Psychiatry Research 241 (2016) 135–140

Contents lists available at ScienceDirect

Psychiatry Research

journal homepage: www.elsevier.com/locate/psychres

Posttraumatic stress symptoms and body mass index among World Trade Center disaster-exposed smokers: A preliminary examination of the role of anxiety sensitivity

Samantha G. Farris [a,b,*], Daniel J. Paulus [a], Adam Gonzalez [c], Brittain L. Mahaffey [c], Evelyn J. Bromet [c], Benjamin J. Luft [d], Roman Kotov [c], Michael J. Zvolensky [a,e]

[a] University of Houston, Department of Psychology, Houston, TX, United States
[b] Alpert Medical School of Brown University, Department of Psychiatry and Human Behavior, Providence, RI, United States
[c] Stony Brook University, Department of Psychiatry, Stony Brook, NY, United States
[d] Stony Brook University, Department of Medicine, Stony Brook, NY, United States
[e] The University of Texas MD Anderson Cancer Center, Department of Behavioral Science, Houston, TX, United States

ARTICLE INFO

Article history:
Received 28 April 2015
Received in revised form
20 April 2016
Accepted 21 April 2016
Available online 22 April 2016

Keywords:
Obesity
Disaster
Anxiety sensitivity
World Trade Center
Posttraumatic stress disorder

ABSTRACT

Among individuals exposed to the World Trade Center (WTC) disaster on September 11, 2001, posttraumatic stress disorder (PTSD) and symptoms are both common and associated with increased cigarette smoking and body mass. However, there is little information on the specific processes underlying the relationship of PTSD symptoms with body mass. The current study is an initial exploratory test of anxiety sensitivity, the fear of internal bodily sensations, as a possible mechanism linking PTSD symptom severity and body mass index (BMI). Participants were 147 adult daily smokers (34.0% female) exposed to the WTC disaster (via rescue/recovery work or direct witness). The direct and indirect associations between PTSD symptom severity and BMI via anxiety sensitivity (total score and subscales of physical, cognitive, and social concerns) were examined. PTSD symptom severity was related to BMI indirectly via anxiety sensitivity; this effect was specific to physical concerns about the meaning of bodily sensations. Interventions focusing on anxiety sensitivity reduction (specifically addressing physical concerns about bodily sensations) may be useful in addressing elevated BMI among trauma-exposed persons.

1. Introduction

1.1. Posttraumatic stress and obesity

Posttraumatic stress symptoms and posttraumatic stress disorder (PTSD) are the most commonly reported mental health consequences of exposure to the World Trade Center (WTC) disaster on September 11, 2001 (e.g., Liu et al., 2014). Trauma symptoms and PTSD are associated with increased healthcare utilization, medical conditions and physical illness, including cardiovascular and metabolic disease (Dedert et al., 2010b; Qureshi et al., 2009). Adult obesity is one common and costly public health problem associated with increased risk for cardiovascular and metabolic disease, with prevalence estimates over 30% in the United States (Ogden et al., 2014, 2012). Epidemiological and clinical data indicate that PTSD is associated with indicators of obesity such as body mass index (BMI), both cross-sectionally (e.g., Perkonigg et al., 2009; Scott et al., 2008) and prospectively (Dedert et al., 2010a; Gunstad et al., 2006; Kubzansky et al., 2014; Pagoto et al., 2012). Following exposure to natural disasters, PTSD is associated with changes in eating behavior (Carmassi et al., 2015). Specifically among WTC disaster-exposed police responders, a probable PTSD diagnosis has been linked to higher self-reported BMI (Luft et al., 2012). Thus, trauma exposure and subsequent development of PTSD symptoms may, among other factors, contribute to overweight/obese BMI. Theoretically, it is posited that posttraumatic stress symptoms and PTSD directly activate certain biological/physiological risk indices associated with obesity (e.g., insulin resistance, metabolic syndrome), which may occur indirectly via certain (a) psychological vulnerabilities and/or (b) additional problematic health behaviors (e.g., alcohol use, cigarette smoking; Dedert et al., 2010b).

