



Anxiety Sensitivity is Associated with Lower Enjoyment and an Anxiogenic Response to Physical Activity in Smokers

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Abstract

The subjective affective response to, and enjoyment of, physical activity are strong predictors of engagement in physical activity. Anxiety sensitivity, the fear of bodily sensations, is a cognitive factor that may inhibit the pleasurable affective experience of physical activity, possibly contributing to low levels of physical activity. The current study evaluated anxiety sensitivity in relation to PA enjoyment and affective experience before and after exercise in smokers. Participants were low-active treatment-seeking smokers ($n = 201$) enrolled in a smoking cessation intervention. At baseline, participants completed self-report assessments of anxiety sensitivity, cigarette dependence, and physical activity enjoyment. State affect was also reported before and after a submaximal exercise test to index pre-exercise activity affect and affective response to exercise. Anxiety sensitivity was significantly negatively correlated with physical activity enjoyment, specifically lower enjoyable physical feelings of physical activity. Anxiety sensitivity was significantly correlated with lower state mood and higher state anxiety prior to the submaximal exercise test, and higher anxiety immediately after the exercise test. Additionally, anxiety sensitivity predicted increased anxiety, but not lower mood, in response to the submaximal exercise test. This is the first study to document an association of anxiety sensitivity with affective determinants of physical activity behavior in smokers. Anxiety sensitivity was associated with lower physical activity enjoyment, higher negative affect prior to and after exercise testing, and an anxiogenic response to exercise. Future work is needed to understand how the current findings generalize beyond smokers.

Keywords Exercise · PACES · Affective response · Anticipated affect · Anxiety vulnerability

Introduction

There is clear evidence that physical activity (PA) reduces risk of early morbidity and mortality (U.S. Department of Health and Human Services 2014). There are also well-documented benefits of regular PA and aerobic exercise for mental health, including depression and anxiety (Asmundson

et al. 2013; Carek et al. 2011; Cooney et al. 2013; de Souza Moura et al. 2015; Ströhle 2009), although the latter has received less attention in the scholarly literature. Emerging evidence indicates that regular PA and structured exercise have positive effects in the treatment of various anxiety disorders including panic disorder, social anxiety disorder, generalized anxiety disorder, and related disorders like post-traumatic stress disorder and obsessive–compulsive disorder (e.g., Abrantes et al. 2017; Bischoff et al. 2018; Goldstein et al. 2018; Herring et al. 2012; Merom et al. 2008; Powers et al. 2015; Wedekind et al. 2010). However, more than half of adults (53.9%) in the United States do not meet the federal guidelines for PA (Centers for Disease Control and Prevention 2013). Additionally, dropout rates from structured PA programs are high (Marcus et al. 2006), especially among individuals with anxiety symptoms or disorders (Sabourin et al. 2011; Smits et al. 2010). Thus, understanding factors

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related to low engagement in PA has the potential to improve both physical and mental health outcomes.

Affective factors related to PA are key determinants of PA engagement (Ekkekakis et al. 2005a; Rhodes et al. 2009; Rhodes and Kates 2015; Williams and Evans 2014). Consistent with hedonic principles, having a positive affective response to PA is associated with greater future PA behavior (Kwan and Bryan 2010; Williams et al. 2008, 2012). In addition, cognitive processing of previous or anticipated affective responses to PA is associated with PA behavior (Rhodes et al. 2009; Williams 2008). For instance, low enjoyment of PA or expectancies of negative affective outcomes in response to PA (i.e., affective forecasting) are linked to lower PA engagement and adherence (Williams and Evans 2014). Moreover, certain emotional states can demotivate PA and negatively influence affective responses to PA (Williams and Evans 2014). Fear and anxiety are particularly relevant demotivating emotional states for PA given that these emotions are characterized by the tendency to avoid behaviors that are, or perceived to be, threatening or likely to produce negative affect (LeDoux 2012). Thus, fear and anxiety may interfere with the affective experience of PA.

