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Negative affect as a mediator of the relationship between vigorous-intensity exercise and smoking

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ABSTRACT

The present cross-sectional study evaluated whether people who engage in vigorous-intensity exercise are better able to regulate negative affective states, thereby changing core maintenance factors of smoking. Participants were a community sample of adults ($n = 270$) who completed self-report measures of physical activity, cigarette smoking, anxiety sensitivity, and negative affect. Consistent with hypothesis, vigorous-intensity exercise was related to lower levels of cigarette smoking, accounting for 10% of the variance in smoking. Additionally, negative affect mediated the relationship between vigorous-intensity physical activity and cigarette smoking, accounting for about 12% of this relation. Furthermore, these relationships were stronger for individuals with high anxiety sensitivity than for those with low anxiety sensitivity; including anxiety sensitivity as a moderator of the mediated relationship increased the amount of variance accounted for by negative affect to 17%. The findings are discussed in relation to developing further scientific insight into the mechanisms and pathways relevant to understanding the association among vigorous-intensity exercise, smoking, and emotional vulnerability.

1. Introduction

Growing evidence points to the role of negative affect in the maintenance of smoking and smoking cessation relapse. For example, when asked about triggers of smoking cessation relapse smokers consistently point to the experience of stress and negative affect (Brandon & Baker, 1991; Piper et al., 2004). These retrospective reports are complemented by prospective studies that indicate that negative affect is an important precipitating factor in smoking lapses and relapses. Specifically, ecological momentary assessments from 215 smokers collected during the two weeks before and four weeks after initiation of smoking cessation treatment indicate that abrupt increases in negative affect are associated with smoking lapses (Shiffman & Waters, 2004). Similarly, baseline negative affect and increases in negative affect during treatment have been shown to be the most reliable predictors of relapse in clinical trials of smoking cessation treatments (Covey, Glassman & Stetner, 1990; Hitsman et al., 1999; Kahler et al., 2002; Lerman et al., 2002; Niaura et al., 2001; Zelman, Brandon, Jorenby & Baker, 1992; Zvolensky et al., 2008). Lastly, reducing negative affect during smoking cessation treatment has been shown to improve abstinence outcomes both with psychological interventions (e.g., Fergusson, Goodwin & Horwood, 2003; Hall, Muñoz & Reus, 1994; Haas, Muñoz, Humfleet, Reus & Hall, 2004) and pharmacological interventions (e.g., Hughes, Stead & Lancaster, 2007; Prochazka, Kick, Steinbrunn, Miyoshi & Fryer, 2004; Richmond & Zwar, 2003). Collectively, these findings suggests that addressing negative affect in smokers may be important especially for those who are more prone to experience negative affect (Brown et al., 2001; Haas et al., 2004).

The relatively poor outcomes of standard smoking cessation treatments (Fiore, 2000; Hughes, Keeley & Naud, 2004; Piasecki, 2006) combined with the observation that targeting negative affect during treatment may be critical to cessation success for many smokers (i.e., those who are prone to experience negative affect) provide justification for investigating the utility of exercise as an intervention for smoking cessation. Indeed, exercise is associated with reduced negative affect (Focht, Knapp, Gavin, Raedeke & Hickner, 2007; Hassmen, Koivula & Uutela, 2000; Penedo & Dahn, 2005; Reed & Ones, 2006; Schlicht, 1994) and more importantly, exercise interventions have shown efficacy for the treatment of mood and anxiety problems (Smits et al., 2008; Stathopoulou, Powers, Berry, Smits & Otto, 2006; Broocks et al., 1998; Martinsen, Hoffart & Solberg, 1989a, 1989b). Furthermore, cross-sectional surveys have consistently shown a negative relationship between physical activity levels and smoking (e.g. Boutelle, Murray, Jeffery, Hennrikus & Lando, 2000; Boyle, O'Connor, Pronk & Tan, 2000; Hu et al., 2002). Likewise, there is initial evidence from randomized controlled trials indicating that exercise interventions can decrease withdrawal symptoms and

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negative affect in smokers (Bock, Marcus, King, Borrelli & Roberts, 1999; Schneider, Spring & Pagoto, 2007; Taylor, Ussher & Faulkner, 2007) as well as improve smoking cessation outcomes among adults receiving standard cessation treatments (cf. Ussher, Taylor & Faulkner, 2008; Marcus, Albrecht, Niaura, Abrams & Thompson, 1991; Marcus et al., 1995; Marcus et al., 1999; Martin, Kalfas & Patten, 1997). For example, Marcus and colleagues (1999) randomized 281 sedentary female smokers to either a 12-week cognitive-behavioral smoking cessation program with vigorous-intensity exercise (three sessions a week of 30 to 40 min at 60–85% of heart rate reserve), or a 12-week cognitive-behavioral smoking cessation program with contact control (three 45–60 minute health education sessions a week). All participants initiated the intervention three weeks prior to the quit date of the smoking cessation program. Results revealed that participants receiving the exercise intervention were more likely than participants in the control intervention to be continuously abstinent during the 8, 20, and 60 weeks following the quit date. Unfortunately, neither this study nor other studies in this area have investigated whether the association between exercise and reduced smoking is accounted for by reductions in negative affect. Evidence for this mediational hypothesis would help determine whether exercise is a viable option for smokers for whom negative affect operates prominently in the maintenance of smoking and smoking cessation relapse.

