



Pergamon

Available online at www.sciencedirect.com

SCIENCE @ DIRECT®

**ADDICTIVE
BEHAVIORS**

Addictive Behaviors 29 (2004) 765–772

Short communication

The effects of controlled deep breathing on smoking withdrawal symptoms in dependent smokers

F. Joseph McClernon^{a,*}, Eric C. Westman^{b,*}, Jed E. Rose^a

^aDepartment of Psychiatry, Nicotine Research Program, Duke University and Durham VA Medical Centers, 2200 W. Main St., B-150, Durham, NC 27705, USA

^bDepartment of Medicine, Smoking Research Laboratory, Duke University and Durham VA Medical Centers, 2200 W. Main St., B-200, Durham, NC 27705, USA

Abstract

This study was designed to assess the effect of controlled deep breathing on smoking withdrawal symptoms. In two laboratory sessions, dependent smokers refrained from smoking for 4 h. During a deep breathing session, participants were instructed to take a series of deep breaths every 30 min. During a control session, participants sat quietly. Controlled deep breathing significantly reduced smoking withdrawal symptoms, including craving for cigarettes and negative affect (tense, irritable), while resulting in the maintenance of baseline arousal (wide awake, able to concentrate) levels. Furthermore, a history of heavy smoking was associated with greater increases in arousal during the deep breathing session. The results of this preliminary study suggest that controlled deep breathing may be useful for relieving symptoms of smoking withdrawal.

© 2004 Elsevier Ltd. All rights reserved.

Keywords: Smoking cessation; Tobacco smoking; Respiration; Nicotine withdrawal; Craving; Emotional states

1. Introduction

Cigarette smoking is a complex behavior involving nicotine delivery, habitual behaviors, and sensory effects (Rose, Behm, Westman, & Johnson, 2000). Upon cessation of smoking,

* Corresponding authors. F. Joseph McClernon is to be contacted at Tel.: +1-919-668-3987; fax: +1-919-681-7504. Eric C. Westman, Tel.: +1-919-416-5242; fax: +1-919-286-6758, Department of Medicine, Smoking Research Laboratory, Duke University and Durham VA Medical Centers, 2200 W. Main St., B-200, Durham, NC 27705, USA.

E-mail addresses: mccle011@mc.duke.edu (F.J. McClernon), ewestman@duke.edu (E.C. Westman).

many smokers will experience a variety of smoking withdrawal symptoms, including cigarette craving, irritability, anxiety, depression, difficulty concentrating, restlessness, increased appetite, and weight gain (Gilbert et al., 2002; Hatsukami, Hughes, Pickens, & Svikis, 1984).

Many smokers cite deep breathing as one of the most commonly used coping strategies during cessation (O'Connell, Fears, Cook, & Gerkovich, 1991; O'Connell et al., 1998), and practitioners frequently recommend "taking deep breaths" as a strategy for reducing symptoms of smoking withdrawal (Shipley, 1997; U.S. Public Health Service, 2001). However, this recommendation is made despite little research supporting the efficacy of deep breathing for the relief of smoking withdrawal symptoms. Furthermore, the mechanism by which deep breathing might reduce smoking withdrawal symptoms is unclear.

The purpose of this study was to assess the effect of controlled deep breathing on smoking withdrawal symptoms in a group of dependent smokers in a laboratory setting. Because previous studies have found controlled breathing to be an effective treatment for panic disorder (Salkovskis, Jones, & Clark, 1986), we hypothesized that controlled deep breathing would reduce negative affect levels associated with smoking withdrawal.

2. Method

2.1. Participants

Twenty-one healthy volunteer smokers (mean age = 40.0; S.D. = 9.4; 67% female) were recruited from the community by newspaper advertisements. Participants smoked 29.3 (S.D. = 11.2) cigarettes per day for 23.1 (S.D. = 10.3) years. The mean Fagerström Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerström, 1991) score was 6.6 (S.D. = 1.9), and the mean Spielberger State-Trait Anxiety Inventory (STAI; Spielberger, 1983) score was 40.8 (S.D. = 11.5). Participants were compensated US\$10 per hour (US\$80 total) for their involvement in the study. Each read and signed informed consents approved by the local Institutional Review Board.