1.2. The role of anxiety sensitivity

One possible psychological vulnerability that may link trauma exposure/PTSD symptoms with obesity is anxiety sensitivity

* Corresponding author at: University of Houston, Department of Psychology, 126 Fred J. Heyne Building, Suite 104, Houston, TX 77204-5502, United States.
E-mail address: sgfarris@uh.edu (S.G. Farris).

http://dx.doi.org/10.1016/j.psychres.2016.04.074
0165-1781/

(McHugh and Otto, 2011). Anxiety sensitivity is a multidimensional, dispositional factor, defined as the tendency to be fearful of arousal-related bodily sensations and interpret these sensations as having harmful social, cognitive, or physical consequences (Reiss et al., 1986). Anxiety sensitivity appears to be both a risk factor for the development of PTSD and an amplifier of the severity of PTSD symptoms (i.e., bidirectional associations; e.g., Marshall et al., 2010). Interestingly, data also suggest that anxiety sensitivity is linked to maladaptive eating (Hearon et al., 2013, 2014) and physical inactivity (Hearon et al., 2014). When experiencing emotional distress (e.g., trauma symptoms), individuals high in anxiety sensitivity may prioritize short-term affect regulation, which may in turn promote behaviors that are negatively reinforcing like emotional eating to attenuate distress or avoidance of activity that might require physical exertion due to the perceived distressing sensations experienced during physical activity. Data also indicate that the dimensions of anxiety sensitivity (fears of social, cognitive, physical consequences from arousal sensations) are differentially related to aspects of PTSD (Berenz et al., 2012; Naragon-Gainey, 2010) and eating behavior (Hearon et al., 2013). For example, concerns about the cognitive consequences of somatic sensations (e.g., "When I feel dizzy, I worry I won't be able to concentrate") appear to be more strongly associated with PTSD (Naragon-Gainey, 2010) and maladaptive eating behavior (Hearon et al., 2013), relative to concerns about the social or physical consequences of arousal sensations.

1.3. The example of cigarette smoking

The PTSD-obesity link may be importantly explored among cigarette smokers. Smoking remains the leading cause of preventable morbidity and mortality in the United States (Agaku et al., 2014; U.S. Department of Health and Human Services, 2014). The base rate of smoking among individuals with PTSD is significantly higher than the general population (45.3% versus 22.5%; Lasser et al., 2000), and WTC disaster exposure is associated with increased rates of cigarette smoking (Biggs et al., 2010). Indeed, trauma exposure and PTSD are linked to various aspects of cigarette smoking, including tobacco dependence, affect-regulatory smoking motives, and cessation difficulties (see review by Feldner et al., 2007). Moreover, it is estimated that about 20% of smokers are overweight (Gregg et al., 2005), and the combination of obese BMI and current smoking are associated with an approximately 3–5 fold relative risk for all-cause mortality, relative to never-smokers with normal range BMI (Freedman et al., 2006). Understanding the health needs of smokers exposed to the WTC disaster is particularly important given the high incidence of upper and lower respiratory symptoms resulting from exposure to the WTC site, which can be exacerbated by smoking (Liu et al., 2012).

Importantly, anxiety sensitivity is related to numerous aspects of cigarette smoking (e.g., Leventhal and Zvolensky, 2015), including the co-occurrence of smoking and PTSD (Farris et al., 2014; Feldner et al., 2007). Conceptually, in the context of PTSD symptoms, smokers with high anxiety sensitivity may be more fearful of somatic sensations (either due to smoking-related physical impairment or trauma-related cues), which may be related to smoking aimed at reducing distress. Cigarette smokers may be particularly concerned about the physical consequences of arousal sensations (e.g., "When I feel pain in my chest, I worry that I'm going to have a heart attack"), relative to social or mental/cognitive consequences of arousal sensations (Farris et al., 2015; Guillot et al., 2015).

