Published in final edited form as:

Addict Behav. 2011 August ; 36(8): . doi:10.1016/j.addbeh.2011.04.001.

Acute Effects of Moderate Intensity Aerobic Exercise on Affective Withdrawal Symptoms and Cravings among Women Smokers

David M. Williams, Ph.D.,
Brown University

Shira Dunsiger, Ph.D.,
Alpert Medical School of Brown University and The Miriam Hospital

Jessica A. Whiteley, Ph.D.,
University of Massachusetts, Boston

Michael H. Ussher, Ph.D.,
St George's, University of London

Joseph T. Ciccolo, Ph.D., and
Alpert Medical School of Brown University and The Miriam Hospital

Ernestine G. Jennings, Ph.D.
Alpert Medical School of Brown University and The Miriam Hospital

Abstract

A growing number of laboratory studies have shown that acute bouts of aerobic exercise favorably impact affect and cravings among smokers. However, randomized trials have generally shown exercise to have no favorable effect on smoking cessation or withdrawal symptoms during quit attempts. The purpose of the present study was to explore this apparent contradiction by assessing acute changes in affect and cravings immediately prior to and following each exercise and contact control session during an 8-week smoking cessation trial. Sixty previously low-active, healthy, female smokers were randomized to an eight-week program consisting of brief baseline smoking cessation counseling and the nicotine patch plus either three sessions/week of moderate intensity aerobic exercise or contact control. Findings revealed a favorable impact of exercise on acute changes in positive activated affect (i.e., energy) and cigarette cravings relative to contact control. However, effects dissipated from session to session. Results suggest that aerobic exercise has potential as a smoking cessation treatment, but that it must be engaged in frequently and consistently over time in order to derive benefits. Thus, it is not surprising that previous randomized controlled trials—in which adherence to exercise programs has generally been poor—have been unsuccessful in showing effects of aerobic exercise on smoking cessation outcomes.

© 2011 Elsevier Ltd. All rights reserved.

Corresponding Author: David M. Williams, PhD, Assistant Professor of Community Health, Brown University, Institute for Community Health Promotion, Box G-S121-8, Providence, RI 02912, phone: 401-863-6248, fax: 401-863-6551, david_m_williams@brown.edu.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Keywords

Moderate intensity exercise; smoking; cigarette cravings; affective withdrawal symptoms

1. Introduction

Exercise has been proposed as a potential treatment for smoking cessation because of its ability to alleviate affective withdrawal symptoms and reduce cravings—factors that are predictive of smoking relapse (Killen & Fortmann, 1997; Shiffman & Waters, 2004). Indeed, a recent comprehensive review of laboratory studies showed that after a brief period of abstinence (ranging from 30 minutes–17 hours) an acute bout of exercise (ranging from 5–40 minutes) can alleviate withdrawal symptoms and cravings (Taylor, Ussher, & Faulkner, 2007).

Conversely, a review of randomized clinical trials, in which exercise is used as a primary treatment or as a treatment adjunct to more conventional smoking cessation treatment (e.g., cognitive behavioral therapy, nicotine replacement), revealed mostly null effects of exercise, with only one out of 13 studies showing a significant effect of exercise. Moreover, these studies have not shown changes in affect or cravings from pre to post intervention (ranging from 8–52 weeks; Ussher, Taylor, & Faulkner, 2008).

One potential explanation for the apparent contradiction between laboratory studies and treatment trials is that the acute effect of aerobic exercise on withdrawal symptoms demonstrated in laboratory studies may be too short-lived to translate into sustained reductions in withdrawal symptoms during treatment trials in which exercise compliance tends to be sporadic (Ussher, et al., 2008). If this hypothesis is correct, then exercise should exert an acute effect (pre-post each exercise session), but not a sustained effect (from one exercise session to the next) on affective withdrawal symptoms.

