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Anxiety sensitivity and Pain Experience: a prospective investigation among World Trade Center Responders

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Abstract

Chronic pain is a significant public health problem and is exacerbated by stress. The World Trade Center (WTC) Disaster represents a unique stressor, and responders to the WTC disaster are at increased risk for pain and other health complaints. Therefore, there is a significant need to identify vulnerability factors for exacerbated pain experience among this high-risk population. Anxiety sensitivity (AS), defined as fear of anxiety-related sensations, is one such vulnerability factor associated with pain intensity and disability. Yet, no work has tested the predictive effects of AS on pain, limiting conclusions regarding the predictive utility and direction of associations. Therefore, the current study examined the prospective associations of AS, pain intensity, and pain interference among 452 (M_{age} = 55.22, SD = 8.73, 89.4% male) responders to the WTC disaster completing a 2-week daily diary study. Using multi-level modeling, AS total score was positively associated with both pain intensity and pain interference, and that AS cognitive concerns, but not social or physical concerns, were associated with increased pain. These results highlight the importance of AS as a predictor of pain complaints among WTC responders and provide initial empirical evidence to support AS as a clinical target for treating pain complaints among WTC responders.

Keywords Pain · Anxiety sensitivity · World Trade Center · Prospective

Chronic pain is a significant public health problem, affecting upwards of 20% of the United States population (Dahlhamer 2018), and is associated with a host of negative outcomes, including functional impairment and substance use and misuse. In general, there is sufficient evidence that stress and stress-inducing situations are associated with reports of increased pain (Gil et al. 2004; Melzack 1999), and the World Trade Center (WTC) Disaster represents a unique stressor that is likely associated with increased pain, particularly among responders to the disaster. Studying the impact of the WTC Disaster not only serves as an important event with an affected population and elevated rates of long-term physical and mental health complaints specifically tied to the disaster (Jordan et al. 2019), but also as an event to better understand the potential impact of other, similar events. In general, first responders, including firefighters, police officers, and emergency medical technicians, are at higher risk than the general population for pain complaints due to occupational demands (Bos et al. 2004; Kim et al. 2007). High rates of pain observed in this population are at least partially attributable to job demands such as lifting heavy equipment, high job-related stress, and exposure to physical danger (Kim et al. 2019). These twin hazards – occupational dangers among responders and the unique

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stress of the WTC disaster – underscore the need to identify factors that contribute to or protect from pain in this population.

One important individual difference factor that may play a key role in pain is anxiety sensitivity (AS), defined as fear of anxiety related sensations (Reiss et al. 1986; Reiss and McNally 1985), is a cognitive-based construct that is comprised of a higher order AS factor as well as three lower-order subfactors, including cognitive (anxiety about the negative consequences of thought, physical (anxiety about the negative medical consequences of physical symptoms), and social concerns (anxiety about the negative social consequences of symptoms; Taylor et al. 2007). Previous research indicates that AS is related to exacerbated pain experience (Ocañez et al. 2010). Among adults with chronic pain, higher AS is associated with higher rates of disability and anxiety (Asmundson and Norton 1995). Furthermore, AS is associated with an increased risk of anxiety in response to pain stimuli (Klages et al. 2006; Lang et al. 2006; Norton and Asmundson 2004; Zvolensky et al. 2001). In a study of adults with and without panic disorder, AS mediated the association between diagnostic status and pain intensity and pain tolerance (Schmidt and Cook 1999); these findings have been replicated among healthy women (Keogh and Mansoor 2001). Other work has found that AS mediates the relations between pain and the misuse of opioids to manage pain (Rogers et al. 2019).

Theoretically, AS may serve as a mechanism for exacerbated pain experience. AS is an important predictor of somatic perturbation (Gonzalez et al. 2011), and for those WTC responders with elevated AS, pain symptoms may be interpreted as catastrophic, increasing fear response to these symptoms, and ultimately increasing and maintaining pain intensity and disability. This perspective is in line with the Fear-Avoidance model of chronic pain (J. W. Vlaeyen and Linton 2000), which suggests that catastrophic interpretations of pain lead to overall greater pain experience and serve to maintain symptoms of pain over time. There is also reason to believe that AS may be related to greater variability in pain experience over time. In general, research suggests that greater variability in pain experience is associated with lower quality of life (Tupper et al. 2013). Although no work has directly linked AS to greater pain variability, previous work suggests that elevated AS is associated with greater variability in panic disorder (physical) symptoms (Schmidt and Bates 2003), as well as prospectively for overall anxiety symptoms (McLaughlin and Hatzenbuehler 2009). Given the content and conceptual overlap between anxiety symptoms and pain, it is likely that AS similarly contributes to variability in pain experience, but no research has tested this hypothesis.

