TITLE

Effect of Brief Exercise on Urges to Smoke in Men and Women Smokers

AUTHORS

Alicia M. Allen,^{1,2} Nermine M. Abdelwahab,¹ Samantha Carlson,¹ Tyler A. Bosch,³ Lynn E. Eberly,⁴ Kola Okuyemi^{1,5}

¹ Department of Family Medicine & Community Health, Medical School, University of Minnesota
717 Delaware Street SE, Minneapolis, MN 55414

² Present Address: Department of Family & Community Medicine, College of Medicine,
University of Arizona, 3950 South Country Club Drive, Suite 330, Tucson, AZ 85742

³ College of Education and Human Development
516 Delaware Street SE, Minneapolis, MN 55455

⁴ Division of Biostatistics, School of Public Health, University of Minnesota
420 Delaware Street SE, MMC 303 Mayo, Minneapolis, MN 55455

⁵ Present Address: Department of Family and Preventive Medicine, University of Utah School of
Medicine, 375 Chipeta Way, Suite A, Salt Lake City, UT 84108

* Corresponding Author:

Alicia Allen, PhD, MPH

Present Address: Department of Family & Community Medicine, College of Medicine, University
of Arizona, 3950 South Country Club Drive, Suite 330, Tucson, AZ 85742

Email: aliciaallen@email.arizona.edu

Phone: 520-626-8157

Fax: 520-626-1080

ABSTRACT

Introduction: Although smoking urges have been demonstrated to vary by gender and also be influenced by exercise, it is unknown if exercise has a differential effect on smoking urges by gender. This study aimed to explore gender-specific effects of an acute bout of exercise on cessation-related symptoms in men and women smokers during acute abstinence.

Methods: We enrolled smokers (≥ 5 cigarettes/day) who were 18-40 years old for a study on exercise and smoking behavior. Participants abstained from smoking for at least three hours, prior to measurement of their maximal oxygen consumption tested, which was the acute bout of exercise. Prior to and after the exercise, participants completed the Questionnaire of Smoking Urges – Brief and the Minnesota Nicotine Withdrawal Scale.

Results: Participants ($n=38$; 61% women) were, on average, 30.0 ± 0.9 years old and smoked 13.0 ± 0.8 cigarettes/day. All measured aspects of cessation-related symptoms significantly improved after the exercise in both men and women. In women there was a significant decline in anticipated relief from negative affect after the exercise (women: -0.45 ± 0.20 , $p=0.0322$; men: -0.41 ± 0.26 , $p=0.1312$). In men there was a significant decline in the intention to smoke after the exercise (men: -0.77 ± 0.23 , $p=0.0053$; women: -0.66 ± 0.37 , $p=0.0909$).

Conclusions: An acute bout of exercise reduced smoking urges in both men and women smokers during an acute state of abstinence. Additional research is needed to replicate these observations in a larger, more diverse sample, and to explore the implication of these observations on cessation.

KEYWORDS

Exercise, Craving, Smoking Urges, Gender

Highlights

- Gender-specific effects of exercise on smoking urges is unknown.
- Smokers reported on smoking urges before and after a VO_2 peak test.
- Both genders had significant declines in urges to smoke, in craving and withdrawal.

1.0 INTRODUCTION

Gender differences in addiction generally show that females are more likely to become addicted to drugs and tend to present with higher rates of relapse compared to males.¹ Among cigarette smokers, women, as compared to men, are more likely to relapse from a smoking cessation attempt and suffer from more smoking-related morbidity and mortality.²⁻⁴ Therefore, identifying smoking cessation interventions that are effective for women is of public health importance.

Exercise has been investigated as a behavioral intervention for smoking cessation. While the effects of exercise on smoking cessation outcomes have been inconclusive,⁵ the benefits of exercise on reduction of cravings, withdrawal and smoking urges have been documented.⁵⁻⁸ The results of a recent meta-analysis indicate there were no sex/gender differences in the effect of exercise on craving.⁹ However, these observations are limited by at least two factors. First, studies included in this meta-analysis used standardized exercise interventions, without regard to participant fitness level. It is possible that a more fit individual would receive less benefit from the same bout of exercise than a less fit individual would. Second, only craving (specifically, strength of desire and desire to smoke) was explored. Thus, less is known about gender-specific effects of exercise on other aspects of cessation-related symptoms (such as smoking urges). This is of interest given men tend to relapse in response to craving, whereas women tend to relapse in response to negative affect.^{10,11}

This study aims to evaluate whether an acute bout of exercise, that is tailored to a participant's fitness level, influences smoking urges (intention to smoke, anticipated relief from negative affect), as well as craving and withdrawal, differently in men and in women smokers. First, we assessed the effect of the acute bout of exercise (6-12 minutes, depending on fitness level) on cessation-related symptoms while participants were in an acute state of abstinence (>3 hours). Second, we explored this effect separately within each gender. We hypothesized that exercise would reduce smoking urges in women smokers more than their male counterparts. Understanding how exercise may influence smoking urges, in addition to craving and withdrawal, differently in men and women may lead to innovative smoking cessation exercise interventions that are more tailored to the needs of women and, therefore, more effective for smoking cessation.

