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Mediators of the association between childhood trauma and pain sensitivity in adulthood: a Multidisciplinary Approach to the Study of Chronic Pelvic Pain Research Network analysis

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Introduction

Individuals with urologic chronic pelvic pain syndrome (UCPPS) exhibit substantial pain symptoms and poor physical and mental health[2; 6; 49]. Approximately 38% of these individuals also meet criteria for at least one other nonurological pain condition[2; 37]

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and 75% experience widespread, nonpelvic pain in addition to localized pelvic pain[40]. The presence of widespread pain is a critical feature of UCPPS as it may indicate centrally-mediated nociplastic[36] pain processes and portend worse clinical outcomes[11; 40; 54; 67]. The ability to predict which individuals with UCPPS are susceptible to the development of widespread pain may provide novel pathways for intervention[11; 38].

Physical and sexual abuse during childhood have been linked to heightened pain sensitivity[65; 72; 77; 90], although findings are mixed[21; 57; 59; 62]. Other forms of trauma and posttraumatic stress disorder (PTSD) are also associated with pain sensitivity[14; 15; 28; 59; 78], although these findings are also inconsistent[14; 15; 22; 27; 28; 76; 84]. Trauma type[57; 76] and sequelae [15; 16; 28; 78; 90] may be differentially associated with pain perception and partly explain these mixed findings. Additionally, physical and sexual abuse may exhibit differential effects on pain sensitivity[83], although both forms of abuse are associated with chronic pelvic pain[44].

Trauma-related outcomes which overlap with pain-related characteristics may contribute to the association between childhood trauma and pain in adulthood. The Mutual Maintenance Model [71] suggests that PTSD and chronic pain maintain each other through shared mechanisms, such as affective distress and heightened cognitive demands that inhibit adaptive coping[71]. Indeed, childhood trauma is associated with affective distress[46; 51] and cognitive dysfunction[89], which are core features of chronic pain[86]. Fewer studies have focused on shared physiological mechanisms, although models of both trauma and pain include alterations in brain structure and function associated with sensory and somatic experiences[31; 32; 74] and individuals with chronic pain and a history of trauma exhibit evidence of central sensitization[72]. Additionally, childhood trauma has been linked to widespread pain and heightened sensitivity to internal and external stimuli[53; 57; 64; 70; 79], which are important features of nociplastic pain and associated with pain sensitivity among individuals with UCPPS[8; 32; 34; 67; 86].

This study explored the association of sexual and nonsexual violent trauma during childhood with experimental pain sensitivity in adulthood using quantitative sensory testing (QST) data from the Multidisciplinary Approach to the Study of Chronic Pelvic Pain (MAPP) Research Network[10; 11]. We also considered the role of nonviolent childhood trauma and recent trauma in adulthood because these frequently co-occur, may exhibit differential effects, and may impact the associations of violent trauma with pain sensitivity[5; 7; 18; 63]. Pressure stimuli were applied to the pubic region and forearm[4; 13] to compare and contrast local pelvic sensitivity to sensitivity at a remote, asymptomatic nonpelvic site. We hypothesized that childhood sexual and nonsexual violent trauma would be associated with heightened pain sensitivity at the pubic region *and* the forearm - suggestive of nociplastic pain[52] - and that patient-reported depressive and anxiety symptoms, cognitive dysfunction, and generalized sensory sensitivity would convey indirect effects.

Materials and Methods

Participants and Procedure

The present study utilized data from the MAPP Research Network's Symptom Pattern Study (SPS), a 3-year observational cohort study described in detail by Clemens et al.[10] Data were collected at six sites across the United States, including Northwestern University (Chicago, Illinois); University of Michigan (Ann Arbor, Michigan); Washington University in St. Louis (St. Louis, Missouri); University of Iowa (Iowa City, Iowa); University of Washington (Seattle, Washington); and University of California, Los Angeles (Los Angeles, California). All study protocols were approved by the Institutional Review Boards at the participating sites. All participants provided informed consent prior to participating in the study.

