescott, Hippe, Schnohr, Hein, & Vestbo, 1998).

WOMEN AND SMOKING CESSATION

Despite the known health risks of tobacco use and the benefits of smoking cessation (Peto et al., 2000), quitting smoking is difficult to accomplish for both men and women. Although many smokers would like to quit, the chance of successful cessation with an unaided attempt is approximately 5% (Fagerström, 2005). Further, long term or permanent abstinence may require several quit attempts (Fiore et al., 2000). Some studies suggest that quitting may be more difficult for women than men and that nicotine replacement therapy (NRT) may not always be as effective for women as men (Perkins, 2001). Yet another challenge is that none of the current medications designed to aid in smoking cessation attempts are recommended for women who are pregnant or breastfeeding—a time when many women may attempt to quit smoking.

It also appears that determinants of successful smoking cessation differ for women as compared to men. Weight concerns, stress, depression, lack of social support, and low education level are among the factors contributing to a poorer outcome in cessation treatment for women relative to men (Cepeda-Benito, Reynoso, & Erath, 2004; Perkins, 2001). Women also report greater physical and emotional dependence on tobacco than men (Björnson et al., 1995). As such, mood management and concerns about weight may be special challenges for women who try to quit smoking.

Adjunct behavioral interventions, such as relapse prevention counseling (Fiore et al., 2000) or cognitive-behavioral counseling (Hall et al., 1998), have been found to increase cessation rates when added to pharmacotherapy. Cognitive behavioral and other treatments that have been tailored to address issues specific to women (e.g., weight concerns, depression, and social support) have shown some success (Leventhal et al., 2007; Perkins et al., 2001). Given these specific obstacles to quitting success, physical activity may be an especially suitable form of behavioral intervention, particularly for women (Leventhal et al., 2007). Furthermore, exercise is negatively correlated with coronary heart disease, acute cardiac events, and cardiovascular risk factors and promotes emotional well-being and addresses weight issues (Thompson et al., 2003). Moreover, because relatively low-cost exercise (e.g., walking) programs have been successfully implemented in community and primary care settings, they may be particularly relevant for women of low socioeconomic status who are at the greatest risk for coronary artery disease and who are more nicotine-dependent (HHS, 1996, 2001).

UTILITY OF EXERCISE IN SMOKING CESSATION

Quitting smoking and regular exercise can independently lead to health promotion. For example, both rapidly reduce the risk of CVD among women (HHS, 1996, 2001), whereas smoking and a sedentary lifestyle are predisposing factors for hypercholesterolemia, hypertension, and even the metabolic syndrome (Schnohr, Jensen, Scharling, & Nordestgaard, 2002). Thus, it is assumed that combining exercise with smoking cessation interventions could provide a remarkable cardiovascular benefit, especially if exercise contributes to smoking cessation. Additionally, epidemiological evidence indicates an inverse association between physical activity and all-cause mortality risk even after statistical adjustment for smoking (Paffenbarger, Hyde, Wing, & Hsieh, 1986). It has been shown that physically active smokers have fewer years of disability prior to death than with smokers who are sedentary (Ferrucci et al., 1999). Thus, even in lieu of smoking cessation, introducing regular exercise into one's lifestyle may improve quality of life (DeRuiter & Faulkner, 2006).

Aerobic exercise may provide specific effects found to be particularly important for women. First, negative affect related to continuing smoking is more common among women than among men (Perkins, 2001). Depressive symptoms, stress, and cigarette cravings associated with smoking cessation also increase the likelihood of relapse among women (Doherty, Kinnunen, Militello, & Garvey, 1995; Niaura et al., 2001). Second, women are more likely than men to report concerns of weight gain as a reason for continuing smoking (Jeffery, Hennrikus, Lando, Murray, & Liu, 2000). Given that regular exercise improves mood, reduces stress, cigarette cravings, and fear of weight gain (Cepeda-Benito et al., 2004; Leventhal et al., 2007) associated with smoking cessation (Sorensen et al., 1992), exercise may be an especially promising treatment for women who want to quit smoking (Haus, Hoerr, Mavis, & Robison, 1994; Marcus et al., 1999).