2.2. Materials

At baseline, participants completed demographic, smoking dependence, trait anxiety (STAI), and smoking motivation questionnaires (Ikard, Green, & Horn, 1969).

During experimental sessions, participants completed 33-item Shiffman and Jarvik smoking withdrawal symptom questionnaires (SJWQ; Shiffman & Jarvik, 1976). The questions were worded "Circle the number that most accurately reflects how you feel RIGHT NOW," scored on a Likert scale from 1 (*not at all*) to 7 (*extremely*). The withdrawal questionnaire consisted of six subscales: craving; negative affect; arousal¹; somatic symptoms; appetite¹;

¹ The items "Did you have trouble sleeping last night?" and "Have you eaten more than usual?" were removed from the arousal and appetite scales, respectively.

and habit. The 20-item STAI (Spielberger, 1983) was administered at the same times as the SJWQ.

2.3. Procedures

Participants were asked to abstain from smoking as of midnight prior to two morning sessions, and abstinence was verified by exhaled carbon monoxide ($\text{CO} < 20$ ppm). During each session, participants refrained from smoking for 4 h in a quiet room while under observation by study personnel. They completed the SJWQ every hour, at approximately 8, 9, 10, and 11 a.m., and at 12 noon. In the controlled deep breathing condition, participants completed two SJWQs hourly—one immediately before and one immediately after every other controlled deep breathing exercise starting with the first. The order of session (controlled deep breathing vs. control) was randomly assigned and counterbalanced.

During the controlled deep breathing session, participants were instructed to take deep breaths every 30 min during the 4 h session to mimic breathing associated with smoking behavior. Participants were monitored during inhalations and were instructed to take in a deep breath over 5 s, hold their breath for 2 s, and then exhale slowly over 5 s. The deep breaths were repeated every 30 s for a total of 5 breaths. All participants engaged in light reading during free portions of the morning.

2.4. Analytic strategy

To assess for the effects of controlled deep breathing on anxiety and smoking withdrawal symptoms, scale scores from (1) all five measurement periods on the control condition day and (2) the measurement period following every other breathing exercise on the controlled deep breathing condition day were entered into a 5 (periods: 1, 2, 3, 4, and 5) \times 2 (conditions: controlled deep breathing and control) repeated measures analysis of variance (ANOVA). Post hoc pairwise comparisons were used to examine significant ANOVA effects. Greenhouse and Geisser's (1959) correction for sphericity of repeated measures was used, although noncorrected *dfs* are reported for clarity. To ensure equivalent pre-session scores, *t* tests were conducted. Preliminary analyses indicated that "order" (controlled deep breathing session first, controlled deep breathing session second) did not account for significant variance and was removed from further analyses. Measures of nicotine dependence, smoking motivation, and trait anxiety were correlated with symptom change scores associated with the controlled deep breathing session.

3. Results

Results of *t* tests comparing scale scores from the first assessment period of each day confirmed equivalent levels ($P_s > .1$) for all withdrawal and state anxiety scales.

Reported craving levels were lower in the controlled deep breathing condition than in the control condition, $F(1,7) = 22.44$, $P = .002$; see Fig. 1. Follow-up pairwise comparisons