1.4. Current study

Shared vulnerability-stress models can be used to understand how individual difference factors may predispose individuals to develop more severe PTSD symptoms and obesity following exposure to certain traumatic events (e.g., Asmundson et al., 2008). Specifically, following exposure to a traumatic event (e.g., WTC disaster), the development and expression of PTSD symptoms may be more prominent among those who are vulnerable to react with fear and distress to arousal states (e.g., anxiety sensitivity). This vulnerability may interfere with individuals' ability to adaptively cope with negative mood states (i.e., traumatic stress symptoms), which may promote obesity via several avenues, including maladaptive eating and poor diet and/or avoidance of physical activity. The current study included an initial exploratory test of anxiety sensitivity as a novel mechanism in the PTSD-obesity association. In a sample of cigarette smokers exposed to the WTC disaster, we examined the associations between PTSD symptom severity and obesity, measured by BMI. Anxiety sensitivity was tested as an indirect predictor of the association between PTSD symptom severity and BMI. Additionally, to increase specificity of the indirect test, the dimensions of anxiety sensitivity (social, cognitive, and physical concerns) were concurrently modeled to examine whether these subscales were uniquely related to the PTSD-BMI association.

2. Methods

2.1. Participants and procedures

Adult daily smokers exposed to the WTC disaster were recruited between years 2012–2014 for a smoking cessation intervention trial (Gonzalez et al., under review). Participants were recruited from the WTC Health Program, the New York City Department of Health WTC Health Registry, local newspapers and New York area Craigslist.com postings. Interested individuals completed a telephone prescreen and those who smoked at least 5 cigarettes per day and were motivated to quit smoking were invited for an in-person baseline assessment. Participants completed a battery of self-report assessments including height/weight measurements, and all participants were compensated $50 for completing the assessment. Written informed consent was obtained prior to initiation of study procedures and the study protocol was approved by the Stony Brook University Institutional Review Board.

Participants were 147 daily smokers (M_{age}=49.0; SD=10.2; 34.0% female) who completed the baseline assessment whether or not they were deemed eligible for the clinical trial. About half of the sample comprised of individuals who were rescue/recovery (53.7%) workers at the time of the WTC disaster. Participants primarily self-identified race as White (57.8%) or Black (30.6%). On average, participants reported smoking 18.9 cigarettes per day (SD=15.1) and being a regular smoker for 28.6 years (SD=11.8). Moderate levels of tobacco dependence were reported (M_{FTND}=5.4; SD=1.9) and 39.5% of the sample met criteria for a probable diagnosis of PTSD (see below).

2.2. Measures

2.2.1. Body mass index (BMI)

BMI was calculated based on self-reported weight and height (kg/m^2) at baseline.

2.2.2. Posttraumatic stress disorder checklist, specific version (PCL-S; Weathers et al., 1993)

The PCL-S is a 17-item self-report assessment of PTSD symptom severity. The PCL-S items correspond to PTSD symptoms defined in the Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV; American Psychiatric Association, 2000). Respondents rate the extent to which they have experienced each of the symptoms in the past month from 1 (*not at all*) to 5 (*extremely*). The version of the PCL-S used in the current study included instructions that prompted participants to answer all items specifically "in relation to 9/11". Item scores are summed to derive a total severity score (possible range 17–85) and three subscales scores that align with the DSM-IV PTSD symptom clusters: Re-experiencing [items 1–5], Avoidance [items 6–12], and Hyperarousal [items 13–17]. The PCL-S items have strong reliability and concurrent validity with clinician-administered PTSD interviews (Keen et al., 2008; Kotov et al., 2015); internal consistency of PCL-S items in the current study was α=0.92. For descriptive purposes, the presence of probable diagnosis of PTSD was derived from the PCL-S based on (a) a total severity score $\geq$ 50, with (b) a symptom pattern consistent with DSM-IV criteria: at least one Re-experiencing symptom, three Avoidance symptoms, and two Hyperarousal symptoms rated as a "moderately" severe or above [response $\geq$ 3 on individual items]

(Liu et al., 2014). In the current sample, agreement between severity rating and symptom count on the PCL-S were very good (Positive Predictive Value [PPV]=0.98; Negative Predictive Value [NPV]=0.75).