EFFECTIVENESS OF EXERCISE IN SMOKING CESSATION

Since the 1980s, several studies have been published on the effects of exercise in smoking cessation (Ussher, Taylor, West, & McEwen, 2000). Most of these studies have focused on assessing the effectiveness of moderate aerobic exercise, whereas some interventions have utilized vigorous exercise programs. Of the three trials conducted during the 1980s, none found significant differences between exercise and control groups. However, these trials had relatively low numbers of participants, and given the modest success rate of smoking cessation intervention, had low statistical power to detect effects (Hill, 1985; Russell, Epstein, Johnston, Block, & Blair, 1988; Taylor, Houston-Miller, Haskell, & Debusk, 1988). These initial intervention studies also failed to produce any physiological exercise effects within the experimental group that suggests the intervention may have been too short in duration or that adherence to the exercise regimen was insufficient.

However, trials conducted during the 1990s that provided a sufficient exercise stimulus, such as more vigorous exercise, produced better results and higher quit rates (Marcus, Albrecht, Niaura, Abrams, & Thompson, 1991; Marcus et al., 1995; Marcus et

al., 1999). The most extensive of those trials included only female participants and used exercise as an adjunct to cessation counseling (Marcus et al., 1999). Findings indicate that participants in the exercise group—who exercised at 65–80% of maximal capacity—had better results at 12-month follow-up (12% smoke-free) than those in the control group (5% smoke-free). Although these rates may appear modest, they have clinical relevance since the average unassisted cessation rate is 3–8% (Fiore et al., 2000).

Since the Marcus et al. study (1999), three additional studies have been conducted on smoking cessation and exercise utilizing the American College of Sports Medicine (ACSM) guidelines for an exercise prescription (Kinnunen et al., 2008; Marcus et al., 1999, 2005; Prapavessis et al., 2007). That is, the ACSM identifies five components of the exercise prescription (i.e., frequency, intensity, duration, mode, and rate of progression) that impact the improvement of cardiorespiratory fitness in adults, and they provide recommendations for modulation of each component (ACSM, 2006). Kinnunen et al. (2008) and Prapavessis et al. (2007) used exercise as an adjunct treatment to NRT, whereas two studies by Marcus et al. (1999; 2005) used exercise as a single modality treatment. Furthermore, although the frequency (three times a week), duration (approximately 30–45 minutes), and mode (walking) of exercise was relatively consistent across the studies, the intensity has varied from moderate (King et al., 1992; Marcus et al., 1999) to vigorous (Marcus et al., 2005; Prapavessis et al., 2007). Marcus et al. (1999) found that exercise improved cessation rates over an equal contact control condition when exercise intensity was vigorous. Positive results were also found by Prapavessis et al. (2007), although they were not statistically significant. The comparison group was a cognitive-behavioral counseling group. Kinnunen et al. (2008) and Marcus et al. (2005) did not find that exercise improved cessation over equal contact control with moderate exercise; although, exercise did improve compared to NRT alone. Summaries of published studies and preliminary data from the Kinnunen laboratory are given in Table 1.

EXERCISE-INDUCED ACUTE AND POST-CESSATION CHANGES IN MOOD, WITHDRAWAL, AND CRAVINGS

The notion that exercise elevates mood is well-established (DiLorenzo et al., 1999; Gauvin & Spence, 1996; Taylor, Ussher, & Faulkner, 2007; Ussher, West, Doshi, & Sampuran, 2006). Similarly, anxiety, irritability, stress, and depression are commonly observed affective states during smoking cessation; hence, it seems logical to use exercise as an intervention to reduce tobacco-abstinence-induced withdrawal symptoms. Furthermore, when developing a gender-specific treatment for women, interventions targeted to reduce negative affect and withdrawal distress are encouraged since these aspects are more troublesome for women than for men (Leventhal et al., 2007). Surprisingly, there are only two published reports that examine the effects of exercise on post-cessation withdrawal syndrome. Neither of these reports found significant effects (Bock, Marcus, King, Borrelli, & Roberts, 1999; Kinnunen Mustonen, 2005), and it is possible that a higher intensity exercise is needed to produce relief in withdrawal. There are two additional studies that examine post-cessation effects of exercise in a smoking cessation

Table 1. Summaries of Studies Based on the 2006 ASCM Guidelines (Hard: 77-93%; Moderate: 64-76%; Light: 50-63%).