Although previous research has documented the importance of understanding the association between AS and exacerbated pain experience and its clinical correlates (Smit et al. 2020), there are notable gaps in the literature. First, no prospective research has examined whether AS is associated with pain. This limitation hinders efforts to understand whether AS serves as a transdiagnostic risk factor over time for exacerbated pain experience, including pain intensity and pain interference, over time, contributing to onset, maintenance, and exacerbation over time; this approach can also help establish a temporal association among these variables which has not previously been documented. Relatedly, a prospective approach allows for the investigation of predictors of pain variability, and this is important given that variability in pain experience is associated with poorer functional outcomes (Mun et al. 2019; Tupper et al. 2013). Second, no work has examined the association between AS and pain experience among responders to the WTC disaster, despite high rates of pain typically following extreme stressors. Third and finally, there is limited study of the AS lower-order factors in terms of pain intensity and pain interference at both the cross-sectional and longitudinal level across populations. Further elucidating AS as a critical, prospective mechanism for the experience of pain will provide empirical evidence to guide the development and adaptation of interventions to treat debilitating pain.

The current study examined the prospective relation between AS and pain intensity and pain interference among a sample of WTC responders. Although no work has examined the relationship between AS and pain in this sample, previous work has documented elevations in AS among this sample, as well as relations of AS with both physical health and substance use problems (Farris et al. 2015, 2016; Zvolensky et al. 2017). It was hypothesized that greater AS would be associated with both greater pain intensity and pain interference, as well as greater overall pain variability. We examined AS lower-order dimensions (i.e., Physical Concerns, Cognitive Concerns, and Social Concerns) as well as overall AS. We hypothesized that, of the AS facets, AS cognitive and physical concerns would be associated with exacerbated pain experience, as reported in two previous investigations among general population samples (Keogh et al. 2006; Zvolensky et al. 2001).

Method

Participants

Participants ($N = 452$, $M_{age} = 55.22$, $SD = 8.73$, 89.4% male) were recruited from the first wave assessment of the WTC Personality and Health Study with follow up waves currently

undergoing data collection (Waszczuk et al. 2019). WTC responders were recruited from a consecutively enrolled cohort of patients seeking treatment from Stony Brook University WTC Health Program, which monitors over 11,000 WTC responders from Long Island, NY (Waszczuk et al. 2019). Participants completed a baseline assessment, which included questionnaires and device training on how to access the survey application on a mobile phone. The baseline visit was followed by 2-weeks of daily diary assessment of pain and other health behaviors (completed at the end of each day, before going to bed). Exclusion criteria included linguistic, cognitive, or physical limitations that would prevent completion of study procedures, such as inability to understand survey questions, attend a baseline appointment, or complete surveys on a mobile device at home. The Institutional Review Board of Stony Brook University approved the study and all participants provided informed consent.

Table 2 Covariance Parameter Estimates (Empty Model)

Table 1. Participant Characteristics	
Race/Ethnicity	
White	90%
Black	7.1%
Asian	0.9%
American Indian/Alaskan Native	0.2%
Education	
Did not complete high school	0.7%
Graduated high school	14/4%
Attended some college	42.5%
Graduated from a 4-year college	25.4%
Attended graduate/professional school	17.0%
Marital Status	
Married/Remarried/Cohabitating	77.7%
Divorced/Widowed/Separated	15.7%
Single	6.4%
Responder Type	
Police Officer	66.1%
Other (construction/public health/ firefighter/EMS)	33.9%
Mental Health Diagnoses	
Anxiety Disorder	13.9%
Depressive Disorder	11.2%
Post-traumatic Stress Disorder	15.1%
Substance Use Disorder	2.0%
Physical Health Diagnoses	
Pain	39.5/100
Cancer	21.1%
Gastroesophageal Reflux Disease (GERD)	42.9%
Injury to extremity	0.9%
Interstitial Lung Disease	2.0%
Obstructive airway disease	30.2%
Spine problems	0.7%
Sarcoidosis	0.9%
Upper respiratory disease	54.8%