Anxiety sensitivity, a core cognitive-affective vulnerability that underlies anxiety psychopathology (Olatunji and Wolitzky-Taylor 2009), is defined as the fear of bodily sensations (McNally 2002; Reiss 1991). Because anxiety itself is associated with increased arousal and physical sensations, anxiety sensitivity may theoretically influence PA in the following sequence: it can (1) intensify the subjective experience of fear and physical states following acute stressors (e.g., Dodo and Hashimoto 2017); and as a result (2) intensify negative affect and bodily discomfort during PA, especially at higher PA intensities (Asmundson et al. 2013); which can (3) result in lower enjoyment and a negative affective response to PA (Ekkekakis et al. 2008); and in turn (4) undermine PA engagement. Indeed, empirical data indicate that anxiety sensitivity is inversely related to PA engagement and fitness levels (Farris et al. 2016; McWilliams and Asmundson 2001; Sabourin et al. 2011; Smits and Zvolensky 2006) and prospectively predicts lower engagement in PA (Hearon et al. 2014; Moshier et al. 2016). Initial evidence also indicates that anxiety sensitivity is associated with increased negative affect (i.e., fear) during structured PA, particularly among individuals with higher body mass index (Smits et al. 2010). Elevated anxiety sensitivity is linked to greater subjective feelings of exertion during prolonged bouts of PA, but not objective physiological arousal (Farris et al. 2017). These findings suggest that anxiety sensitivity promotes biased cognitive processing of affective experiences during PA. Although not yet examined, anxiety sensitivity may also contribute to the negative affective response immediately following PA and affective processing of PA, including low enjoyment of PA and elevated negative

affect prior to PA. These theorized associations are consistent with the affect and health behavior framework and dual-processing perspectives (Williams and Evans 2014), which posit that interplay between affect and health behavior operate via automatic and reflective processing of affect.

Cigarette smokers is one subgroup of the population for which the link between anxiety sensitivity and PA is particularly important to understand. The comorbidity between anxiety and depressive psychopathology and cigarette smoking is well-documented (e.g., Lasser et al. 2000; Morris et al. 2014; McCabe et al. 2004; Piper et al. 2010) and anxiety sensitivity is one established mechanism underlying the comorbidity of anxiety/depressive disorders and smoking (Leventhal and Zvolensky 2015). Anxiety sensitivity is thought to maintain smoking through negative reinforcement processes (McCarthy et al. 2010), in which smoking serves as a “quick fix” strategy to avoid or escape distress states. Cigarette smoking may increase vulnerability to physical discomfort and associated affective distress during PA due to smoking-induced cardiopulmonary impairments (i.e., poor ventilatory efficiency; reduced pulmonary perfusion; chronic airway inflammation; O’Donnell et al. 2017). These physiological impairments can contribute heightened dyspnea with exertion, and as a result, intolerance of exercise (O’Donnell et al. 2017).

The current study aimed to evaluate anxiety sensitivity in relation to affective factors relevant to PA in a sample of low-active treatment-seeking smokers. Specifically, we evaluated anxiety sensitivity in relation to: (a) PA enjoyment, (b) negative affect (i.e., higher state anxiety and lower state mood) immediately prior to a submaximal exercise test, and (c) the affective response to a submaximal exercise test. We hypothesized that anxiety sensitivity would be associated with: (1) lower PA enjoyment, (2) higher state anxiety and lower mood prior to exercise testing, and (3) a greater negative affective response to exercise testing. These associations were examined with and without adjusting for theoretically-relevant covariates (i.e., cigarette dependence, sex, and body weight). Additionally, given that depressive symptoms contribute to affective factors related to PA (Abrantes et al. 2017; Leventhal 2012), potentially mediated through depression-specific mechanisms (e.g., reduced hedonic capacity), we also controlled for depression symptom severity.