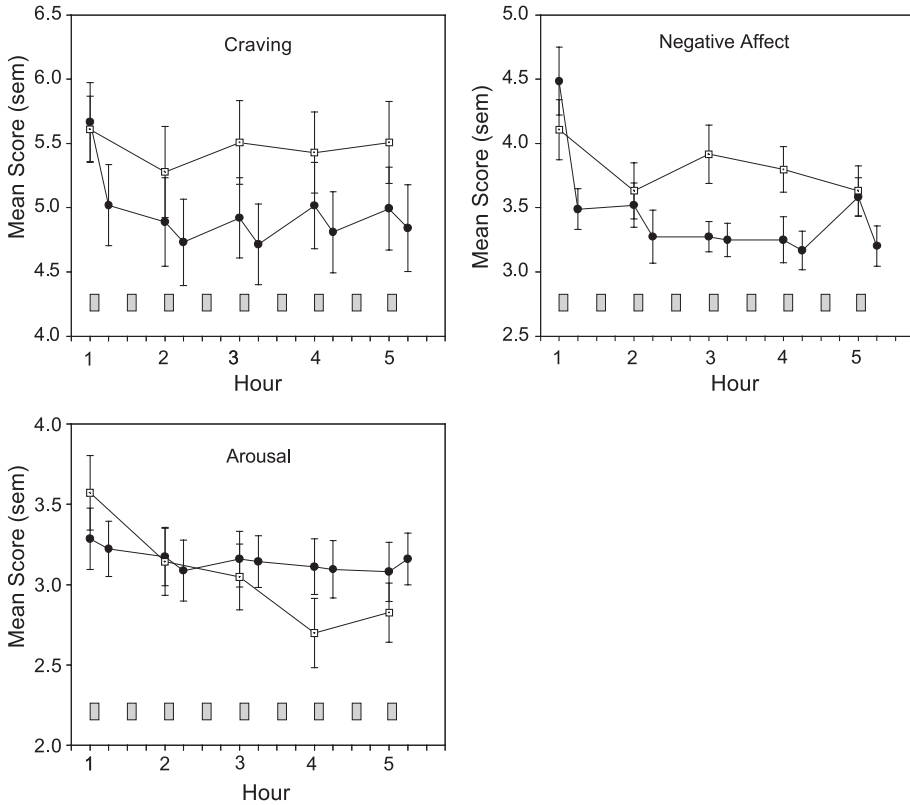


Fig. 1. Mean self-report craving, negative affect, and arousal levels during controlled deep breathing (●) and control (□) sessions. During the deep breathing session, participants took five deep breaths over a 5-minute period (■) every half hour, but measures of anxiety and withdrawal symptoms were completed only before and after controlled deep breathing on the hour. Deep breathing resulted in reduced craving and negative affect levels, $F(1,7)=22.44$ and 23.00 , respectively; $P_s < .01$, while resulting in the maintenance of self-report arousal levels, $F(4,28)=4.23$; $P < .05$.

indicated significantly ($P < .05$) lower craving levels in the deep breathing condition relative to the control condition at each of the five assessment periods.

Negative affect levels were also significantly lower in the controlled deep breathing condition relative to the control condition, $F(1,7)=23.00$, $P=.002$; see Fig. 1. Pairwise comparisons indicated significantly ($P < .05$) lower negative affect levels during the deep breathing condition in all but the second assessment period.

Over period, arousal decreased significantly, $F(4,28)=7.61$, $P=.004$, and a Period \times Con-Condition interaction was observed, $F(4,28)=4.23$, $P=.025$; see Fig. 1. Examination of means and follow-up pairwise comparisons indicated largely equivalent arousal levels until Period 4, when scores dropped significantly ($P < .05$) below baseline levels in the control condition. Arousal scores were higher in the controlled deep breathing condition compared to the control condition at Periods 4 ($P < .05$) and 5.

A main effect of period was observed for somatic symptoms scores, $F(4,28)=7.97$, $P=.002$, indicating significant decreases in somatic symptoms' levels over time across conditions. No significant effects were observed for state-anxiety, appetite, or habit scores.

To assess the effects of controlled deep breathing on symptom reports, t tests were conducted between each assessment point for the craving and negative affect scales during the controlled deep breathing session. Significant decreases in craving levels were observed after the first, $t(20)=3.05$, $P=.006$, and third, $t(20)=2.17$, $P=.047$, deep breathing exercises. Furthermore, a significant increase in craving level was observed from after the fifth deep breathing exercise to before the seventh exercise, $t(20)=-2.32$, $P=.031$. For negative affect levels, significant decreases were observed after the first, $t(20)=4.62$, $P<.001$, and ninth, $t(20)=3.34$, $P<.003$, deep breathing exercises, while a significant increase was observed from after the seventh to before the ninth breathing exercise, $t(20)=-3.22$, $P=.004$.

Correlations were calculated between controlled deep breathing session symptom change scores (first assessment–last assessment) and baseline nicotine dependence and smoking motivation scores (all P s two-tailed). Number of cigarettes per day and the FTND scores were positively associated with changes in arousal levels, $r=.609$ and $r=.444$, respectively (P s $<.05$), such that deep breathing resulted in increased reported arousal levels for heavier smokers. Decreases in appetite during the controlled deep breathing session were associated with more years of smoking ($r=-.483$), smoking for relaxation ($r=-.495$), and smoking for habit withdrawal ($r=-.672$, all P s $<.05$). Finally, decreases in habit-related symptoms (missing something to do with hands/mouth) were associated with more years of smoking ($r=-.484$), smoking for stimulation ($r=-.439$), smoking for craving ($r=-.550$), smoking for taste ($r=-.460$), and smoking for tension reduction ($r=-.484$).