2.0 METHODS

2.1. Study Sample. This project is a secondary-data analysis from a larger study that examined the role of exercise on self-initiated quit attempts (results forthcoming) in young adult smokers (e.g., 18-40 years old). Potential participants completed a telephone interview followed by an in-person clinical examination to assess the following inclusion criteria: (1) current smokers ($\geq$ five cigarettes/day for $\geq$ six months), (2) between the ages of 18 and 40 years old, (3) inactive ($<$ two planned exercise sessions per week), (4) interest in increasing their exercise ($\geq$ 7 out of ten-point Likert-type scale), (5) planning to quit smoking within the next six months, and (6) stable mental/physical health based on an examination conducted by a nurse practitioner. Exclusion criteria for the study included any contraindications to starting an exercise program (e.g., high blood pressure, recent history of heart attack or other cardiac event, unstable angina, and any other unstable pulmonary or cardiovascular condition).

2.2. Study Procedures. All data for this paper were collected during the four-hour in-person screening visit. Prior to attending this visit, participants were instructed to abstain from cigarettes for at least three hours. Participants were also asked to abstain from strenuous exercise for two days, all types of exercise for twelve hours, all food for an hour and a half, and caffeine for an hour and a half. This was done for safety purposes, as well as to ensure maximal oxygen consumption testing accuracy and validity given these activities may influence test outcomes (e.g., nicotine, a stimulant, may have increased heart rate).

At the clinic visit, participants completed a maximal exercise test on a Precor 842i cycle ergometer. All exercise tests were monitored by a physician, with two to three additional study staff present for data collection and protocol implementation. Prior to the exercise test, participants underwent a 12-lead electrocardiogram (ECG; Quinton Q-Stress) in supine, sitting, and standing position. Upon normal ECG results, participants initiated the exercise test. During the test, heart rate and cardiac rhythm were continuously monitored by ECG. Blood pressure was measured immediately prior to testing, at two minute intervals during the test and for six minutes following recovery or until patient returned to baseline. Briefly, each participant was instructed to cycle at a rate of 50-70 rotations per minute (rpms); every two minutes the resistance was increased by an amount associated with a 1-2 metabolic equivalent (MET) increase in intensity with the goal of promoting volitional fatigue or reaching a predetermined maximal oxygen consumption (VO_2 Max) criteria for test termination within 6-12 minutes. Maximal oxygen consumption was assessed by the attainment of two of the following criteria: peak heart rate within 10 beats/minute of the age-predicted maximum heart rate ($220 - \text{age}$), peak respiratory exchange ratio (RER) ≥ 1.1 , and/or rating of perceived exertion

(RPE) ≥ 18 . Participants wore a nose clip during the testing to ensure that all expired air was captured in a Mouthpiece Saliva Trap Type (Green). Respiratory gas was measured using breath by breath analysis averaged over 30 seconds to assess peak oxygen consumption (VO_2 peak), CO_2 production, and RER using a mass spectrometer MGA 1100 with BIPS software (Beck's Physiological Systems).

To measure study outcomes of cessation-related symptomatology, two validated questionnaires were administered approximately 30 minutes prior to the exercise test and approximately 15 minutes after the exercise test, by which time participants' blood pressure had returned to baseline. The first questionnaire was the Questionnaire of Smoking Urges (QSU) Brief.¹² This questionnaire yields two subscales – Factor 1 and Factor 2. Factor 1 assesses the strong desire and intention to smoke, with smoking perceived as rewarding. Factor 2 is the anticipation of relief from negative affect with an urgent desire to smoke. The second questionnaire was the Minnesota Nicotine Withdrawal Scale (MNWS).¹³ The MNWS includes two subscales: craving and withdrawal, each resulting from eight items scored on a five-point Likert-type scale from 0 (no symptoms) to 4 (severe symptoms). Upon completion of the after-test questionnaires, participants were allowed to smoke. Participants were compensated with a \$30 Visa gift card at the end of the screening visit. All procedures were approved by the University of Minnesota's Human Research Protection Program.