The present study analyzed data exclusively from UCPPS SPS participants who completed extensive phenotyping including self-report measures and QST (described below). Inclusion and exclusion criteria for UCPS SPS participants are described in detail elsewhere[10]. Briefly, participants were required to: 1) have UCPPS symptoms present for a majority of the time in the most recent 3 months; 2) be 18 years of age or older; and 3) exhibit a response 1 on the bladder/prostate or pelvic pain/pressure/discomfort scale in the past 2 weeks. Participants who had been enrolled in the earlier MAPP Epidemiology and Phenotyping Study (EPS)[43] were permitted to re-enroll with a score of 0 on the pain/pressure/discomfort scale. Exclusion criteria included symptomatic urethral stricture; on-going neurological conditions affecting the bladder; bladder fistula; active autoimmune or infectious disorders; history of cystitis caused by tuberculosis or radiation or chemotherapies; prior augmentation cystoplasty or cystectomy; history of pelvic cancer; current major psychiatric disorders; or severe cardiac, pulmonary, renal, or hepatic disease; unilateral orchalgia (without pelvic symptoms); and prior prostate procedures.

Eligible participants completed an extensive baseline session, including administration of standardized urologic and non-urologic assessment instruments, collection of biosamples, and QST. Participants were followed longitudinally for 6, 18, and 36 months. We focused on baseline QST data in the current study, which was available for most of the participants (n = 523). A small minority (n = 54) did not complete QST at baseline; for these participants, we analyzed the first QST data available.

Measures

Demographics.—Participants were asked to indicate their gender (0 = male; 1 = female) and the highest educational level they attained (0 = less than college; 1 = college degree). Participants were also asked to provide their date of birth, from which age was calculated.

Childhood trauma.—The Childhood Traumatic Events Scale (CTES)[56] was used to assess traumatic events experienced prior to the age of 17, including: death of a very close friend or family member; major upheaval between parents (i.e., divorce, separation); a traumatic sexual experience (i.e., raped, molested); being the victim of violence (i.e., child abuse, mugged or assaulted other than sexual); extreme illness or injury; and any

other major upheaval that may have shaped one's life or personality significantly with an open-ended response option. For each item, participants indicate whether they did or did not experience the event (0 = no; 1 = yes). For the present study, violent interpersonal trauma was of particular interest. Thus, *childhood sexual violent trauma* (a traumatic sexual experience [i.e., raped, molested]) and *childhood nonsexual violent trauma* (victim of violence [i.e., child abuse, mugged or assaulted other than sexual]) were retained as binary predictors. To obtain a childhood nonviolent trauma load score, nonviolent trauma experiences were summed (death of a very close friend or family member; major upheaval between parents; extreme illness or injury) to obtain a *childhood nonviolent trauma sum* with scores ranging from 0 (no nonviolent childhood trauma) to 3 (experienced all forms of nonviolent childhood trauma). Responses to the self-reported other major upheaval category were reviewed for forms of violent trauma; none were found that were not accounted for by the other questions. Thus, this item was not further analyzed. Previous research has frequently analyzed childhood sexual and nonsexual violent trauma independently and, alternatively, sum scores are often reported as a proxy for trauma load[7]. Participants also reported how traumatic the event was and how much they confided in others at the time (see Supplemental Figure 1; available online as supplemental digital content), as well as how old they were when the event occurred (see Supplemental Figure 2; available online as supplemental digital content).

Recent trauma.—The Recent Traumatic Events Scale (RTES)[56] was used to assess traumatic experiences within the last three years, including: death of a very close friend or family member; major upheaval between the participant and the participant's spouse (i.e., divorce, separation); a traumatic sexual experience (i.e., raped, molested); being the victim of violence other than sexual; extreme illness or injury; a major change in the kind of work one does (e.g., a new job, promotion, demotion, lateral transfer); and any other major upheaval that may have shaped one's life or personality significantly with an open-ended response option. Sexual and nonsexual violent trauma were incorporated into the sum score because prevalence rates were low and the type of recent trauma was not relevant to our hypotheses. For each item, participants indicated whether they did or did not experience the event (0 = no; 1 = yes). To obtain a recent trauma load score, items were summed for a total score ranging from 0 (no recent trauma) to 7 (experienced all forms of recent trauma).