Method

Participants

Participants were adult smokers with at least mild depressive symptoms who were seeking treatment for smoking cessation, enrolled in a randomized controlled trial that

compared the efficacy of two adjunctive interventions to cognitive-behavioral smoking cessation treatment and nicotine replacement therapy: (a) 12-session, group aerobic exercise intervention or (b) 12-session, group health-education control intervention. Inclusion criteria included: being between ages 18–65, low active (i.e., not engaging in more than 90 min of weekly moderate-to-vigorous PA in the last 12 weeks), smoking ≥ 10 cigarettes per day, and having at least mild depressive symptoms [≥ 6 on the Center for Epidemiological Studies Depression Scale (Radloff 1977)]. The current study is a secondary data analysis of pre-treatment baseline data. Of the 231 participants enrolled in the trial, 30 cases were excluded from analyses due to missing/incomplete self-report data ($n=23$) or missing/invalid walk test data ($n=7$). The final sample included 201 participants ($M_{age} = 46.2$, $SD = 11.0$; 71.1% female) who self-identified race as white (80.6%), black/African-American (9%), more than one race (5%), American Indian/Alaska Native (1%), Asian (1%), or other (3.5%).

Measures

Demographic information was self-reported by participants, including age, biological sex, and race. Body mass index (BMI) was calculated based on measured weight and height as an index of body weight ($[\text{weight}(\text{lbs})/[\text{height}(\text{in})]^2 \times 703]$).

The *Anxiety Sensitivity Index-3* (ASI-3; Taylor et al. 2007) is an 18-item self-report measure in which individuals rate the extent to which they are concerned about various possible consequences from anxiety-related physical symptoms (e.g., “It scares me when my heart beats rapidly”). Responses are rated on a five-point Likert scale ranging from 0 (*very little*) to 4 (*very much*) and summed to create a total score (possible range 0–72). The ASI-3 items have strong and improved psychometric properties relative to prior measure items of the construct (Taylor et al. 2007). The ASI-3 items also have strong psychometric properties in smokers enrolled in smoking cessation treatment (Farris et al. 2015). The internal consistency of the ASI-3 items was $\alpha = 0.93$.

The *Fagerström Test for Cigarette Dependence* (FTCD; Fagerström 2012; Heatherton et al. 1991) is a 6-item self-report assessment of cigarette dependence severity. Higher scores reflect greater physiological dependence on cigarettes (possible range 0–10). The internal consistency of the FTCD items was $\alpha = 0.61$.

The *Smoking History Questionnaire* (Brown et al. 2002) was used to describe the sample in terms of smoking characteristics (e.g., cigarettes per day).

Smoking status was biochemically verified by expired carbon monoxide breath sample, with ≥ 10 parts per million indicating current smoking.

The *Quick Inventory of Depressive Symptomatology* (QIDS; Rush et al. 2013) is a 16-item clinician-administered assessment of past week depressive symptoms. Items assess the severity of the nine diagnostic symptoms for major depressive disorder. Each item is assigned a score (0–3), with higher scores reflecting more severe frequency and severity of symptoms, and the total score for the nine domains is used to derive a summed index of depression severity (possible range 0–27). The QIDS was administered by highly-trained research assistants who were supervised by licensed clinical psychologists.

The *Physical Activity Enjoyment Scale* (PACES; Kendzierski and DeCarlo 1991) is a widely used self-report measure of physical activity enjoyment. The PACES includes 18 items in which respondents are asked to rate “how you feel at the moment about the physical activity you have been doing” using a 7-point bipolar Likert scale (e.g., “It’s not at all stimulating/It’s very stimulating”). Seven items are positively valenced, such that higher scores reflect greater levels of physical activity enjoyment. Eleven items are negatively valenced, and thus are reverse-scored for consistency in directional interpretation of scores. A total summed score (possible range 18–126) has been previously used to index overall levels of PA enjoyment (Kendzierski and DeCarlo 1991), including among low-active individuals (Abrantes et al. 2017; Murrock et al. 2016). The internal consistency of the PACES items was $\alpha = 0.92$. However, prior studies examining the factor structure of the PACES have found 1-factor (Heesch et al. 2006; Mullen et al. 2011), 2-factor (Román et al. 2014), and 3-factor structures (Murrock et al. 2016), suggesting that this performance measure may vary based on sample characteristics.