2.2.3. Anxiety Sensitivity Index-3 (ASI-3; Taylor et al., 2007)

The ASI-3 is an 18-item self-report assessment of the extent to which individuals fear arousal-related anxiety sensations. Items are rated from 0 (*very little*) to 4 (*very much*). The ASI-3 yields a total summed score and three subscales: Physical concerns (e.g., "It scares me when my heart beats rapidly"), Cognitive concerns (e.g., "It scares me when I am unable to keep my mind on a task"),[1] and Social concerns (e.g., "It is important for me not to appear nervous"). The ASI-3 measure has strong psychometric properties (Taylor et al., 2007), including reliability (internal consistency, test-retest reliability) and convergent, predictive, and discriminant validity among treatment-seeking smokers (Farris et al., 2015). Internal consistency of the total score and subscale items ranged from α=0.81–0.93 in the current study.

2.2.4. Fagerström Test for Nicotine Dependence (FTND; Fagerström, 1978)

The FTND is a 6-item assessment of gradations in physiological dependence on tobacco; higher scores indicate greater tobacco dependence (possible/observed range 0–10). Internal consistency was relatively low for FTND items in this sample (α=0.46), which is not atypical for this measure (see Korte et al., 2013).

2.3. Data analytic strategy

Of the 147 participants in the baseline assessment, 33 cases had missing data on key study variables due to errors in protocol administration including: BMI (n=23), PCL-S (n=4), and ASI-3 (n=8). Missing data were imputed using the expectation-maximization algorithm in SPSS 22.0. Results from the dataset with imputed missing data were identical in terms of significant and non-significant findings to results from the raw (non-imputed) dataset. Additionally, cases with and without missing data did not differ on any demographic variables. Thus, below we report the results from the expectation-maximization data.

First, descriptive analyses were conducted to examine the bivariate associations between study variables. Second, regression-based analyses were utilized to examine the effect of PTSD symptom severity on BMI via (a) anxiety sensitivity (indexed by the ASI-3 total score) and (b) three anxiety sensitivity subscales (ASI-3 – Physical, Cognitive, and Social concerns). Analyses were conducted using PROCESS (v 2.15), a conditional process modeling macro that tests for both direct and indirect effects using an ordinary least squares-based path analytical framework (Hayes, 2013). The 95-percentile confidence intervals (CIs) for regression estimates were obtained analytically, and bootstrapping with 10,000 resamples was used to estimate CIs for the indirect effects (for details, see Hayes, 2009; Preacher and Hayes, 2008, 2004).

3. Results

On average, scores on the PCL-S were in the moderate to high range for PTSD symptom severity (M=46.5; SD=14.2; range 17–81). Means, standard deviations, and zero-order correlations between the study variables are provided in Table 1. Of note, there were no significant gender differences in the variables presented in Table 1, including BMI (consistent with epidemiological data; Flegal et al., 2013). Anxiety sensitivity (ASI-3 total score) and the ASI-3 Physical concerns subscale, specifically, were significantly positively correlated with BMI. PTSD symptom severity was not significantly correlated with BMI. It is well-documented that a statistical indirect effect can exist in the absence of a total or direct effect or bivariate-level correlations (Hayes, 2013), therefore we tested the indirect effects of PTSD symptom severity on BMI, through anxiety sensitivity (total score and subscales).

3.1. Indirect effect of anxiety sensitivity

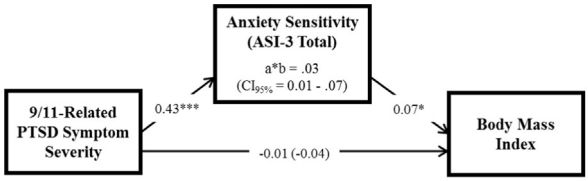
Fig. 1 presents the results from the regression model that tested the association between PTSD symptom severity and BMI via anxiety sensitivity (ASI-3 Total score). PTSD symptom severity was significantly and positively associated with anxiety sensitivity (b=0.43, t=5.19, p<0.0001), and anxiety sensitivity was positively associated with BMI (b=0.07, t=2.25, p=0.026). In the test of mediation, PTSD symptom severity was associated with BMI through anxiety sensitivity (a*b=0.03, $CI_{95\%}$=0.01–0.07) which was a small to medium sized effect (k^2=0.07).