Thus, the purpose of the present study was to examine both acute and sustained effects of moderate intensity exercise on affective withdrawal symptoms and cigarette cravings in the context of our previously conducted randomized controlled pilot study (Williams et al., 2010). We hypothesized that participants would experience favorable changes in affective states and greater reduction in cigarette cravings from pre-to-post exercise, but that these effects would dissipate from one exercise session to the next.

2. Methods

2.1 Participants

Participants ($N=60$) were healthy, low-active (<60 min/week of routine exercise) women (age 18–65) smokers (≥ 5 cigarettes/day for ≥ 1 year) enrolled in a smoking cessation trial (Williams et al., 2010; Table 1). All participants were required to obtain physician's consent and provide written informed consent.

2.2 Measures

2.2.1 Smoking status—Participants responded to the questions “are you currently smoking?” (yes/no) and (if not smoking) “have you smoked even one puff in the past 24 hours?” Carbon monoxide (CO) concentration of <10 ppm confirmed self-reported quit status.

2.2.2 Nicotine dependence—The overall score (14-items) from the Nicotine Dependence Syndrome Scale (NDSS; Shiffman, Waters, & Hickcox, 2004) was used to

assess nicotine dependence at baseline. The NDSS showed adequate reliability in the present study ($\alpha=.72$).

2.2.3 Cigarette cravings—Cigarette cravings were assessed with five items, rated from 0 (Not at all) to 100 (The strongest feeling possible), such as: “I have a desire for a cigarette right now;” “If it were possible, I would smoke now” (Shiffman et al., 2003). This scale showed adequate reliability at all time points in the present study ($\alpha=.88$).

2.2.4 Affective state—The Activation-Deactivation-Adjective-Checklist (ADACL) requires participants to rate their current experience of a number of affective states from 1 (Not at all) to 4 (Extremely). The ADACL has been shown to map on to the rotated dimensions of the circumplex model of affect (Ekkekakis, Hall, & Petruzzello, 2005). Accordingly, it has a total of four 5-item subscales: two subscales representing the dimension ranging from positive activation (energy) to negative deactivation (tiredness) and two subscales representing the dimension ranging from negative activation (tension) to positive deactivation (calmness). Energy, tiredness, tension, and calmness subscales showed adequate reliability at all time points in the present study ($\alpha=.92, .80, .69, .74$, respectively).

2.3 Procedures

Following consent and baseline assessment, all participants received a standard eight-week smoking cessation treatment, including: (a) brief (15–20 min) baseline counseling from a Ph.D. level psychologist; and (b) provision of the nicotine patch. Randomization into either exercise or control conditions occurred immediately following the baseline counseling.

2.3.1 Exercise Condition—Participants in the exercise condition engaged in three sessions per week of brisk walking for 50 minutes per session, thus equaling the recommended 150 minutes of moderate intensity aerobic exercise per week (Haskell et al., 2007; USDHHS, 2008). All exercise was performed on treadmills at our research center and monitored by research staff. Research staff limited their interactions with participants to assessment and scheduling. Because of scheduling conflicts, multiple participants sometimes exercised at the same time; however, interaction among participants was strongly discouraged. Also, in order to increase compliance, participants were able to watch a television tuned to the Gameshow Network. Participants in the exercise condition were asked not to engage in exercise outside of the supervised sessions.

2.3.2 Wellness Contact Control Condition—Participants in the wellness condition watched 30-minute films, three times per week, on a variety of health and lifestyle issues presented in previous trials, such as general health, safety, headaches, emotional and mental well-being, and sleep (Marcus et al., 1999, 2005). Films included minimal information on smoking cessation or exercise. Scheduling, assessments, and frequency of sessions were identical to the exercise condition. As with the exercise condition, interactions with staff and other participants were minimized. Participants in the wellness contact control condition were asked not to increase their exercise behavior.

2.3.3 Assessment Procedures—Cigarette craving and affective state were assessed immediately prior to and immediately following each exercise/wellness session. Participants were also asked to complete the cravings questionnaire immediately after arriving at their next destination after their exercise/wellness session. Smoking status was assessed at each session in order to control for its effects when examining the acute effects of exercise on craving and affect.