4. Discussion

In this study, we found preliminary evidence that controlled deep breathing relieved several symptoms of smoking withdrawal. Relative to the control condition, controlled deep breathing significantly reduced levels of craving and negative affect while resulting in the maintenance of self-report arousal. These findings may be particularly important given that the craving for cigarettes and negative affect are among the most commonly reported symptoms of tobacco withdrawal (Gilbert et al., 2002; Hatsukami et al., 1984) and are reportedly strong predictors of relapse (Ockene et al., 2000).

In addition to overall reductions in craving for cigarettes and negative affect, controlled deep breathing resulted in significant reductions in the level of these symptoms at multiple points during the session; that is, symptom reductions that occurred largely after the first breathing exercise were maintained over the course of the session by additional exercises. Moreover, in the case of arousal, controlled deep breathing appeared to help smokers maintain levels over the course of the session. These time-course effects suggest that controlled deep breathing, when employed as in the present study, may provide smokers with quick relief from withdrawal symptoms that can then be maintained by continued use.

Correlational analyses indicated that controlled deep breathing may be particularly helpful to heavy smokers, as they experienced greater increases in arousal levels during the deep breathing session than their less dependent counterparts. Furthermore, longer term smokers had greater reductions in both appetite and habit-related withdrawal symptoms. These findings suggest that heavier, longer term smokers may exact additional benefits from controlled deep breathing as part of a cessation attempt—a potentially useful finding given the high relapse rates for this group (Ockene et al., 2000).

4.1. Mechanisms of action

How might controlled deep breathing reduce smoking withdrawal symptoms? A number of reports suggest that controlled slow respiration and deep breathing can reduce physiological arousal and self-reported anxiety (McCaul, Solomon, & Holmes, 1979), and reduce the frequency and intensity of panic attacks in patients with panic disorder (Salkovskis et al., 1986).

The anxiolytic effects of paced respiration noted above may account for the observed reductions in self-report negative affect levels but do not provide an adequate explanation for the effect observed for craving reports. Recent evidence highlights the importance of sensory components of cigarette smoking in the addiction process. Smoking denicotinized cigarettes, for instance, results in decreased craving for cigarettes and is rated by smokers as providing greater satisfaction and reward than receiving their preferred amount of nicotine intravenously (Rose et al., 2000). Controlled deep breathing by smokers, particularly in a manner that mimics cigarette smoking, may therefore result in a sensory and motor experience similar enough to smoking to relieve craving for cigarettes.

We therefore hypothesize that controlled deep breathing may provide some relief from the symptoms of smoking withdrawal via (1) inherently anxiolytic effects of deep breathing and (2) partial reproduction of the sensory and motoric characteristics of cigarette smoking.

4.2. Clinical implications

The observed effects of controlled deep breathing in this study suggest that it may be a useful addition to cognitive, behavioral, and pharmacological smoking cessation interventions. Furthermore, it may provide unique benefits to heavier smokers. We propose that the more closely a breathing exercise reproduces respiration during smoking, the greater the beneficial effect it may provide. For instance, taking breaths through a cigarette substitute or straw may prove more effective than the type of breathing exercise used in our study.

The smokers in our study did not use controlled deep breathing on an as-needed or ad-lib basis but rather completed the exercise on a fixed schedule. While the question of differential effectiveness as a function fixed versus ad-lib use is an empirical one, our results provide preliminary evidence that fixed, scheduled use can be beneficial. Such a scheduled intervention, if used as a cessation treatment, would likely require some sort of electronic timing device/reminder.

4.3. Limitations

This study is limited in several ways. The most obvious limitation is that the control condition required participants to only read quietly and did not include a distracting although theoretically nontherapeutic behavioral alternative to controlled deep breathing; that is, participants may have guessed that the breathing exercises were meant to reduce withdrawal symptoms and responded to questionnaires accordingly—a situation that would not have occurred in the control condition. While this design limitation would not explain why the breathing exercises reduced some (e.g., craving, negative affect) but not other (e.g., state anxiety, somatic) withdrawal symptoms, future designs should include control behaviors that require active regulation of breathing by participants (e.g., taking quick shallow breaths).