A standardized *submaximal exercise test* was completed using the Rockport 1.0 mile treadmill walk test (Pober et al. 2002). The 1-mile walk test was supervised and conducted by an exercise physiologist. This exercise testing protocol includes a 3–5-min warm-up, during which the treadmill speed is gradually increased until the participants chose the fastest walking speed that they believed could be maintained for one mile. The exercise physiologist encouraged increases in treadmill speed until heart rate reached the target range for moderate-intensity PA (64–76% of age-predicted maximal heart rate; American College of Sports Medicine 2010). Mean rating on the Borg Rating of Perceived Exertion (RPE) scale (Borg 1982) in this sample was 12.2 ($SD = 1.7$), indicating moderate intensity exercise.

The *Acute Symptoms Self-Rating Scale* was used to assess state mood and anxiety before and after exercise testing, which has been used in previous studies (Abrantes et al. 2012). Participants were asked to rate 2 items on a 10-point Likert scale, mood (0 = *Worst ever* to 10 = *Best ever*) and anxiety (0 = *No anxiety* to 10 = *Extreme anxiety*), immediately before and following the exercise test. Pre-walk

test ratings were used to index *pre-exercise affect*, and the change in ratings from pre- to post-exercise test were used to index *affective response* to exercise.

Procedure

Participants were recruited from the community via flyers, website postings, and clinic referrals between 2014 and 2018. Participants attended an initial baseline appointment during which self-report assessments were completed. Medical clearance for moderate-intensity PA was obtained from participants' primary care physician prior to baseline exercise testing. Once approved for PA, participants completed a second baseline appointment during which the exercise testing was completed. The second baseline assessment was typically completed within 2 weeks after the initial baseline assessment. Participants were compensated \$25 for completion of each baseline assessment (\$50 in total).

Data Analytic Strategy

First, given the prior inconsistencies documented in the factor structure of the PACES, an exploratory factor analysis (EFA) using principal components with promax rotation analysis was conducted to examine the underlying structure of the PACES in the current sample. The original responses for all items (non-reversed scores) were entered. The EFA allowed all items to load on all factors and did not force any factor loading to be zero (DeVellis 2017). Factor loadings of 0.40 and greater were considered good (Nunnally and Bernstein 1994). The minimum average partial (MAP; Velicer 1976) test was used to verify component solution based on the lowest average squared correlation, which was confirmed by the parallel analysis with both 1000 and 5000 random sample datasets (O'Connor 2000).

Next, zero-order bivariate associations were examined between anxiety sensitivity and the criterion variables. Then, partial correlations were examined between anxiety sensitivity and the criterion variables, after accounting for theoretically-relevant covarying factors, including cigarette dependence, sex, BMI, and depressive symptom severity.

For affective response to the submaximal exercise test, which is determined based on the change in affect from pre-to-post PA, initial paired samples *t* tests were conducted to examine the average acute affective response to (change from) exercise testing. Cohen's *d* was used as an effect size index, where small, medium, and large effects are indicated by *d*'s of 0.20, 0.50, and 0.80, respectively. Then, multiple linear regression analyses were conducted for anxiety sensitivity predicting post-exercise affect, controlling for pre-exercise affect given that the outcome of interest was the acute affective response to (*change* from)

exercise. Subsequent analyses were conducted controlling for the abovementioned covariates.