	Intensity by new ASCM guidelines	Mean exercise intensity as % of heart rate max	8 weeks quit rates	3-4 months quit rates
Marcus et al., 1999 no NRT randomized	Hard	83% (actual)	19.4%	16.2%
	n/a	Equal contact control	10.2%	8.2%
Marcus et al., 2005 partial NRT (patch) randomized	Moderate	74.3 % (actual)	14.7%	7.3%
	n/a	Equal contact control	11.1%	3.7%
Prapavessis et al., 2007 NRT (patch) randomized	Hard	81.6 % (intended)	70% (6 weeks)	70% (4 months)
	n/a	Cognitive behavioral counseling	77% (6 weeks)	49% (4 months)
Kinnunen et al., 2008 NRT (gum) randomized	Moderate	77.1 % (actual)	28.3 %	24.2% (4 months)
	n/a	Equal contact control	28.6 %	23.2% (4 months)
	n/a	Standard care	14.7 %	14.7 % (4 months)

program (Schneider, Spring, & Pagoto, 2007; Ussher, West, McEwen, Taylor, & Steptoe, 2003). In both studies, participants were instructed to exercise on their own rather than in a supervised exercise session. Interestingly, both of these studies found that those participants who self-selected higher doses of exercise reported reductions in post-cessation negative affect (Schneider et al., 2007; Ussher et al., 2003).

Contrary to post-cessation effects, there is an abundance of research reporting how single bouts of exercise reduce withdrawal and cravings. A systematic review by Taylor, Ussher, and Faulkner (2007) summarized evidence from 14 studies investigating acute exercise effects. Only one of the studies investigated these effects during a smoking cessation attempt, whereas others were done in a laboratory with smokers temporarily abstinent for 12-24 hr. All studies that compared exercise to a passive control condition found that exercise significantly reduced cigarette cravings and withdrawal symptoms. These effects varied in intensity (i.e., hard/vigorous, moderate, or light) and with isometric exercise. Two studies directly compared two levels of intensity and found no differential impact on the reduction of craving or withdrawal (Daniel, Cropley, Ussher, & West, 2004; Everson, Daley, & Ussher, 2006). It should be noted that the duration of exercise was relatively short in these studies. Eleven of the reviewed studies included only short bouts of exercise varying from 5 to 15 min, and three studies had 20- to 30-min bouts. Since exercise-induced acute effects on withdrawal symptoms are well-established in laboratory settings, their investigation in a real-life smoking cessation attempt seems

pertinent. Furthermore, no studies to the authors' knowledge have related acute exercise-induced effects to smoking cessation withdrawal relief and abstinence rates.

In addition to impact on mood and cravings, exercise may aid in smoking cessation by increasing self-efficacy and distress tolerance; it may also aid in smoking cessation by reducing weight concerns and general depression and by providing a socially supportive environment (Craft, 2005; Gauvin & Spence, 1996; HHS, 1996; Schneider et al., 2007; Taylor et al., 2007). The established benefits of exercise and the hypothetical mechanisms by which cessation may be facilitated are summarized in Table 2.

STUDY DESIGN CONSIDERATIONS OF EXERCISE IN SMOKING CESSATION

Ussher (2005) provided a critical review of the trials conducted before 2004: The evaluation revealed that, among 11 trials that fulfilled all criteria for a controlled design, only three were able to validly show that exercise had a positive impact on smoking cessation maintenance. However, an inspection of the design characteristics in these studies warrants continued enthusiasm for the potential promising effect of exercise in promoting smoking cessation.

First, many trials either utilized small samples or employed exercise interventions that did not adequately impact certain physiological outcomes, such as fitness. Therefore, there is a need for additional research with larger sample sizes and exercise interventions that are well-defined and have the duration and intensity requirements needed to produce sufficient changes in fitness. These changes are important in smoking-cessation research due to what appears to be a dose-response relationship between treatment success and dose of the intervention.

A second proposed explanation for the lack of efficacy demonstrated in these trials is that the exercise interventions may have been started too late (i.e., at the time of smoking cessation). Relapse to smoking often occurs during the very first weeks following cessation; therefore, in order to get the optimal benefits from exercise, such as positive mood, exercise programs should be initiated prior to the quit day. Thus, we suggest that exercise should be started a few weeks in advance of quitting.

Another shortcoming in the previous literature is a lack of NRT or other relevant medication within the intervention. All clinical practice guidelines published in the U.S. in 2000 (Fiore et al., 2000), and later in Europe, have emphasized both pharmacological (e.g., NRT) and a non-pharmacological (e.g., behavioral counseling) components in the treatment of tobacco dependence. Thus, exercise should be tested as an adjunct of NRT and counseling, rather than as a stand alone intervention (Ussher et al., 2000). Furthermore, trials that assess the participants' adherence to the exercise regimen are needed in order to determine if exercise represents an adjunct treatment option for women.