2.3. Statistical Analysis. Descriptive statistics (means and standard errors) were computed to describe the study sample. Fisher's exact tests and two-sample t-tests were used to assess differences in characteristics by gender. The relationships between VO_2 score/exercise test duration and QSU/MNWS change scores, by gender and overall, were assessed using Pearson's correlation coefficients. Paired t-tests were used to test for a change in the QSU and MNWS scores from before the exercise test to after the exercise test. Changes in QSU and MNWS were assessed for all participants, as well as separately by gender, and gender differences were assessed by comparing the change scores by gender using two-sample t-tests. P-values <0.05 were considered statistically significant. SAS v. 9.4 (SAS Institute Inc., Cary, NC) was used for analyses.

3.0 RESULTS

3.1. Study Sample. Participants (n=38) included 23 women (60.5%) and 15 men (39.5%). The average age was 30.0 ± 0.9 years old, with 68.4% identifying as white, and 60.5% reporting at least some college. The average cigarettes/day reported was 13.0 ± 0.8 .

There were no statistically significant differences in demographics or smoking behavior by gender (Table 1), but there were in exercise test outcomes. Specifically, men exhibited a significantly higher absolute VO_2 peak ($28.7 \text{ ml/min/kg} \pm 1.3$) and longer duration of test (9.7 ± 0.2 minutes) compared to the women (VO_2 peak: $23.2 \pm 1.0 \text{ ml/min/kg}$ [$p=0.0016$] and test duration: 8.6 ± 1.1 minutes [$p=0.0005$]). Baseline cessation-related symptomatology, as assessed prior to the exercise testing, did not differ by gender.

3.2. Overall Effect of Exercise on Cessation-Related Symptomatology. Upon completion of the exercise test, all items of cessation-related symptomatology were significantly lower (Table 2). The effect ranged from a 14% decline in the intention to smoke (QSU Factor 1; Pre= 4.95 ± 0.28 vs. Post= 4.24 ± 0.32 ; $p=0.0060$) to a 38% decline in withdrawal (MNWS; Pre= 0.89 ± 0.11 vs. Post= 0.55 ± 0.08 ; $p=0.0004$). Exercise test duration and change in withdrawal were negatively correlated, such that across all participants, for longer durations, the change in withdrawal was smaller ($r=-0.40$, $p=0.0129$); the correlation of test score with change in withdrawal was also negative but smaller ($r=-0.21$, $p=0.2105$). There were no other significant correlations between exercise test duration or score and the change in craving or smoking urges, within either gender or overall.

3.3. Effect of Exercise on Cessation-Related Symptomatology by Gender. When we explored the change in cessation-related symptomatology separately within each gender, we noted the following: First, after the exercise test, the intention to smoke (QSU Factor 1) declined significantly in men (-0.77 ± 0.23 , $p=0.0053$) and in women, but to a lesser non-significant extent (-0.66 ± 0.37 , $p=0.0909$). While the anticipated relief of negative affect (QSU Factor 2) declined by about the same amount in each gender after the exercise test, there was a bit more variability in the change in men (women: -0.45 ± 0.20 , $p=0.0322$; men: -0.41 ± 0.26 , $p=0.1312$). Gender was not a statistically significant predictor of the change in any cessation-related symptom ($ps > 0.824$).

4.0 DISCUSSION

We observed that an acute bout of exercise, on average 8 to 10 minutes in duration, significantly reduced cessation-related symptomatology in adult daily cigarette smokers who were in a state of acute abstinence. These results replicate previous work which identified similar decreases in craving, withdrawal, and smoking urges after exercise.⁵⁻⁸ These data also extend the current literature by examining acute effects of exercise on smoking urges within each gender. Both smoking urges subscales (anticipated relief in negative affect and intention to smoke) declined similarly in both women and men.

While the reduction of withdrawal was inversely correlated with exercise test duration, the reduction of craving and smoking urges was not correlated with either exercise test duration or VO₂ peak score. This did not vary by gender. This suggests that, for both men and women, an acute bout of exercise, regardless of duration or individual physical fitness level, will reduce urges to smoking. Indeed, this observation concurs with a recently completed pilot study that observed a reduction in reactivity to smoking cues among participants who were randomized to an intervention designed to use physical activity to combat smoking urges.¹⁴ In contrast, the reduction of withdrawal symptoms was inversely correlated with duration of exercise, but not VO₂ peak score. This suggests that longer bouts of exercise may not be more advantageous and that this may not vary by individual fitness level. Future research may explore how to use acute bouts of exercise to directly combat smoking urges and withdrawal symptoms during attempts at smoking cessation.