2.4 Data Analyses

Longitudinal regression models using Generalized Estimating Equations (Zeger & Liang, 1986) were used to examine the acute and sustained effects of treatment on affect and cravings. To examine between-treatment-group differences in pre-post session changes, we examined the interaction between treatment assignment and session time (i.e., pre- versus post-session) while controlling for the main effects of treatment assignment and session time, as well as baseline values of the outcome variable (i.e., affect or craving), quit status at time the outcome variable was assessed, and potential confounders as determined by preliminary analysis. In the context of these analyses, we examined the simple effects of treatment on pre-session scores as an indicator of sustained (session-to-session) effects of treatment on the outcome variable. All reported effects are model estimates adjusted for the above covariates.

3. Results

3.1 Between-group Comparison of Baseline Characteristics

At baseline, the exercise group was more likely to be employed ($\chi^2=5.89$, $df=1$, $p=0.02$) and to have lower nicotine dependence (NDSS; $t=2.20$, $df=55$, $p=0.03$); thus, these variables were controlled in subsequent models. There were no differences between groups on other baseline variables (Table 1).

3.2 Positive Activation / Negative Deactivation

Results revealed a significant interaction between treatment assignment and session time on the energy scale of the ADACL ($\beta=0.29$, $se=0.12$, $p=0.01$). Specifically, at post-session, exercise participants reported higher mean energy compared with wellness participants ($\beta=0.35$, $se=0.16$, $p=0.03$), whereas no significant differences were found at pre-session ($p=0.65$). A significant interaction between treatment assignment and session time was also observed for the tiredness scale of the ADACL ($\beta=-0.28$, $se=0.07$, $p<0.001$), with exercise participants reporting lower mean tiredness compared with wellness participants at post-session ($\beta=-0.34$, $se=0.13$, $p=0.01$) but not at pre-session ($p=0.66$).

3.3 Negative Activation / Positive Deactivation

There were no significant interactions between treatment assignment and session time on the tension or calmness scales of the ADACL, nor any main effects of treatment assignment on pre-session scores.

3.4 Cigarette Cravings

Results revealed a nearly significant interaction between treatment assignment and session time on cravings ($\beta=-5.42$, $se=2.93$, $p=0.07$ for post-session compared with pre-session; $\beta=-8.11$, $se=5.87$, $p=0.17$ for rating at next destination compared with pre-session). Specifically, cravings were slightly *higher* among exercise participants relative to wellness participants at pre-session ($\beta=4.16$, $se=3.33$, $p=0.21$), but slightly *lower* among exercise participants relative to wellness participants at both post-session ($\beta=-1.27$, $se=2.24$, $p=0.57$) and next destination ($\beta=-3.95$, $se=5.88$, $p=0.50$). The *change* in treatment *differences* in cravings (i.e., from higher among exercise participants prior to exercise/wellness to lower among exercise participants after exercise/wellness) drove the nearly significant interaction.

4. Discussion

This was the first study to assess the acute effects of moderate intensity aerobic exercise versus a contact control on affect and cravings among smokers who were attempting to quit.

Consistent with hypotheses, positive activated affect (i.e., energy) increased pre- to post-exercise relative to pre- to post-changes in the contact control condition. Likewise, negative deactivated affect (i.e., tiredness) decreased pre- to post-exercise relative to pre- to post-changes in the contact control condition. These findings are consistent with the rotated positive activation-negative deactivation dimension proposed in the circumplex model (Watson & Tellegen, 1985) in that positive activation (i.e., energy) increased as negative deactivation (i.e., tiredness) decreased.