POTENTIAL MECHANISMS CONTRIBUTING TO THE SMOKING CESSATION-EXERCISE RELATIONSHIP

The previously described interventions have primarily focused on two ways in which exercise can aid smoking cessation; those are the proposed mechanisms of mood regu-

Table 2. Established Benefits of Exercise and Plausible Mechanisms by Which Exercise May Aid Smoking Cessation

Established benefits of exercise	Plausible mechanism	Representative studies/reviews
Elevated mood Reduced anxiety	Withdrawal relief	DiLorenzo et al., 1999 Gauvin & Spence, 1996 Ussher et al., 2006
Reduced drug cravings	Reduced cravings	Bock et al., 1999 Daniel et al., 2006 Taylor et al., 2007 Ussher et al., 2001
Improved sleep cycle	Withdrawal relief	Driver & Taylor, 2000 Taylor et al., 2007
Decreased stress reactivity	Increases distress tolerance Withdrawal relief	Crews & Landers, 1987 Taylor et al., 2007 Traustadottir et al., 2005
Increased self-efficacy and self-esteem	Self-efficacy predicts smoking cessation success Relapse prevention	Craft, 2005 Fox, 2000 Gauvin & Spence, 1996 McAuley et al., 2000 Marcus et al., 1994
Weight management	Reduction in weight gain	Asikainen et al., 2004 HHS, 1996 Kawachi et al., 1996 Perkins et al., 1997 Schneider et al., 2007 Taylor et al., 2007
Reductions in concerns related to weight gain	Reduction in weight concerns	
Modification of neurotransmitters (e.g., serotonin, endogenous opiates)	Substitute reinforcer for nicotine	Stathopoulou et al., 2006 Taylor et al., 2007

lation and weight control. These were chosen because they have proved to be especially relevant for smoking cessation among women. However, various types of exercise programs also have the potential to promote smoking cessation via other mechanisms. Among commonly reported causes for failed smoking cessation attempts are withdrawal symptoms and cravings for cigarettes. Although exercising several times a week certainly elevates mood, it may not alleviate acute withdrawal symptoms. Taylor et al.'s (2007) systematic review suggests that short bouts of exercise, both aerobic and isometric, may lead to a reduction in negative mood, tobacco withdrawal, and cravings; however, this mechanism has not been adequately tested in the context of an actual smoking cessation attempt. More research is needed to investigate the efficacy and feasibility of various types of exercise, intensity, and frequency on the smoking cessation process. For example, Marcus et al. (1999) have suggested that vigorous exercise provides highest cessation rates; but conversely, most smokers have never exercised regularly prior to a quit attempt. Thus, exercise programs that are too vigorous or too frequent may be

overwhelming during the cessation process and, as a result, satisfactory compliance may not be achieved. Moreover, the literature is replete with confusion in the terminology used to describe exercise intensity, and most studies overlap exercise intensity even though they may be operationalized differently. That is, the ACSM established specific heart rate ranges to coincide with exercise intensity labels (e.g., moderate, hard), but researchers often used terminology (e.g., vigorous exercise) inconsistent with ACSM's labels for heart rate range. It was also more common for studies to report target heart rate exercise training zones spanning only two exercise intensity levels (i.e., moderate and hard). Thus, it was difficult to determine actual training intensity or the relative percentage of subjects training at each intensity level in reviewed studies. Lastly, the ACSM (2006) recently re-adjusted the target heart rate training zones corresponding to exercise intensity labels. Consequently, studies conducted prior to 2006 may report that subjects exercised at a moderate intensity, but by current criteria, many of these subjects may actually have exercised at a light intensity. Therefore, the importance of exercise intensity is unclear in the smoking cessation literature partly due to study design, inconsistent or inappropriate use of accepted exercise intensity descriptors, and the re-categorization of exercise training heart rate zones and their associated descriptors.

It has been observed that similar cognitive mechanisms, such as self-efficacy, are associated with both smoking cessation and increased physical activity (King, Marcus, Pinto, Emmons, & Abrams, 1996). Interestingly, participants with high motivation to quit smoking and increase exercise may have higher drop-out rates, making it difficult to determine the efficacy of the intervention. For example, drop-out was a problem in a recent study by Stotts, Schmitz, and Grabowski (2003) where participants tried to quit smoking and drinking concurrently. Participants with high motivation for both changes at baseline dropped out more frequently than those whose motivation in the beginning was high for one behavior change only. Similarly, in those interventions where smoking cessation and weight control were targeted concurrently, quitting smoking was not very successful (Cheskin, Hess, Henningfield, & Gorelick, 2005; Hall, Tunstall, Vila, & Duffy, 1992). However, exercise interventions that were started some weeks before the quit day seemed quite promising (Kinnunen et al., 2008; Marcus et al., 1999). There is one interpretation of these data that has not been considered: It may be that targeting two behaviors (i.e., smoking and exercise) for change can only have additive effects when one behavior supports the other. That is, exercise and smoking cessation may be effective only when exercise serves to lessen withdrawal symptoms and cravings. Accordingly, this implies that combining treatments may be particularly useful for subsets of smokers, and/or that the exercise prescription may need to be very specific with respect to frequency and intensity to facilitate smoking cessation. Lastly, independent of exercise effects on smoking cessation, exercise may have health promoting qualities, such as improved weight control, blood pressure control, and lipid and glucose metabolism, which are all important in decreasing the total risk of morbidity, especially in smokers.