Measures

Demographics. Participants provided demographic information, including age, sex, race, occupation, education level, and marital status Additionally, all participants were evaluated by a physician for WTC-connected conditions, including both physical and mental health conditions, that were approved by the National Institute for Occupational Safety and Health (NIOSH 2021). This information was used to describe the sample, and age and sex were included as covariates in the statistical models.

Anxiety Sensitivity Index – 3 (ASI-3; Taylor et al. 2007). The ASI-3 is an 18-item, self-report measure designed to assess AS and its three facets: cognitive concerns (e.g., *"It scares me when I am unable to keep my mind on a task"*), physical concerns (e.g., *"It scares me when my heart beats rapidly"*), and social concerns (e.g., *"It scares me when I blush in front of people"*). AS has been robustly related to more severe and disabling pain outcomes in meta-analytic studies (Ocañez et al. 2010). AS was collected at baseline, and baseline AS total score ($\alpha = 0.93$), as well as sub-facet scores (cognitive ($\alpha = 0.90$), physical ($\alpha = 0.90$), social ($\alpha = 0.77$)) were used as predictors in the current study.

PROMIS Pain Intensity and Interference (Amtmann et al. 2010). Three items from the PROMIS pain item bank were included to measure pain intensity and interference; two to measure pain intensity (*today, how intense was your pain at its worst/average?*) and one to measure pain interference (*today, how much did pain interfere with your daily activities?*). These items were administered daily for 2 weeks and accurately captured clinically significant variability in pain experience, given past research highlighting the significance of relatively rapid fluctuations in pain experience using similar time frames (Stone et al. 2005; Tupper et al. 2013). A daily pain intensity sum score was created, and daily pain interference was examined as a single item.

Data Analysis

Analyses were conducted using SAS Version 9.4. Multilevel models (daily diary assessments nested within participants) were conducted using *PROC MIXED*. Intercept was estimated as random effects, and the effect of time was included in each model. Missing data were estimated using maximum likelihood estimation, the *g matrix* was specified as unstructured, and the *r matrix* was specified as spatial power to account for the autoregressive effects among residual variances over time (Schwartz et al. 2007). Further, to examine variability in outcome as a function of independent variables, the residual variance was modelled as a function of the independent variables (Kuppens and Yzerbyt 2014). Study variables were standardized.

Two models for each dependent variable (pain intensity and pain interference) were examined. First, an unconditional empty model was examined for each outcome to calculate the intraclass correlation (ICC), which indicates stability of pain over time. Then, random intercept models, including age, sex, and time as covariates (at level 1) and AS total score as a between-person predictor of pain intensity and pain interference, were examined in separate models. A second set of models, using AS subscales (cognitive, physical, social) as level 2 predictors of pain intensity and pain interference, were also examined.

Results

Participant characteristics

See Table 1 for participant characteristics.

Multi-level regression analyses

Values of the ICC showed that 78% of the variance in pain intensity and 71% of the variance in pain interference was accounted for by within-person differences, suggesting that considerable stability in pain levels was observed, but differences over time were also significant (p < .001; see Table 2).

Pain Intensity

The conditional model indicated that the AS total score was a significant positive predictor of pain intensity ($b = 0.50$, $se = 0.07$, $p < .001$; see Table 3), such that a 1 SD increase in AS total score was associated with a 0.50 SD increase in pain intensity. Age and sex were not significantly associated with mean pain intensity; however, time was a significant predictor. Variability analyses suggest that variability in pain intensity during the 2-week daily diary period is significantly related to AS total score ($b = 0.18$, $se = 0.02$, $p < .001$), such that greater AS total score is associated with greater variability in pain intensity.