Table 1
Means, standard deviations, and bivariate correlations (n=147).

Variable	1.	2.	3.	4.	5.	6.	7.	8.
1. Sex	–	-0.04	0.07	−0.03	−0.02	−0.03	−0.03	0.01
2. FTND		–	0.24**	0.13	0.11	0.06	0.16	0.02
3. PCL-S			–	0.40**	0.33**	0.40**	0.29**	−0.02
4. ASI-3 Total				–	0.86**	0.89**	0.83**	0.16*
5. ASI-3 Physical					–	0.67**	0.49**	0.29**
6. ASI-3 Cognitive						–	.64**	0.10
7. ASI-3 Social							–	0.01
8. BMI								–
Mean or n	50	5.4	46.6	22.6	7.5	6.2	8.7	29.5
SD or %	34.0%	1.89	14.09	15.20	6.11	6.07	5.61	5.15

Sex (0=Male; 1=Female); FTND=Fagerström Test for Nicotine Dependence; PCL-S (PTSD Checklist – Specific Version); ASI-3 (Anxiety Sensitivity Index-3 – Total score, Physical, Cognitive, and Social concerns subscales); BMI (Body Mass Index). Numbers across header correspond with variables numbered 1-8.

* $p < 0.05$.
** $p < 0.01$.



*Note: * p < .05, ** p < .01, ***p < .001. a*b = indirect effect. path c (path c') are presented for the associations between PTSD severity and BMI.*

Fig. 1. Unstandardized regression coefficients for model testing indirect effects of anxiety sensitivity.

3.2. Specific indirect effects of anxiety sensitivity subscales

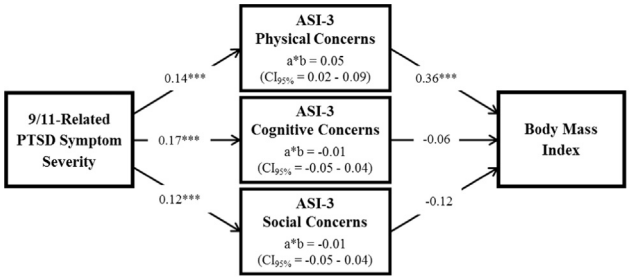
Next, the indirect specific subscale effects of the anxiety sensitivity were tested (see Fig. 2). Specifically, PTSD symptom severity was positively and significantly associated with all three subscales (p's < 0.001); the ASI-3 Physical concerns subscale was uniquely positively associated with BMI (b=0.36, t=4.01, p < 0.001), whereas the Cognitive and Social concerns subscales were not (p's > 0.05). Results indicated that the ASI-3 Physical concerns subscale emerged as the only significant indirect effect (a*b=0.05, $CI_{95\%}$=0.02–0.09), whereas the indirect effects of ASI-3 Cognitive concerns and Social concerns subscales were non-significant.[2]

3.3. Model specificity

Post-hoc analyses were conducted to test the specificity of the current models – specifically, by reversing the model predictor and mediator(s). Thus, two additional regression models were conducted to test opposing indirect effects of the association of anxiety sensitivity (ASI-3 total score; subscale scores) and BMI

[1] Item 14 of the ASI-3 was not administered due to clerical error. For each participant, average scores on the cognitive concerns scale were supplemented for the missing value.

[2] Adjusted models were conducted controlling for possible covarying factors, including sex, WTC responder status, level of nicotine dependence, and neuroticism. The pattern of results remained unchanged. Results are available from the first author upon request.