Depressive and anxiety symptoms.—Depressive and anxiety symptoms were measured using the Hospital Anxiety and Depression Scale[91]. Each scale includes seven items and reference symptoms experienced over the past week. Sample items include, "I still enjoy the things I used to enjoy" (depressive symptoms) and "Worrying thoughts go through my mind" (anxiety symptoms). Response options ranged from 0 (e.g., not at all) to 3 (e.g., most of the time). For each scale, items were summed for total scores ranging from 0 to 21. Higher scores indicate greater depressive or anxiety symptoms.

Cognitive dysfunction.—The 38-item Multiple Ability Self-Report Questionnaire (MASQ)[69] was used to measure cognitive dysfunction. The MASQ includes five subscales assessing language (e.g., "My speech is slow or hesitant"), visual perceptual ability (e.g., "I get lost when traveling around"), verbal memory (e.g., "I forget to mention important issues

during conversations”), visual-spatial memory (e.g., “I have difficulty remembering the faces of people I have recently met”), and attention/concentration (e.g., “I can focus my attention on a task for more than a few minutes at a time”). Response options ranged from 1 (never) to 5 (always). For the current study, a total sum score was obtained to assess overall cognitive dysfunction, with scores ranging from 38 to 190. Higher scores indicate greater cognitive dysfunction.

Generalized sensory sensitivity.—The Complex Medical Symptoms Inventory[87] and a 2D body map were used to evaluate generalized sensory sensitivity, which is characterized by widespread pain, increased sensitivity to sensations within the body (i.e., interoception), and increased sensitivity to external stimuli[67]. In the present study, these three components were combined into a single brief score, as described in the supplemental material provided by Schrepf et al.[67] The brief measure included the sum score of widespread pain (i.e., sum of painful body regions across seven potential regions), somatic awareness (i.e., sum of three somatic awareness items [dry mouth; rapid heart rate; problems with balance] experienced for 3 months during the last year), and sensory sensitivity (i.e., sum of three sensory sensitivity items [sensitivity to certain chemicals; sensitivity to sound; frequent sensitivity to bright lights] experienced for 3 months during the last year). The sum of widespread pain incorporated all body regions, including the groin and pelvis.

Quantitative sensory testing.—A handheld, analog pressure algometer (FPK Algometer, Wagner Instruments, Greenwich, CT) was used to deliver pressure pain to the suprapubic region (midway between the umbilicus and pubic symphysis) and the dominant forearm (midway between the wrist and elbow with palm facing up) using a 1 cm² rubber-tipped probe. The suprapubic stimulation site aimed to assess local evoked pain sensitivity at the symptomatic pelvic region, whereas the arm site assessed pain sensitivity at a remote, asymptomatic body area as a control. At each site, the research assistant applied six pressure stimuli, in a pseudo-random order, at a rate of approximately 0.5 kgf/cm²/s using a metronome to reach intensities of 2 or 4 kgf/cm²[39]. Each pressure was held for a 5-second duration, with a 15–20 second interstimulus interval. Participants rated the pain intensity of each pressure using a 0 to 100 numerical rating scale (NRS; 0 = no pain, 100 = pain as bad as it could be) following each stimulus presentation. The present study evaluated only NRS scores at 4 kgf/cm² of pressure because the pressure was rated as painful by the majority of participants and there was good variation in responses ($M_{\text{pain at 4kg-pubic}} = 49.04$, $Med = 50.00$, $Range = 0-100$; $M_{\text{pain at 4kg-arm}} = 37.18$, $Med = 35$, $Range = 0-100$). The three 4 kgf/cm² NRS ratings for each site were averaged and two scores were obtained: pain sensitivity at the suprapubic region (pain at 4kg-pubic) and pain sensitivity at the arm (pain at 4kg-arm).

Data Analysis Plan

Preliminary analyses.—Descriptive statistics were obtained for study measures. Histograms and Q-Q plots were used to evaluate the distribution of study variables. All variables appeared reasonably normally distributed. Independent samples t-tests were used to evaluate differences on variables of interest among individuals who did and did not experience a sexual or nonsexual violent experience during childhood. Experiences of other

forms of childhood and recent trauma were also assessed using contingency analyses and associated χ^2 tests. Finally, Pearson correlations were evaluated for all model variables. Each set of analyses were evaluated with alpha at 0.05.