Because our participants were not trying to quit smoking and knew they could resume smoking after the session, the severity of smoking withdrawal symptoms they experienced may have been smaller than would be expected during a cessation attempt. Furthermore, participants in this study were observed in a controlled laboratory setting and were presumably free of the everyday environmental stressors and drug-related cues typically associated with smoking. Both of these issues call into question the generalizability of our findings and emphasize the need for clinical trials employing smokers motivated to quit smoking.

Acknowledgements

This study was funded by the Veterans Affairs Merit Review Program. Special thanks go to the Medical Research Service of the Durham Veterans Affairs Medical Center, to Christine Perkins, Loretta Braxton, and Keith Tomlin for assistance in preparing and reviewing drafts of the manuscript.

References

- Gilbert, D. G., McClernon, F. J., Rabinovich, N. E., Plath, L. C., Masson, C. L., Anderson, A. E., & Sly, K. F. (2002). Mood disturbance fails to resolve across 31 days of cigarette abstinence in women. *Journal of Consulting and Clinical Psychology, 70*, 142–152.
- Greenhouse, S. W., & Geisser, S. (1959). On methods in the analysis of profile data. *Psychometrika, 24*, 95–112.
- Hatsukami, D. K., Hughes, J. R., Pickens, R. W., & Svikis, D. (1984). Tobacco withdrawal symptoms: An experimental analysis. *Psychopharmacology, 84*, 231–236.
- Heatherington, T. F., Kozlowski, L. T., Frecker, R. C., & Fagerström, K. O. (1991). The Fagerstrom test for nicotine dependence: A revision of the Fagerström tolerance questionnaire. *British Journal of Addiction, 86*, 1119–1127.
- Ikard, F. F., Green, D. E., & Horn, D. (1969). A scale to differentiate between types of smoking as related to the management of affect. *International Journal of the Addictions, 4*, 649–659.
- McCaul, K. D., Solomon, S., & Holmes, D. S. (1979). Effects of paced respiration and expectations on physiological and psychological responses to threat. *Journal of Personality and Social Psychology, 37*, 564–571.
- Ockene, J. K., Mermelstein, R. J., Bonollo, D. S., Emmons, K. M., Perkins, K. A., Voorhees, C. C., & Hollis, J. F. (2000). Relapse and maintenance issues for smoking cessation. *Health Psychology, 19*, 17–31.

- O'Connell, K. A., Fears, B. A., Cook, M. R., & Gerkovich, M. M. (1991). Overcoming the urge to smoke: The strategies of long-term abstainers and late relapsers. *Psychology of Addictive Behaviors*, 5, 1–8.
- O'Connell, K. A., Gerkovich, M. M., Cook, M. R., Shiffman, S., Hickcox, M., & Kakolewski, K. E. (1998). Coping in real time: Using ecological momentary assessment techniques to assess coping with the urge to smoke. *Research in Nursing and Health*, 21, 487–497.
- Rose, J. E., Behm, F. M., Westman, E. C., & Johnson, M. (2000). Dissociating nicotine and nonnicotine components of cigarette smoking. *Pharmacology, Biochemistry and Behavior*, 67, 71–81.
- Salkovskis, P. M., Jones, D. R., & Clark, D. M. (1986). Respiratory control in the treatment of panic attacks: Replication and extension with concurrent measurement of behaviour and pCO₂. *British Journal of Psychiatry*, 148, 526–532.
- Shiffman, S., & Jarvik, M. E. (1976). Smoking withdrawal symptoms in two weeks of abstinence. *Psychopharmacology*, 50, 35–39.
- Shiple, R. H. (1997). *QuitSmart stop smoking guide*. Durham, NC: JB Press.
- Spielberger, C. D. (1983). *Manual for the state-trait anxiety inventory*. Palo Alto: Consulting Psychologists Press.
- U.S. Public Health Service. (2001). Tips for the first week: You can quit smoking [On-line]. Available: <http://www.surgeongeneral.gov/tobacco/1stweek.htm>.