This study aimed to provide a preliminary test of the hypothesis that the association between exercise and smoking is, at least in part, accounted for by reduced negative affect. Using cross-sectional data, we examined self-reported negative affect as a mediator of the relationship between self-reported vigorous-intensity exercise levels and smoking. We chose to evaluate the relationship between *vigorous-intensity* exercise and smoking because there is evidence to suggest that the association between exercise and cigarette smoking is stronger for vigorous-intensity exercise relative to moderate- or low-intensity exercise (cf. Kaczynski, Manske, Mannell & Grewal, 2008). We also investigated the possibility that the strength of these meditational effects would vary as a function of anxiety sensitivity. Anxiety sensitivity, conceptualized as an emotional vulnerability variable, is a relatively stable trait (Peterson & Plehn, 1999; Weems, Hayward, Killen & Taylor, 2002) characterized by the fear of both anxiety and related autonomic arousal sensations (e.g., racing heart, sweating, nausea; Reiss, Peterson, Gursky & McNally, 1986). We selected anxiety sensitivity as a possible moderator of the hypothesized mechanism because of the increasing evidence that individuals with elevated levels of anxiety sensitivity, relative to persons with low levels of anxiety sensitivity, are more likely to smoke in response to negative affect (Brown, Kahler, Zvolensky, Lejuez & Ramsey, 2001; Brown, Lejuez, Kahler & Strong, 2002; Novak, Burgess, Clark, Zvolensky & Brown, 2003; Zvolensky, Bonn-Miller, Bernstein & Marshall, 2006). Furthermore, smokers with higher levels of anxiety sensitivity are more likely to report negative affect reduction as a smoking outcome expectancy than smokers with lower levels of anxiety sensitivity (Brown et al., 2001; Zvolensky et al., 2007). Accordingly, negative affect reduction as a mechanism underlying the relationship between exercise and smoking may be more salient for individuals with high versus low anxiety sensitivity. We tested the following specific hypotheses: (1) vigorous-intensity exercise engagement would be associated with decreased smoking; (2) the relationship between vigorous-intensity exercise engagement and smoking would be partially mediated by negative affect; and (3) anxiety sensitivity would moderate these mediated relationships such that the mediational role of negative affect would be stronger for individuals with high levels of anxiety sensitivity relative to those with low levels of anxiety sensitivity. Based on the available evidence, we predicted that anxiety sensitivity would moderate the relationship between negative affect and smoking (i.e. the "b" path, see Fig. 3) as opposed to the relationship between exercise and negative affect (i.e. the "a" path, see Fig. 3).

Table 1
Demographics of sample.

Variables	
Age	
M	22.4
SD	9.0
Gender	
% Female	52.6
Race	
% White	90.4
Education	
% H.S. Diploma/GED or less	77.8
% Some college or more	21.2

2. Material and methods

2.1. Participants

The sample consisted of 270 young adult smokers and non-smokers (see Table 1). Interested persons responded to advertisements for a study on emotional vulnerability within the greater Burlington, Vermont community. Exclusion criteria for the current study included: (1) limited mental competency or the inability to provide informed, written consent; (2) current suicidal or homicidal ideation; (3) current or past history of psychosis; (4) current (past 6-month) Axis I psychopathology (except for substance use disorders); (5) current major medical problems (e.g., heart disease, cancer); (6) current substance dependence (other than nicotine); and (7) self-reported pregnancy.

The racial distribution of the sample generally reflected that of the State of Vermont (State of Vermont Department of Health, 2007; see Table 1). Those that identified themselves as smokers (approximately 50%) averaged 12.99 cigarettes per day ($SD = 7.61$) with a mean age of onset for daily cigarette use of 16.20 ($SD = 3.15$) years of age. Mean expired air CO levels among smokers in this sample was 15.3 ppm (2.8%), which is consistent with that of a regular daily smoker (10 ppm cutoff; Cocores, 1993). The mean score on the Fagerström Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker & Fagerström, 1991) among smokers was 3.53 ($SD = 2.05$), indicating a relatively low-level of nicotine dependence.

2.2. Measures

2.2.1. Diagnostic screen

The Structured Clinical Interview-Non-Patient Version for DSM-IV (SCID-N/P; First & Gibbon, 2004) screening questions were administered to rule out psychopathology and assess for current suicidal ideation (see exclusionary criteria).

2.2.2. Vigorous-intensity exercise

The Exercise Habits Questionnaire Revised (EHQ-R; Zvolensky, 2008) is a self-report measure used to obtain information about participants' engagement in physical activity. The EHQ-R asks respondents to indicate for 29 different physical activities (e.g., running, stair stepping, walking/hiking, swimming, hockey, golf, martial arts, rock climbing, yoga) the number of sessions they have completed in the past two weeks as well as the time spent per session (e.g., less than 20 min; 20–29 min; 30–39 min; 40–49 min; 50 min or more). This information was used in combination with the compendium of physical activities (Ainsworth et al., 2000) to calculate total minutes of weekly vigorous-intensity exercise.[1]

[1] For minutes spent per session, we used the midpoint of the range (e.g. 1 = <20 min equaled 10 min; 2 = 20–29 min equaled 24.5 min) and for "50 min or more," we used 50 min. We classified activities associated with metabolic equivalent (METS) values greater than 6 as vigorous (Ainsworth et al., 2000).