A subsequent model examining AS sub-facets as predictors of pain intensity indicated that AS cognitive concerns ($b = 0.40$, $se = 0.11$, $p = .0003$), but not physical ($b = 0.05$, $se = 0.10$, $p = .60$) or social ($b = 0.13$, $se = 0.11$, $p = .56$) concerns, were significantly, positively associated with mean pain intensity; time remained a significant predictor. Age and sex were not significantly associated with pain intensity (see Table 4). Examining AS sub-facets are predictors of residual variance in pain intensity suggests that AS cognitive concerns ($b = 0.14$, $se = 0.03$, $p < .001$) and social concerns ($b = 0.05$, $se = 0.03$, $p = .04$) were associated with increased variability over time.

	Pain Intensity				Pain Interference			
	b	***se***	***t***		***b***	***se***	***t***	
	3.34	0.52	6.43		1.52	0.22	6.91	
AS	0.05	0.11	0.52	0.60	0.06	0.05	1.22	0.22
AS	0.40	0.11	3.63		0.19	0.05	4.06	
Cog-								
AS	0.13	0.11	1.15	0.25	0.03	0.05	0.62	0.53
Age		0.01	0.16	0.88			-0.27	0.79
Sex	-0.03	0.25	-0.12	0.90	0.06	0.10	0.59	0.55
Time	-0.01	0.004	-2.48	0.01		0.002	-1.77	0.07

Pain Interference

In terms of pain interference, AS total score was a significant positive predictor of interference ($b = 0.24$, $se = 0.03$ $p < .001$; see Table 3), indicating that for every one standard deviation increase in AS total score, pain interference increases by 0.24 SD. Time, age, and sex were not

Table 3 Parameter Estimates – Anxiety Sensitivity Total Score

	Pain Intensity				Pain Interference			
Covariance Parameter	***b***	***se***	***z value***	***p*value**	***b***	***se***	***z value***	***p*value**
Intercept	1.95	0.57	3.40	0.0003	0.41	0.05	8.92	< 0.001
Variance	0.95	0.54	1.78	0.04	0.13	0.03	4.40	< 0.001
Spatial Power	0.95	0.04	24.27	< 0.001	0.89	0.04	22.99	< 0.001
Residual	0.55	0.02	28.36	< 0.001	0.17	0.01	31.34	< 0.001

Table 4 Parameter Estimates – Anxiety Sensitivity Subscale Scores

	Pain Intensity				Pain Interference			
Effect	***b***	***se***	***t value***	***p*value**	***b***	***se***	***t value***	***p*value**
Intercept	3.38	0.52	6.55	< 0.001	1.52	0.22	6.92	< 0.001
AS Total Score	0.50	0.08	6.60	< 0.001	0.24	0.03	7.34	< 0.001
Age	0.001	0.01	0.13	0.90	-0.0001	0.004	0.14	0.88
Sex (male)	-0.06	0.25	-0.26	0.79	0.04	0.10	0.37	0.71
Time	-0.01	0.004	-2.48	0.01	-0.003	0.002	-1.78	0.08

significant predictors. In terms of variability in pain interference, AS total score was a significant positive predictor ($b = 0.19$, $se = 0.02$, $p < .001$), such that greater AS total score was associated with greater variability in pain interference over time.

AS sub-facets analyses revealed a similar pattern to pain intensity, such that AS cognitive concerns ($b = 0.19$, $se = 0.04$, $p < .001$), but not physical ($b = 0.06$, $se = 0.05$, $p = .22$) or social ($b = 0.03$, $se = 0.05$, $p = .54$) concerns, were significantly and positively associated with pain interference. No effects were evident for time, age, or sex (see Table 4). Examining AS sub-facets as predictors of variability in pain interference suggests that AS physical concerns ($b = 0.07$, $se = 0.03$, $p = .02$) and cognitive concerns ($b = 0.36$, $se = 0.03$, $p < .001$) were positively associated with variability in pain interference, and social concerns ($b = -0.07$, $se = 0.03$, $p = .02$) was negatively associated with variability in pain interference.