Despite the novel exploration of gender-specific effects of a tailored acute bout of exercise on smoking urges, this project is not without limitations. First and foremost, this study has a small sample. Further, conducting analyses separately in women and men increases the chances of Type II error (e.g., false negative) given the smaller sample sizes of the gender specific groups. Second, our sample lacks diversity and contains selection bias. Our sample was predominantly white young inactive adults and only included participants who were motivated to increase their exercise. It is unknown how our observations apply to others. Third, although participants were asked to abstain from smoking for at least three hours prior to the session, we did not biochemically verify abstinence. However, because the exercise test was completed approximately two hours after arrival to the study visit, it was known that participants abstained for at least the duration of the study visit. Lastly, it is possible that the exercise test may have invoked anxiety or similar feelings as participants had to wear a mask and were under close observation. Therefore, the observations may not apply to other types of exercise and/or exercise under different conditions.

Overall, a short bout of tailored exercise significantly reduced cessation-related symptomatology in both men and women smokers. Future research should replicate these findings with larger, more diverse study samples, which will allow for formal statistical testing of gender differences, and longer bouts of abstinence.

Acknowledgements

We extend our thanks to Kimberly Nagel, Emily Lekah, Angela Tipp, and Jane Schulz, for their participation in recruitment and data collection, as well as Dr. Otto Sanchez, Mary Whipple, Ericka Tripp and Dereck Salisbury for their assistance with implementation of the exercise test. We also thank Scott Bischoff for his editorial assistance.

REFERENCES

1. Becker JB, Hu M. Sex differences in drug abuse. *Front Neuroendocrinol.* 2008;29(1):36-47. doi:10.1016/j.yfrne.2007.07.003.
2. Allen AM, Hatsukami D, Oncken C. Women and Smoking: Gender Influences on the Epidemiology, Health Effects, and Cessation of Smoking. *Curr Addict Reports.*
3. Smith PH, Bessette AJ, Weinberger AH, Sheffer CE, McKee SA. Sex/gender differences in smoking cessation: A review. *Prev Med (Baltim).* 2016. doi:10.1016/j.ypmed.2016.07.013.
4. CDC. *Smoking and Tobacco Use; Surgeon General's Reports; 2001.*; 2001. http://www.cdc.gov/tobacco/data_statistics/sgr/2001/index.htm. Accessed October 10, 2013.
5. Ussher MH, Taylor AH, Faulkner GEJ. Exercise interventions for smoking cessation. *Cochrane database Syst Rev.* 2014;8:CD002295. doi:10.1002/14651858.CD002295.pub5.
6. 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. doi:10.1111/j.1360-0443.2006.01739.x.
7. Schnoll RA, Hitsman B, Blazekovic S, et al. Longitudinal changes in smoking abstinence symptoms and alternative reinforcers predict long-term smoking cessation outcomes. *Drug Alcohol Depend.* 2016;165:245-252. doi:10.1016/j.drugalcdep.2016.06.017.

8. Nikos Zourbanos¹, * AH, Anastasia Tsiami¹, et al. An initial investigation of smokers' urges to smoke and their exercise intensity preference: A mixed methods approach. *Cogent Med.* 2016;3.
9. Haasova M, Warren FC, Ussher M, et al. The acute effects of physical activity on cigarette cravings: exploration of potential moderators, mediators and physical activity attributes using individual participant data (IPD) meta-analyses. *Psychopharmacology (Berl)*. 2014;231(7):1267-1275. doi:10.1007/s00213-014-3450-4.
10. Xu J, Azizian A, Monterosso J, et al. Gender effects on mood and cigarette craving during early abstinence and resumption of smoking. *Nicotine Tob Res.* 2008;10(11):1653-1661. doi:10.1080/14622200802412929.
11. Nakajima M, al'Absi M. Predictors of risk for smoking relapse in men and women: a prospective examination. *Psychol Addict Behav.* 2012;26(3):633-637. doi:10.1037/a0027280.
12. Cox LS, Tiffany ST, Christen AG. Evaluation of the brief questionnaire of smoking urges (QSU-brief) in laboratory and clinical settings. *Nicotine Tob Res.* 2001;3(1):7-16. doi:10.1080/14622200020032051.
13. Hughes JR, Hatsukami D. Signs and symptoms of tobacco withdrawal. *Arch Gen Psychiatry.* 1986;43(3):289-294. <http://www.ncbi.nlm.nih.gov/pubmed/3954551>. Accessed March 7, 2016.
14. Nair US, Patterson F, Rodriguez D, Collins BN. A telephone-based intervention to promote physical activity during smoking cessation: a randomized controlled proof-of-concept study. *Transl Behav Med.* November 2016. doi:10.1007/s13142-016-0449-x.