Path analysis: Model building.—Multiple models were then tested and compared to determine the best fitting model for the final analyses. There were no concerns regarding collinearity (all variance inflation factor (VIF) scores < 2). See Figure 1 for the list of models tested. Age, sex, and college education were included in all models with direct associations on all variables of interest to control for their effects. Models were run using full information maximum likelihood (FIML) method of estimation to account for missing data, with bootstrap standard errors (SEs) with 50 draws. These models prioritized the evaluation of model fit, rather than coefficient estimates. Numerous indices were used to evaluate the best fitting model, including the χ^2 goodness-of-fit test, the root mean square error of approximation (RMSEA), the comparative fit index (CFI), the Tucker-Lewis index (TLI), Akaike's Information Criterion (AIC), and Bayesian Information Criterion (BIC). An increase in degrees of freedom was preferred. A nonsignificant increase in the χ^2 goodness-of-fit test for more degrees of freedom was considered favorable. A decrease in RMSEA and increase in CFI and TLI indicated a better fitting model. AIC and BIC for each model were also assessed, with the model showing the lowest AIC and BIC considered the best fitting model. This information was considered to determine the preferred model, which was subsequently tested as the final model[3].

Path analysis: Final model.—Path analysis was then conducted to assess the final preferred model using FIML method of estimation with bootstrap SEs with 10,000 draws. Age, sex, and college education were included in all models with direct associations on all variables of interest to control for their effects. Childhood sexual violent trauma and childhood nonsexual violent trauma were included as distal binary predictors. Thus, no violent trauma was included as the reference category and direct and indirect effects are relative to this reference group. The childhood nonviolent trauma sum was also included as a distal predictor to account for the co-occurrence of trauma. Overall model fit was evaluated with the χ^2 goodness-of-fit test, RMSEA, CFI, and TLI[61]. RMSEA = 0.05 indicates good fit. CFI and TLI = 0.95 indicates good fit. Bentler-Raykov squared multiple correlation coefficients (R^2) were assessed to determine the variance explained in the mediators and outcomes of interest. Coefficients in which the bias-corrected bootstrap 95% confidence intervals (95% CI) did not include zero were considered statistically significant.

Path analysis: Probing indirect effects.—In order to further understand the indirect effects, analyses were assessed using seemingly unrelated regression and modeling each indirect pathway simultaneously. Bias-corrected and accelerated (BCa) 95% CIs were then assessed to determine significance, with BCa 95% CIs not including zero considered statistically significant. Complete case analysis was used for probing indirect effects. The proportion of the total indirect effect accounted for in each outcome was calculated by dividing the absolute value of the coefficient for each distal predictor (childhood sexual violent trauma; childhood nonsexual violent trauma; and childhood nonviolent trauma sum) by the sum of the absolute values of indirect effects from each distal predictor on the

outcome. Specific indirect effects for each mediator were calculated by dividing the absolute value of the coefficient for each specific indirect path by the sum of the absolute values of indirect effects for each distal predictor. Analyses were conducted using StataIC v.15 (StataCorp, College Station, Texas, USA).

Results

Sample descriptives.

The analyses included 577 UCPPS study participants ($M_{\text{age}} = 44.81$, $SD = 15.68$; 66.55% female). Descriptive results are provided in Table 1. Participants who experienced childhood sexual violent trauma or childhood nonsexual violent trauma were more often female, experienced more types of nonviolent childhood trauma, experienced more types of recent trauma, and reported higher depressive symptoms, higher anxiety symptoms, more cognitive dysfunction, higher generalized sensory sensitivity, and higher perceived pain in the pubic region in response to pressure stimuli.

As shown in Table 2, 22.7% of the overall sample experienced childhood sexual violent trauma and 18.8% reported childhood nonsexual violent trauma. Participants who experienced childhood sexual violent trauma more often experienced all other forms of childhood trauma, as well as many recent traumatic experiences in adulthood, including recent violence, being extremely ill or injured, and experiencing some other major upheaval.