Discussion

The current study examined the longitudinal association of AS with pain intensity and pain interference among a sample of WTC responders. The results of the current study provide initial empirical support for a significant prospective link between AS and pain intensity and interference. These results are in line with past cross-sectional research suggesting that AS may be a general risk and maintenance factor for pain experience (Drahovzal et al. 2006; Ocañez et al. 2010; Thompson et al. 2008), and confirms and extends this work using a longitudinal design. Additionally, these results provide initial empirical support for the hypothesized model linking AS to pain experience over time; specifically, interpreting anxiety-related stimuli as potentially catastrophic, leads to more severe and debilitating pain over time. Subfacet analyses suggested that AS cognitive concerns were related to both pain intensity and pain interference. While these findings replicate past work (Keogh et al. 2006), the current results did not find support an AS physical concerns, which has been found in a past study of healthy participants. (Keogh et al. 2006). A possible interpretation of these findings is that the cognitive component (thoughts) around pain and anxiety-eliciting stimuli, not the actual physical experience of pain and anxiety, that contributes to longevity of pain. Previous work identifies that pain and cognition are tightly linked in a feedback loop (Moriarty and Finn 2014; Seminowicz and Davis 2007; J. W. S. Vlaeyen et al. 1990), and it is possible that the results of the current study suggest that catastrophic interpretations of thoughts, not physical experience may lead to greater pain experience. More research in this area is needed.

Variability analyses suggest that AS total score and cognitive concerns were associated with greater variability in pain intensity, and that AS total score, AS cognitive concerns, and AS physical concerns were associated with greater variability in pain experience, while AS social concerns was associated with less variability in pain experience. Currently, the literature on predictors of pain variability is nascent and mixed, but it appears that better understanding factors that influence variability may directly impact treatment outcomes (Winger et al. 2019). Some research suggests that greater pain variability is associated with poor quality of life (Tupper et al. 2013), while other work suggests that greater pain variability is associated with placebo response to treatment (Treister et al. 2019). Given the dearth of literature on this topic, it may also be helpful to consider mental health literature, that suggests that greater mood variability is associated with more severe clinical outcomes (Russell et al. 2007). More research in this area of clinical importance is needed.

The current results may have potentially important clinical implications for WTC responders as well as provide understanding for the impact of other, similar disasters. First, given that robust research provides evidence at the cross-sectional, experimental, and now longitudinal level for the importance of AS in understanding pain experience, assessing levels of AS may be an important clinical activity. For WTC responders with elevated AS, addressing this individual difference factor with a targeted intervention may reduce pain burden and improve quality of life. Past work using cognitive-behavioral therapy (including interoceptive exposure) targeting AS has effectively reduced AS and other pain-related cognitions (Watt et al. 2006). Work among clinical pain samples also suggests an acceptance, mindfulness, and value-based approach improves quality of life as well as decreases AS (McCracken and Keogh 2009). These types of therapeutic approaches may be usefully applied to WTC responder populations with elevated AS.

The current study has limitations. First, all measures in the current study were collected via self-report. Therefore, some of the observed results may be due to shared method variance. While the daily diary design of the current study may lower shared method variance to some degree, future research could employ a multimethod assessment approach for AS and pain (Bakhshaie et al. 2020). Second, while the current sample included WTC responders that were often exposed to potentially dangerous situations, it is possible that the results may differ among a subset of those with chronic pain (pain greater than 3 months). Therefore, it would be important to examine the relative generalizability of the current results to both responders with chronic pain, as well as the chronic pain population at large. Third, the current study included primarily white, male participants. Given observed

sex differences in pain experience (Bartley and Fillingim 2013), replication of the results in a more sex-balanced responder sample more diverse in terms of race/ethnicity is warranted. Fourth, while the sample did report experiencing pain consistent with past research among disaster responders, it overall was mild pain (Jensen et al. 2003) and there was no specific information on clinical pain status as well as location of pain. Future research should therefore seek to further quantify the multidimensional aspects of pain experience and replicate the current findings. Finally, the assessment of AS was limited to a single time point. Past work has found that AS is malleable and can change over time (e.g., Watt et al. 2006). Future research could therefore examine how the concurrent relationship between AS and pain may change over time or examine cross-lagged associations.

Overall, the current results provide initial support for a longitudinal association between AS, pain intensity, and pain interference, such that AS is associated with greater overall pain experience among WTC responders. These initial findings suggest AS may be an important individual difference factor for better understanding pain intensity and interference among WTC responders.

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