Table 1. Study Sample (n=38)

	All (n=38)	Women (n=23)	Men (n=15)	p-value ¹
Demographics				
Age ²	30.0±0.9	28.6±1.3	31.8±1.3	0.1621
Race ³				0.8783
African American or Black	4 (10.5%)	2 (8.7%)	2 (13.3%)	
American Indian or Alaskan Native	3 (7.9 %)	2 (8.7%)	1 (6.7%)	
Other/Mixed Race	5 (13.2%)	4 (17.4%)	1 (6.7%)	
White	26 (68.4%)	15 (65.2%)	11 (73.3%)	
Education ³				0.2699
High school graduate or equivalent	8 (21.0%)	3 (13.0%)	5 (33.33%)	
Some college or 2yr degree	23 (60.5%)	16 (69.6%)	7 (46.7%)	
College graduate or 4yr degree	7(18.0%)	4 (17.4%)	3 (20.0%)	
Smoking Behavior				
Cigarettes/Day ²	13.0±0.8	12.4±1.1	14.1 ±1.3	0.2127
First Morning Cigarette Smoked <30 minutes ³	22 (57.9%)	15 (65.2%)	7 (46.7%)	0.3235
Exercise Test Results				
Test Duration (minutes) ²	9.0±0.2	8.6±1.1	9.7±0.2	0.0005
Absolute VO ₂ Peak (ml/min/kg) ^{2,4}	25.4±0.9	23.2±1.0	28.7±1.3	0.0016

¹ p-values from Fisher's exact tests or two-sample t-tests² reported as mean± standard error³ reported as n (%)⁴ missing data from one participant due to equipment failure during testing

Table 2. Cessation-Related Symptoms in Relation to Exercise Test by Gender (n=38)

	Pre-VO2 ¹	Post-VO2 ¹	Difference (post – pre) ¹	p-value ²	Gender Difference ¹	p-value ³
Withdrawal ⁴						
All (n=38)	0.89±0.11	0.55±0.08	-0.34±0.09	0.0004	-0.03±0.18	0.8698
Men (n=15)	0.75±0.14	0.43±0.09	-0.32±0.10	0.0080		
Women (n=23)	0.99±0.16	0.63±0.12	-0.35±0.13	0.0128		
Craving ⁴						
All (n=38)	2.71±0.16	2.08±0.20	-0.63±0.17	0.0009	-0.05±0.36	0.8862
Men (n=15)	2.40±0.25	1.80±0.34	-0.60±0.21	0.0140		
Women (n=23)	2.91±0.19	2.26±0.25	-0.65±0.26	0.0184		
Total Smoking Urges ⁵						
All (n=38)	3.58±0.24	3.01±0.25	-0.57±0.18	0.0032	0.04±0.38	0.9225
Men (n=15)	3.19±0.32	2.59±0.38	-0.59±0.23	0.0198		
Women (n=23)	3.83±0.33	3.27±0.33	-0.56±0.26	0.0470		
Intention to Smoke ⁵						
All (n=38)	4.95±0.28	4.24±0.32	-0.71±0.24	0.0060	0.11±0.50	0.8239
Men (n=15)	4.47±0.42	3.69±0.50	-0.77±0.23	0.0053		
Women (n=23)	5.26±0.36	4.60±0.41	-0.66±0.37	0.0909		
Anticipated Relief from Negative Affect ⁵						
All (n=38)	2.21±0.24	1.77±0.22	-0.44±0.15	0.0077	-0.04±0.32	0.9044
Men (n=15)	1.91±0.33	1.49±0.33	-0.41±0.26	0.1312		
Women (n=23)	2.40±0.34	1.95±0.30	-0.45±0.20	0.0322		

¹ Values are mean ± standard error² p-values are from paired t-tests on cessation-related symptoms change³ p-values are from two-sample t-tests on cessation-related symptoms change by gender (women-men)⁴ Minnesota Nicotine Withdrawal Scale ¹³⁵ Questionnaire of Smoking Urges – Brief ¹²