There were, however, no changes in negative activated affect (i.e., tension) or positive deactivated affect (i.e., calmness) from pre- to post-exercise relative to pre- to post-changes in the contact control condition. Moreover, consistent with hypotheses and with our previous examination of sustained treatment effects on separate measures of anxiety, depression, and withdrawal symptoms in this sample (Williams et al., 2010), the absence of differences in pre-exercise/control affect from session-to-session indicated that there were no sustained effects of exercise on either affective dimension. Thus, while exercise exerted an acute effect on feelings of energy and tiredness, those effects dissipated from one session to the next.

Findings for cigarette cravings were more complicated. A marginally significant interaction effect revealed greater decreases in cravings from pre- to post-exercise relative to contact control. This interaction was accounted for by two opposing effects, neither of which was significant on its own. Specifically, results showed (a) *higher* mean cravings pre-exercise relative to pre-control, indicating that exercise resulted in slightly higher cravings from session-to-session; and (b) *lower* mean cravings post-exercise relative to post-control, indicating a relative decrease in acute cravings following the exercise session.

The present findings are consistent with those from a similar study in which women who were attempting smoking cessation and enrolled in a *vigorous intensity* aerobic exercise program displayed favorable acute (pre- to post-exercise) changes in affect and cigarette cravings, but no sustained effects of exercise (i.e., session-to-session) on affect or cravings (Bock, Marcus, King, Borrelli, & Roberts, 1999).

Limitations of the present study raise questions for future research. First, while participants in both the exercise and wellness contact control conditions viewed television during their sessions, the content differed significantly (Gameshow Network versus wellness information), thus potentially differentially impacting affective response. Second, it remains unclear as to exactly when the acute effects of exercise on withdrawal symptoms dissipate. Such information may be obtained through the use of ecological momentary assessment procedures (Shiffman, Stone, & Hufford, 2008) and will be important for determining optimal prescription for frequency of exercise. Finally, although we found no evidence in the present study of change over the course of the eight-week program in the direction or magnitude of acute effects of exercise on affect and cravings (i.e., no three-way interactions), it is possible that over an extended time, exercise loses its acute effects. Questions such as these must be addressed in clinical trials using state-of-the-art assessment methodology (e.g., EMA) and longer follow-up periods.

5. Conclusions

The present findings help to reconcile previous laboratory research showing favorable effects of exercise on affect and withdrawal symptoms among smokers (Taylor, Ussher, & Faulkner, 2007) with smoking cessation intervention research showing null effects of exercise on smoking cessation (Ussher, Taylor, & Faulkner, 2008). Specifically, the effects of exercise on proposed mechanisms of smoking cessation (i.e., affect and withdrawal

symptoms) appear to be short-lived, thus requiring adequate and sustained compliance with exercise programs in order to impact smoking cessation outcomes. In light of these findings, it is not surprising that previous randomized controlled trials—in which adherence to exercise programs has generally been poor—have been unsuccessful in showing effects of aerobic exercise on smoking cessation outcomes.