Participants who reported childhood nonsexual violent trauma also more often reported all other forms of childhood trauma, with the exception of the death of a friend or family member. Reporting childhood nonsexual violent trauma was also associated with recent traumatic events, including the death of a friend or family member, recent violence, being extremely ill or injured, and experiencing some other major upheaval.

Bivariate associations.

As shown in Table 3, the variables of interest were generally intercorrelated. Of note, pain sensitivity in the pubic region was significantly correlated with experiencing childhood sexual violent trauma, childhood nonsexual violent trauma, younger age, female sex, more types of nonviolent childhood trauma, more types of recent traumatic events, higher depressive symptoms, higher anxiety symptoms, higher cognitive dysfunction, and higher generalized sensory sensitivity. Pain sensitivity in the arm was significantly associated with older age, female sex, higher education, higher cognitive dysfunction, and higher generalized sensory sensitivity. Pain sensitivity in the pubic region and the arm were significantly positively associated.

Model building.

As seen in Figure 1 and Table 4, four models were compared. Model 3 resulted in a decrease in RMSEA, as well as an increase in CFI and TLI, compared to Model 2. The increase in χ^2 was nonsignificant, and the model exhibited a nonsignificant χ^2 goodness of fit. Furthermore, AIC and BIC increased minimally. In comparison, further increasing degrees of freedom in Model 4 resulted in a significant increase in χ^2 , as well as an increase in

RMSEA and decrease in CFI and TLI. AIC and BIC for Model 4 also increased. Thus, Model 3 was determined to be the preferred model.

Path analysis.

Direct effects for the final model are displayed in Figure 2 and Table 5. Overall, the model fit the data well (χ^2 (df = 8) = 13.42, $p = .098$; RMSEA = .034 (90% CI [.000, .065]); CFI = .996; TLI = .965). The findings suggest that experiencing violence during childhood and more types of nonviolent childhood trauma were associated with experiencing more types of recent trauma. Experiencing childhood sexual violent trauma and more types of recent trauma were associated with more depressive symptoms and more anxiety symptoms. Experiencing childhood sexual violent trauma, childhood nonsexual violent trauma, and more types of recent trauma were associated with higher cognitive dysfunction and higher generalized sensory sensitivity. In turn, higher cognitive dysfunction and higher generalized sensory sensitivity were associated with higher pain sensitivity in the pubic region and higher pain sensitivity at the arm.

Probing indirect effects.

Specific indirect effects are shown in Table 6. Overall, there was a significant total indirect effect of childhood trauma on pain sensitivity at both the pubic region and the arm. Experiencing childhood sexual violent trauma and childhood nonsexual violent trauma were significantly associated with pain sensitivity in the pubic region. Childhood nonsexual violent trauma carried the majority of the total indirect effect. Experiencing childhood sexual violent trauma also contributed a significant minority of the total indirect effect. The impact of nonviolent trauma was small. The proportion of the specific indirect effect for both sexual and nonsexual violent trauma during childhood suggests that generalized sensory sensitivity was the primary mediator of this association.

Experiencing childhood sexual and nonsexual violent trauma were both significantly associated with higher pain sensitivity at the arm through generalized sensory sensitivity, although the overall impact of childhood violent trauma was nonsignificant. This is likely due to the counterintuitive impact of experiencing childhood sexual and nonsexual violent trauma on lower pain sensitivity through anxiety symptoms. The calculated proportion of indirect effects was consistent, however, with childhood sexual and nonsexual violent trauma carrying the majority of the total indirect effect. Generalized sensory sensitivity carried the majority of the specific indirect effect.

Discussion

Research evaluating the impact of childhood trauma on experimental pain sensitivity has been mixed[21; 57; 59; 62; 65; 77; 90]. To our knowledge, few studies have considered potential mediators of this association[59], although research suggests that individual-level characteristics such as trauma sequelae may impact this association[15; 16; 28; 78; 90]. Our findings suggest that, among UCPPS participants, childhood trauma may be associated with heightened pain sensitivity to the extent that trauma history is associated with a subsequent increase in generalized sensory sensitivity.