Results

On average, participants reported smoking for 25.9 years ($SD = 10.8$), smoked 19.1 ($SD = 8.6$) cigarettes per day, and had moderate levels of cigarette dependence ($M = 5.4$, $SD = 2.1$). On average, the sample had an overweight BMI ($M = 29.2$, $SD = 6.6$) and mild levels of depressive symptoms ($M = 6.0$, $SD = 4.2$). Anxiety sensitivity was elevated in the sample, with an average ASI-3 score of 14.2 ($SD = 13.6$). Approximately one-third (31.8%) of the sample had ASI-3 scores ≥ 17 , reflecting a moderately elevated level of anxiety sensitivity. Anxiety sensitivity was significantly correlated with cigarette dependence ($r = .25$, $p < .001$) and depression severity ($r = .43$, $p < .001$), but not sex ($r = .10$, $p = .147$) or BMI ($r = .01$, $p = .935$).

Physical Activity Enjoyment

EFA Results

The MAP test indicated a solution of three components, which had the lowest average squared correlation ($r^2 = .023$), and this solution was confirmed by the parallel analysis. The three-factor solution explains 61.2% of total variance. Table 1 provides the loadings of the PACES items. The first factor comprised of 7 items reflecting enjoyable "physical feelings" of PA, which accounted for 44.2% of variance in the rotated solution. The second factor was comprised of 6 negatively valenced items on the PACES, reflecting "negative affect" related to PA, which accounted for 9.7% of variance in the rotated solution. The third factor was comprised of 4 positively valenced items, reflecting "positive affect" related to PA, which accounted for 7.3% of variance in the rotated solution. One negatively valenced item (Frustration) had items loadings < 0.40 across all factors, and thus was not retained on any factor. All 18 items were used to create the total score to maintain consistency across studies in interpreting mean scores. The three factors were significantly intercorrelated: physical feelings and negative affect ($r = -.58$), physical feelings and positive affect ($r = .62$), and negative affect and positive affect ($r = -.51$, all p 's $< .001$). The mean and standard deviations for the PACES total and three factor scores are included in Table 2. The observed range was 18–126, indicating sufficient variability in the PACES in this sample of low-active individuals.

Table 1 Items in each factor and factor loadings for the PACES ($N=201$)

PACES item	Component		
	Physical feelings	Negative affect	Positive affect
1. I enjoy it/I hate it	0.116	−0.188	0.651
2. I feel bored/I feel interested	0.042	0.862	0.115
3. I dislike it/I like it	0.023	0.763	−0.140
4. I find it pleasurable/I find it unpleasurable	0.132	−0.098	0.573
5. I am very engaged in this activity/I am not engaged	−0.136	0.134	0.913
6. It's no fun at all/It's a lot of fun	0.193	0.807	−0.195
7. I find it energizing/I find it tiring	0.631	−0.067	0.119
8. It makes me depressed/It makes me happy	−0.321	0.662	0.190
9. It's very pleasant/It's very unpleasant	0.199	0.031	0.631
10. I feel good physically/I feel bad physically	0.761	0.146	0.220
11. It's very invigorating/It's not invigorating	0.793	0.040	0.140
12. I am very frustrated by it/I'm not at all frustrated by it	−0.320	0.122	−0.145
13. It's very gratifying/It's not at all gratifying	0.885	0.047	−0.042
14. It's very exhilarating/It's not at all exhilarating	0.729	−0.141	−0.008
15. It's not at all stimulating/It's very stimulating	−0.067	0.759	0.164
16. Strong sense of accomplishment/No sense of accomplishment	0.924	−0.046	−0.216
17. It's very refreshing/It's not at all refreshing	0.895	0.056	0.009
18. Would rather be doing something else/would rather be doing nothing else	−0.001	0.549	−0.197
Total items	7	6	4
Internal consistency	0.92	0.85	0.76

Bolded text reflects items retained on each PACES factor

PACES physical activity enjoyment scale

Physical feelings = factor 1, negative affect = factor 2, positive affect = factor 3

Table 2 Bivariate and partial correlations between anxiety sensitivity and PA processes