EXERCISE AS A TOBACCO HARM REDUCTION STRATEGY

In tobacco control, harm reduction can be defined as an effort to reduce health harms among continuing tobacco users, such as reducing toxins in tobacco smoke, promoting conversion of smoking to smokeless tobacco, or long-term complete substitution of nicotine as replacement therapy for tobacco (Gray & Henningfield, 2006). Another harm reduction strategy is decreased tobacco use—with or without conjoint use of NRT (Fiore et al., 2000). With the exception of medicinal nicotine products, no scientific evidence exists that these harm reduction strategies reduce tobacco-related morbidity or mortality (Godtfredsen, Prescott, Vestbo, & Osler, 2006; McNeill, 2004; Tønnesen, 2002). It has been suggested that a broader range of potentially effective harm reduction strategies should be considered. A recent review suggested that regular exercise could potentially be considered an additional harm reduction strategy (DeRuiter & Faulkner, 2006).

There are at least two types of smokers who may be targeted for harm reduction via exercise interventions (DeRuiter & Faulkner, 2006): smokers who are not willing to quit and smokers who are willing to quit but are unable to quit abruptly (Fagerström, 2005). In reference to the health-promoting effects of exercise, it is logical to assume that the detrimental effects associated with smoking could be partly offset through regular exercise. According to the review by DeRuiter and Faulkner (2006), exercise seems to fulfill, at least partially, those criteria of a potential novel harm reduction approach presented by Hatsukami, Henningfield, and Kotlyar (2004). Based on those criteria, an innovative harm reduction approach should reduce the occurrence of disease and death, not present additional health or safety risks, not reduce the likelihood of eventual cessation, not increase the level of tobacco dependence, and allow smokers to become free of tobacco. Concerning the last criterion, there is only slight evidence that exercise as such would be effective in smoking cessation. However, DeRuiter and Faulkner (2006) considered that this criterion could be fulfilled via additional health benefits obtained from exercise, as well as via beneficial effects on variables, such as stress, anxiety, and weight concerns, which mediate smoking relapse.

CONCLUSIONS AND FUTURE DIRECTIONS

At present, there seems to be slight evidence that regular exercise would be more helpful in long term smoking cessation in women in comparison to those more traditional cessation methods only. However, most intervention studies have been conducted with small samples, using inadequate exercise interventions, and with inattention to compliance in such a way that actual training effects may have been missed. Future research projects should address these issues and determine if there are optimal combinations of exercise and counseling to achieve better exercise adherence among smokers, particularly women smokers. Women who continue to smoke tend to have several CVD risk factors or health-compromising behaviors along with a lower socioeconomic status (Ruggiero, Webster, Peipert, & Wood, 2003). The consensus data lead to several recommendations that are readily apparent. Smoking cessation treatments need to become more readily available and accessible for all women so that they can experience the relatively

immediate benefits of quitting. A program should be designed that is ultimately successful for women's needs: It should identify and remove barriers preventing women from utilizing treatments, offer social support, and address weight concerns and negative affect, in addition to pharmacotherapy and standard smoking cessation counseling.

The aim of this paper was to comprehensively review findings regarding the efficacy of exercise for smoking cessation and to report on the relationships and hypothesized mechanisms mediating exercise and smoking cessation among women. We conclude that the benefits of exercise regarding women's health in general, and especially related to CVD, are well established. However, more research should explore the role of exercise in the treatment of tobacco dependence and other addictions. Moreover, further research should not be restricted to only efficacy studies of exercise in smoking cessation: It should also extend to the exploration of exercise as a harm reduction tool for those women who are not able to permanently quit smoking. This line of inquiry may also further research regarding the potential benefits of exercise in treatment or harm reduction of other addictions.

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