Traumatic experiences are common and associated with worse symptoms.

Our findings suggest that about one out of five individuals with UCPPS experienced childhood sexual violent trauma or childhood nonsexual violent trauma. Combined across both types of sexual and nonsexual violent trauma, 31.3% reported one or both forms. In a nationally representative sample of adults in the United States, approximately 17.9% reported childhood physical abuse and 11.6% reported childhood sexual abuse[47]. Among healthy controls in the MAPP Research Network, 10% reported childhood sexual violent trauma and 9% reported childhood nonsexual violent trauma[66]. Prevalence rates of childhood sexual and physical abuse across previous studies of individuals with pelvic pain are generally higher, but vary widely (19.4%-62.5%)[5; 12; 41; 42; 60; 82]. Our prevalence rates fit within this range. Additionally, other potentially traumatic events during childhood frequently co-occurred. This high rate of co-occurrence has been supported by previous research[18; 20; 63].

Sexual and nonsexual violent trauma during childhood were directly associated with negative health-related outcomes. In particular, childhood sexual violent trauma was associated with higher depressive symptoms, anxiety symptoms, cognitive dysfunction, and generalized sensory sensitivity, whereas childhood nonsexual violent trauma was directly associated with higher cognitive dysfunction and generalized sensory sensitivity. Previous research supports the far-reaching health consequences of childhood trauma[20; 35; 48]. Childhood trauma may lead to a cascade of inter-related biological and psychological outcomes including, but not limited to, alterations in neurobiological systems responsible for threat perception and sensory processing; immune dysregulation; altered physiological reactivity to stress; and higher rates of mental health disorders (e.g., PTSD, depression, and anxiety)[19; 31; 35; 46; 48; 73; 75; 85]. Sexual and nonsexual violent trauma may be especially linked to negative health consequences due to the interpersonal nature of the event and the potential sense of betrayal that accompanies these forms of trauma[24; 26]. Betrayal is a violation of trust that can have a severe impact on one's sense of self, others, and the world in general and is considered distinct from the stereotypical fear considered as the core of the trauma response[24]. However, we were unable to assess the role of perceived betrayal due to the limitations of our data.

Recent trauma in adulthood may also be an important conduit for the impact of childhood trauma on health-related outcomes. Our findings suggest that a mechanistic model in which recent adult trauma load acts as a partial mediator linking childhood trauma to affective distress, cognitive dysfunction, and generalized sensory sensitivity best fit the observed data structure. Previous research suggests that childhood trauma is associated with trauma load in adulthood[7; 17]. The reasons for this are complex and multifaceted. In addition to the previously mentioned impact of trauma on biological and psychological outcomes, trauma has also been linked to increased risk behavior and alterations in social information processing[45; 80]. The multitudinous consequences of childhood trauma may have contributed to the recent trauma load, particularly reflected by future traumatic health problems, violence exposure, and unspecified trauma, reported in the present sample[35; 48; 55]. These associations may also highlight the persistent contextual disadvantage in which many individuals who experience childhood trauma are embedded across their lifetime[55].

Our findings further suggest that recent trauma load in adulthood is more strongly associated with current symptoms compared to distal childhood trauma experiences. Previous research similarly suggests that proximal traumatic experiences may be more important for pain related outcomes compared to childhood abuse[5]. In addition to temporal proximity, recent trauma load may contribute to overwhelming stress and an inability to adapt resulting in dysregulation of the nervous, endocrine, and immune systems[29]. This dysregulation can impact affective distress, cognitive dysfunction, and indicators of nociplastic pain, which may also overlap with posttraumatic stress symptoms[29; 58]. Importantly, some of the effect of childhood trauma on pain-related outcomes in adulthood may be *through* its association with an increased trauma load throughout life, representing just one possible mechanistic pathway[55]. The complex and long-term trajectories of childhood trauma highlight the critical need for empathic, trauma-informed care for patients with UCPPS and other chronic pain diagnoses. Additionally, trauma history assessment and PTSD/Complex PTSD screening among patients with UCPPS are necessary as these conditions tend to be underdiagnosed, undertreated, and may lead to worse symptoms and poor treatment response.