	Mean (SD)	Bivariate correlation		Adjusted correlation	
		<i>r</i>	<i>p</i>	<i>Partial r</i>	<i>p</i>
PA enjoyment					
PACES total	84.1 (18.5)	−0.173	0.014	−0.121	0.090
Factor 1 (physical feelings)	35.9 (8.9)	−0.176	0.012	−0.137	0.056
Factor 2 (negative affect)	21.3 (7.1)	0.117	0.100	0.053	0.462
Factor 3 (positive affect)	17.6 (94.7)	−0.138	0.050	−0.099	0.164
Pre-exercise affect					
Mood	7.0 (1.5)	−0.207	0.003	−0.090	0.207
Anxiety	2.7 (2.6)	0.223	0.002	0.135	0.058
Post-exercise affect					
Mood	7.8 (1.5)	−0.019	0.792	0.052	0.469
Anxiety	1.5 (2.2)	0.254	<0.001	0.174	0.014

r bivariate correlation, *Partial r* partial correlation adjusting for cigarette dependence, sex, BMI, and depressive symptoms

Anxiety Sensitivity and PACES

Correlation results are presented in Table 2. At the bivariate level, anxiety sensitivity was significantly negatively associated with PACES total score and PACES physical

feeling, and positive affect, but not negative affect subscale. Anxiety sensitivity remained negatively correlated with PACES Physical Feeling at a trend level in the adjusted model ($p = .056$).

Negative Affect Prior to Submaximal Exercise Testing

As presented in Table 2, bivariate correlations indicated that anxiety sensitivity was significantly negatively associated with pre-exercise mood ratings, reflecting higher levels of negative mood. This association was non-significant in the adjusted model. Anxiety sensitivity was also significantly positively associated with pre-exercise anxiety ratings, reflecting higher levels of state anxiety, which remained significant at a trend level in the adjusted model ($p = .058$).

Affective Response to Submaximal Exercise Testing

Anxiety sensitivity was significantly correlated with higher post-exercise anxiety in the bivariate and adjusted models but was not associated with post-exercise mood (Table 2). Regarding affective response to exercise (change in affect), paired t tests revealed a significant acute affective response to exercise testing. Specifically, exercise produced an average 0.76 point increase in mood ratings [$t(200) = 7.39$, $p < .001$, Cohen's $d = 0.52$] and 1.24 point reduction in anxiety ratings [$t(200) = -8.91$, $p < .001$, Cohen's $d = 0.64$]. See Table 3 for regression results. Results from the unadjusted model indicated that every 1-point increase on the ASI-3 was associated with 0.02-point increase in post-exercise anxiety rating ($t = 2.07$, $p = .040$, $sr^2 = 0.021$), suggesting anxiety sensitivity was associated with small increases in anxiety from exercise. In the adjusted models, the effect of anxiety sensitivity on post-exercise anxiety was not significant. Regression results revealed that anxiety sensitivity

was not significantly associated with acute mood response to exercise.

Discussion

Findings support the association between anxiety sensitivity, a cognitive mechanism underlying anxiety psychopathology, and affective factors related to PA engagement. As hypothesized, anxiety sensitivity was associated with lower enjoyment of current PA, measured with the PACES. We also identified a multidimensional structure of the PACES described by three inter-related domains that reflected enjoyable physical feelings from PA (e.g., "I feel energized"), positive beliefs related to PA (e.g., "It's very pleasant"), and negative beliefs related to PA (e.g., "I feel bored", where higher scores reflect lower enjoyment). A three-factor structure has been previously reported in low-active adults with functional limitations (Murrock et al. 2016), suggesting that at least in low-active adults, subfacets of PA enjoyment may offer unique information about affective factors related to PA. Findings indicated that anxiety sensitivity was uniquely associated with lower enjoyable *physical feelings* from PA. Thus, anxiety sensitivity may attenuate the positive physical feelings from PA (e.g., vigor and stimulation) due to heightened fear of such sensations and lower consequent enjoyment of PA.