References

- Bock BC, Marcus BH, King TK, Borrelli B, Roberts MR. Exercise effects on withdrawal and mood among women attempting smoking cessation. *Addictive Behaviors*. 1999; 24(3):399–410. [PubMed: 10400278]
- Ekkekakis P, Hall EE, Petruzzello SJ. Evaluation of the circumplex structure of the Activation Deactivation Check List before and after a short walk. *Psychology of Sport and Exercise*. 2005; 6:83–101.
- Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin BA, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc*. 2007; 39(8):1423–1434. [PubMed: 17762377]
- Killen JD, Fortmann SP. Craving is associated with smoking relapse: findings from three prospective studies. *Experimental and Clinical Psychopharmacology*. 1997; 5(2):137–142. Retrieved from <http://psycnet.apa.org/journals/pha/>. [PubMed: 9234050]
- Marcus BH, Albrecht AE, King TK, Parisi AF, Pinto BM, Roberts M, et al. The efficacy of exercise as an aid for smoking cessation in women: A randomized controlled trial. *Archives of Internal Medicine*. 1999; 159(11):1229–1234. Retrieved from <http://archinte.ama-assn.org/>. [PubMed: 10371231]
- Marcus BH, Lewis BA, Hogan J, King TK, Albrecht AE, Bock B, et al. The efficacy of moderate-intensity exercise as an aid for smoking cessation in women: a randomized controlled trial. *Nicotine and Tobacco Research*. 2005; 7(6):871–880. [PubMed: 16298722]
- Shiffman S, Shadel WG, Niaura R, Khayrallah MA, Jorenby DE, Ryan CF, et al. Efficacy of acute administration of nicotine gum in relief of cue-provoked cigarette craving. *Psychopharmacology (Berlin)*. 2003; 166(4):343–350. [PubMed: 12601502]
- Shiffman S, Stone AA, Hufford MR. Ecological momentary assessment. *Annual Review of Clinical Psychology*. 2008; 4:1–32.
- Shiffman S, Waters A, Hickcox M. The nicotine dependence syndrome scale: a multidimensional measure of nicotine dependence. *Nicotine and Tobacco Research*. 2004; 6(2):327–348. [PubMed: 15203807]
- Shiffman S, Waters AJ. Negative affect and smoking lapses: a prospective analysis. *Journal of Consulting and Clinical Psychology*. 2004; 72(2):192–201. [PubMed: 15065954]
- Taylor AH, Ussher MH, Faulkner G. The acute effects of exercise on cigarette cravings, withdrawal symptoms, affect and smoking behaviour: a systematic review. *Addiction*. 2007; 102(4):534–543. [PubMed: 17286639]
- USDHHS. Physical Activity Guidelines Advisory Committee Report, 2008. Washington, DC: U.S. Department of Health and Human Services; 2008.
- Ussher MH, Taylor A, Faulkner G. Exercise interventions for smoking cessation. *Cochrane Database of Systematic Reviews*. 2008; 4 CD002295.
- Watson D, Tellegen A. Toward a consensual structure of mood. *Psychological Bulletin*. 1985; 98(2): 219–235. Retrieved from <http://psycnet.apa.org/journals/bul/>. [PubMed: 3901060]
- Williams DM, Whiteley JA, Dunsiger S, Jennings EG, Albrecht AE, Ussher MH, et al. Moderate intensity exercise as an adjunct to standard smoking cessation treatment for women: a pilot study. *Psychology of Addictive Behaviors*. 2010; 24(2):349–354. [PubMed: 20565161]
- Zeger SL, Liang KY. Longitudinal data analysis for discrete and continuous outcomes. *Biometrics*. 1986; 42(1):121–130. Retrieved from <http://www.biometrics.tibs.org/>. [PubMed: 3719049]

Table 1Baseline Participant Characteristics by Treatment Condition (N = 60^a)

	Exercise (<i>n</i> = 30) No. (%) or <i>M</i> (<i>SD</i>)	Wellness (<i>n</i> = 30) No. (%) or <i>M</i> (<i>SD</i>)
Age, years	41.5 (12.3)	43.3 (11.0)
Non-Hispanic-white	25 (83.3%)	26 (86.7%)
College graduate	12 (40.0%)	11 (36.7%)
Household income < \$40,000	15 (50.0%)	15 (50.0%)
Currently employed	28 (93.3%) [*]	22 (73.3%) [*]
Married	6 (20.0%)	5 (16.7%)
Body mass index (<i>n</i> = 54)	26.0 (4.3)	28.9 (8.1)
Age started smoking	17.4 (5.4)	18.1 (8.0)
Number of serious quit attempts	3.4 (5.6)	3.5 (3.8)
Cigarettes/Day		
10	8	6
11–20	14	17
21–30	7	4
31	1	3
Fagerstrom Test for Nicotine Dependence	4.5 (2.3)	5.1 (2.2)
Nicotine Dependence Syndrome Scale ^b	−0.7 (0.8) [*]	−0.2 (1.0) [*]

^aN = 60 unless otherwise indicated.^bHigher values correspond to higher levels of nicotine dependence.^{*}*p* < .05