*Note: ***p < .001. a*b = indirect effect. The path c/c' for PTSD symptom severity on BMI is not displayed for ease in viewing. PTSD symptom severity was not associated with BMI: path c (b = -0.01, t = -0.20, p = .838); path c' (b = -0.03, t = -1.11, p = .270).*

Fig. 2. Unstandardized regression coefficients for model testing indirect effects of anxiety sensitivity subscales.

through PTSD symptom severity. The first model (with a single predictor; ASI-3 total score) was tested using PROCESS. The second model was conducted using MEDIATE macro (Hayes and Preacher, 2014), which allows for simultaneous testing of multiple predictors (the three ASI-3 subscales). PTSD symptom severity was entered as the indirect variable (M) in both models. Results of the first alternative model revealed that the indirect effect of anxiety sensitivity (ASI-3 total score) via PTSD symptom severity was non-significant with regard to BMI (a*b = −0.01, $CI_{95\%}$ = −0.05 to 0.02). The same pattern of results emerged for the second alternative model. Specifically, there were non-significant indirect effects of anxiety sensitivity subscales via PTSD symptoms severity (all bootstrapped $CI_{95\%}$'s contained 0).

3.4. Post-hoc analyses

An exploratory post-hoc test was conducted to examine whether the PTSD symptom clusters were differentially associated with BMI via anxiety sensitivity. Analyses were conducted using the MEDIATE macro (Hayes and Preacher, 2014), which included the test of multiple predictors (the three PTSD symptom clusters). The three PCL-S subscale scores (Re-experiencing, Avoidance, and Hyperarousal) were entered simultaneously as predictors (X_{1-3}), anxiety sensitivity (ASI-3 total score) was entered as M, and BMI was entered as Y. Results indicated that PTSD Avoidance symptoms were associated with BMI through anxiety sensitivity (ASI-3 total score; a*b=0.04, $CI_{95\%}$=0.01–0.12); the indirect effects for PTSD Re-experiencing and Hyperarousal symptoms via anxiety sensitivity were non-significant (all bootstrapped $CI_{95\%}$'s contained 0).

4. Discussion

In this preliminary examination, as hypothesized, PTSD symptom severity was positively associated with anxiety sensitivity among the sample of smokers exposed to the WTC disaster. This finding is consistent with prior non-smoking (Marshall et al., 2010) and smoking-specific (Vujanovic et al., 2010) studies, and uniquely extends this line of work to WTC disaster-exposed smokers. Additionally, anxiety sensitivity (Physical concerns subscale, specifically) was positively associated with BMI. These initial findings complement prior work (non-smoking or trauma-specific) that has found that overweight/obese individuals, relative to normal weight persons, have significantly higher levels of anxiety sensitivity (Hearon et al., 2013), and that anxiety sensitivity is associated with both maladaptive eating and avoidance of physical activity (Hearon et al., 2013; Smits et al., 2010).

Additionally, anxiety sensitivity was a significant indirect predictor in the association between PTSD symptom severity and BMI among this sample of WTC-exposed smokers. Importantly, while PTSD symptom severity was not directly associated with BMI, it is still possible for PTSD to affect BMI via intermediary processes (e.g., Hayes, 2013). Specifically, PTSD symptom severity may be related to anxiety sensitivity in a direct (and possibly transactional; Marshall et al., 2010) manner, which may subsequently be related to health factors, such as BMI. Indeed, PTSD symptom severity was directly associated with the anxiety sensitivity which in turn was associated with BMI. An alternative model (examining the associations between anxiety sensitivity and BMI via indirect effect of PTSD symptom severity) was non-significant, supporting the potential directionality of these effects (albeit in a cross-sectional dataset). This set of findings is broadly in line with other work that found that anxiety sensitivity is related to greater calorie consumption following periods of increased negative affect (Hearon et al., 2014). Thus, negative affect broadly, or specific to PTSD symptoms, appears to interplay with anxiety sensitivity in terms of eating/weight-related factors. Moreover, results appear to be driven by PTSD avoidance symptoms specifically. It is possible that avoidance of interoceptive and exteroceptive cues related to the WTC disaster is associated with anxiety sensitivity, which promotes physical inactivity (Vujanovic et al., 2013) as a means of avoiding somatic distress states (Smits et al., 2010), which in turn may contribute to higher BMI. Collectively, these data suggest that among WTC disaster-exposed smokers, PTSD symptom severity may be associated with heightened sensitivity to somatic arousal (and beliefs that these sensations have catastrophic physical consequences), which in turn, is associated with higher BMI.