Anxiety sensitivity was also associated with higher negative affect (i.e., elevated anxiety and lower mood) immediately prior to moderate-intensity submaximal exercise testing. Anxiety sensitivity is characterized by the fear of,

Table 3 Regression results predicting affective response to exercise test

	Unadjusted model				Adjusted model			
	<i>b</i>	<i>t</i>	<i>p</i>	<i>sr</i> ²	<i>b</i>	<i>t</i>	<i>p</i>	<i>sr</i> ²
Post-exercise mood								
Pre-exercise mood	0.571	9.496	<0.001	0.313	0.577	9.266	<0.001	0.307
Anxiety sensitivity	0.011	1.657	0.099	0.014	0.013	1.702	0.090	0.015
Cigarette dependence	–	–	–	–	–0.064	–1.431	0.154	0.010
Sex	–	–	–	–	–0.074	–0.360	0.719	0.001
BMI	–	–	–	–	0.016	1.099	0.273	0.006
Depression	–	–	–	–	0.008	0.334	0.739	0.001
Post-exercise anxiety								
Pre-exercise anxiety	0.517	11.807	<0.001	0.386	0.520	11.615	<0.001	0.410
Anxiety sensitivity	0.017	2.070	0.040	0.021	0.015	1.608	0.109	0.013
Cigarette dependence	–	–	–	–	0.043	0.776	0.439	0.003
Sex	–	–	–	–	–0.286	–1.120	0.264	0.006
BMI	–	–	–	–	0.000	0.027	0.979	0.000
Depression	–	–	–	–	0.011	0.346	0.730	0.001

Anxiety sensitivity=ASI-3; cigarette dependence=FTCD; sex=coded 0 (male), 1 (female); depression=QIDS

BMI body mass index

and negative expectancies about, the outcomes of behaviors that acutely increase discomfort (e.g., Farris et al. 2015). This tendency to forecast negative affective and physical outcomes may contribute to heightened negative affect immediately prior to a bout of PA. In effect, anxiety sensitivity may amplify anxious anticipation of PA, and the resulting affective states may motivate behavioral avoidance (Williams and Evans 2014). Additionally, cognitive-affective factors about PA specifically (e.g., expecting to experience negative affect after PA) predict a more negative affective response to PA (Sala et al. 2016), which can undermine future PA engagement. It is also possible that the association between anxiety sensitivity and elevated negative affect prior to exercise testing is non-specific to PA and is driven by the trait tendency to negative affectivity, thus future work would be bolstered by evaluating negative affect in anticipation of initiating a structured bout of PA, specifically.

In this sample, moderate-intensity submaximal exercise testing produced medium-sized acute reductions in anxiety and increases in mood. This positive affective response is consistent with the well-documented acute anxiolytic and mood enhancing effects of PA (Petruzzello et al. 1991; Reed and Ones 2006; Wipfli et al. 2008). However, anxiety sensitivity blunted the positive affective response to PA and instead predicted an anxiogenic response to PA (i.e., increased anxiety). Individuals with elevated anxiety sensitivity likely have increased attentional bias to and awareness of bodily sensations resulting from physical exertion during exercise (Farris et al. 2017), which likely contributes to heightened anxiety during exercise (Smits et al. 2010) and an anxiogenic response following exercise. The inclusion of additional individual-level factors (e.g., level of cigarette dependence, sex, depression severity, BMI) did not significantly improve model prediction but did mitigate the contribution of anxiety sensitivity on the anxiogenic response to submaximal exercise testing. These individual difference factors may have process-level influences (e.g., mediating, moderating effect) on this anxiogenic response to PA, which requires inquiry in future research (Ekkekakis et al. 2005b; Ekkekakis and Lind 2006). Anxiety sensitivity was not associated with the acute mood response to exercise testing, suggesting some specificity for the relationship between anxiety sensitivity and an anxious response to exercise.

These findings must be considered in light of the clinical characteristics of the present sample. The sample consisted of low-active cigarette smokers who were motivated for smoking cessation. The association between anxiety sensitivity and affective factors related to PA are not proposed to be specific to smokers, although impaired cardiopulmonary functioning, among other factors, could enhance the negative affective experience of PA. The patterning of results generally remained the same after adjusting for level of cigarette dependence, which typically accounted for a minimal 1–2%

of variance in the affective factor linked to PA. Additionally, although statistically controlled for cigarette dependence and other relevant factors (e.g., BMI, sex, depressive symptoms), future research is needed to understand how these processes interplay with anxiety sensitivity to contribute to the affective experience and response to PA (e.g., Smits et al. 2008) in order to identify key affective barriers to PA in health-vulnerable subsets of the population.

There are several additional limitations. First, the external validity of this study is potentially limited by the laboratory-based setting in which the submaximal exercise testing occurred, and the perception of being evaluated could have influenced affect ratings before and after testing. Second, future studies are needed to evaluate the generalizability of these findings across the type, duration, and intensity of PA performed. For example, anxiety sensitivity may show stronger negative associations with the affective experience surrounding PA of higher intensities (Moshier et al. 2013), alternative forms of PA (e.g., running versus weight training; LeBouthillier and Asmundson 2017), or longer durations of PA (Farris et al. 2017). Third, we assessed *discrete* negative affect states (i.e., anxiety, mood) before and after exercise. Although this approach has been used in prior work (e.g., Abrantes et al. 2012, 2018), affective response to PA is more commonly evaluated based on the circumplex model (Russell 1980) in which affective valence (pleasantness-unpleasantness) and activation are assessed (Ekkekakis and Petruzzello 2002). Last, the sample had limited racial and ethnic heterogeneity and was primarily female. Thus, the sample may not necessarily be generalizable to other low-active groups of smokers, and future work is needed to replicate the current findings.

In conclusion, we offer novel evidence of the association between anxiety sensitivity and affective predictors of PA including: (1) lower levels of PA enjoyment, particularly because of physical feelings resulting from PA; (2) elevated anxiety and lower mood immediately prior to submaximal exercise testing; and (3) an anxiogenic affective response to submaximal exercise testing. Psychoeducation about anxiety and physiological sensations can aid in reducing anxiety sensitivity (Smits et al. 2008), with an attempt to reframe or at least define sensations during exercise as safe or even desirable (i.e., indicative of strength, effort to become healthier). Individuals with anxiety vulnerability may also benefit from carefully tailored PA prescriptions aimed at bolstering the affective experience of PA, including self-paced PA intensities (Williams 2008), which is particularly well-suited for individuals with lower cardiorespiratory fitness (Baldwin et al. 2016). In addition, shorter initial bouts of PA (e.g., 10 min) that may generate less anticipatory anxiety relative to longer bouts of PA and produce a more positive affective response (Farris et al. 2017). These interventions would theoretically build

tolerance and acceptance to PA-induced physical distress through repeated exposure (to decrease negative affect to PA), while also increasing the positive affective associations and responses to PA, which in combination could facilitate engagement in longer bouts of higher-intensity PA for ideal cardiorespiratory and health benefits.

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Compliance with Ethical Standards

Conflict of Interest Dr. Brown has equity ownership in Health Behavior Solutions, Inc., which is developing products for tobacco cessation although not products directly related to this publication. The terms of this arrangement have been reviewed and approved by the University of Texas at Austin in accordance with its policy on objectivity in research. Dr. Price receives travel funds from Springer and is a consultant to Wiley, Springer, University of Texas at Austin, and the Cleveland Clinic. Dr. Uebelacker's spouse is employed by AbbVie Pharmaceuticals. Drs. Farris and Abrantes, and Ms. Legasse has no disclosures to report.

Ethical Approval All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Animal Rights This article does not contain any studies with animals performed by any of the authors.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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