The current study was an initial examination of the PTSD-BMI association (via anxiety sensitivity) among treatment-seeking smokers exposed to the WTC disaster. It is important that future studies examine whether the current findings replicate among broader and more representative samples of trauma-exposed or disaster-exposed smokers. Additionally,although the current effects were observed among smokers, for whom anxiety sensitivity appears to be a core psychological vulnerability related to PTSD and other psychological disorders (Leventhal and Zvolensky, 2015), the pattern of results may not be unique to cigarette smokers. That is, it is important to test whether the observed pattern of results is confirmed in samples exposed to other types of trauma, with and without smoking histories. It is also possible that other subscales of anxiety sensitivity may be more prominent in the PTSD-BMI association among non-smokers, given evidence of elevated cognitive anxiety sensitivity concerns in PTSD (Naragon-Gainey, 2010). Health monitoring of individuals exposed to the WTC disaster may be bolstered by assessing anxiety sensitivity to further understand how this psychological mechanism may be related to obesity and other obesity-related health problems linked to trauma exposure and PTSD (e.g., diabetes; Miller-Archie et al., 2014).

There are several limitations to the current study. First, BMI was assessed via self-report. This introduces two potential biases: (a) BMI is prone to a number of problems, as it does not address variation in physical characteristics (e.g., waist circumference; Romero-Corral et al., 2008), cannot differentiate muscle mass from fat (Frankenfield et al., 2001; Piers et al., 2000), and does not show a consistent relation to health (e.g., Lim et al., 2007); and (b) self-reported BMI may be subject to reporting bias, as there is a tendency for respondents to over-estimate height and under-estimate weight, resulting in underestimation of BMI (Ezzati et al., 2006; Connor Gorber et al., 2007; Stewart, 1982). While self-reported BMI is commonly used in epidemiological health monitoring (e.g., Pagoto et al., 2012), future work could build upon the present findings by employing alternative obesity indicators such as the fat mass index. Second, there are likely many risk factors that influence BMI among trauma-exposed smokers. Only two possible

factors were modeled here (PTSD symptom severity and anxiety sensitivity). Third, alternative lifestyle factors related to BMI were not examined (e.g., eating behavior, physical activity), but are important factors to consider.

Fourth, data were cross-sectional in nature, which precludes hypothesis testing related to causality. Thus, it is unknown how BMI may have changed as a result of the WTC disaster or due to PTSD symptoms, or how anxiety sensitivity may be temporally related to PTSD symptom severity and/or BMI. Lastly, the sample was primarily male (only 34.0% of the sample was female), participants were all *treatment-seeking* smokers, and 23.1% of cases had missing data that were imputed. Collectively, these sample considerations should be considered when interpreting the generalizability of the current findings.

Overall, the findings from the present preliminary study suggest that among WTC disaster-exposed smokers, PTSD symptom severity may be associated with higher BMI due to the tendency to catastrophically interpret arousal sensations. Collectively, it may be clinically important to facilitate reductions in anxiety sensitivity in the service of quitting smoking (Zvolensky et al., 2014, 2008). One such reduction strategy is engagement in physical activity (Smits et al., 2010), which could also aid in reductions in body mass, and increased tolerance for physical sensations (Smits et al., 2008).

Acknowledgments

This work was funded by the National Institute for Occupational Safety and Health (CDC200-201-42057). The funding source had no other role other than financial support. Ms. Farris is supported by pre-doctoral National Research Service Award (F31-DA035564-03). The authors declare that there is no conflict of interest.

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