Generalized sensory sensitivity plays an important role in the association between childhood trauma and pain sensitivity.

Generalized sensory sensitivity was an important mechanism conveying the effect of childhood trauma on heightened pain sensitivity in both pelvic and nonpelvic sites. These findings echo those in previous research utilizing the MAPP data, in which generalized sensory sensitivity was associated with suprathreshold pain sensitivity at a nonpelvic site[34]. Generalized sensory sensitivity appears to be a core component of the nociplastic pain phenotype[67], in which altered central nervous system factors are believed to lead to the amplification and/or dysregulation of sensory stimuli and the spatial spread of pain[88]. For example, previous research has shown increased visual and auditory sensitivity among patients with fibromyalgia[25; 33]. Although the cause of centralized pain is unclear, numerous precipitating factors have been proposed, including interactions between genetic vulnerability and environmental factors such as traumatic stress[9]. PTSD is also associated with alterations in brain structure and function indicative of disordered multisensory processing[31]; these regions (e.g., thalamus; posterior and anterior insula) at least crudely correspond to those implicated in the experience of physical pain intensity[33; 50; 68; 81]. Indeed, previous research has linked trauma, particularly violent trauma, to the components of generalized sensory sensitivity as well as conditions indicative of nociplastic pain[1; 53; 57]. Recent research also suggests that posttraumatic stress symptoms may uniquely contribute to somatic awareness and external sensory sensitivity after accounting for chronic pain[58]. Thus, some UCPPS patients may exhibit a nociplastic pain phenotype, potentially impacted by traumatic stress during childhood, which in turn affects sensitivity to painful stimuli. Importantly, although self-reported increases in generalized sensory sensitivity requires subjective evaluations filtered through a cognitive and affective lens, it nevertheless likely reflects a physiological component of nociplastic pain. Therefore, clinicians and researchers should recognize the physiological impact of trauma and its consequent role in the pain and broader sensory experience. Incorporating a simple body map or brief measure

of generalized sensory sensitivity[67] into research and practice may aid in advancing this goal.

Sexual and nonsexual violent trauma during childhood were associated with higher cognitive dysfunction which, in turn, was associated with higher pain sensitivity. Despite these direct associations, the specific indirect effects failed to reach significance. Previous research supports the link between childhood trauma and worse cognitive functioning[89], which is a cardinal symptom of centralized pain[86]. These findings warrant more extensive evaluations of the role of cognitive dysfunction in the association between trauma and pain sensitivity, particularly in the context of other centralized pain characteristics.

Strengths and Limitations

The MAPP SPS is the largest study evaluating pain perception among UCPPS patients. Additionally, although the survey data included in our model utilized cross-sectional data, the referenced time frames (i.e., childhood, recent events [within the past 3 years], current symptoms) in combination with QST data supports the temporal relationships presented in the mediation model. However, several limitations are worth noting. We considered ratings of standardized, suprathreshold pain stimuli. This included only pain intensity ratings from a single modality (i.e., pressure pain). Other QST measures would be important to consider. We did not assess how specific pelvic pain disorders may have impacted these findings, which may be an important area for future research. Our measure of trauma was also limited. Due to the wording of the questions about sexual and nonsexual violent trauma, participants would need to subjectively consider their past experiences as trauma. Many survivors of childhood abuse, however, do not label the experiences as abuse[30]. Future studies should consider the use of behaviorally specific measures of childhood trauma. Additionally, future studies should evaluate the role of emotional abuse and neglect and other types of adverse childhood experiences[20; 23], which may be differentially associated with health-related and pain perception outcomes. We also did not consider other factors related to the traumatic experience (e.g., age at time of event). Finally, we combined men and women in our model. Future research should explore these associations among men, women, transgender, and non-binary individuals.

Conclusion

Our findings suggest that sexual and nonsexual violent trauma during childhood are indirectly associated with pain sensitivity among adult UCPPS patients. Heightened generalized sensory sensitivity played a unique role in conveying these effects, highlighting the need for clinicians and researchers to recognize the importance of physiological sensitivity to the pain experience for individuals with a history of childhood trauma.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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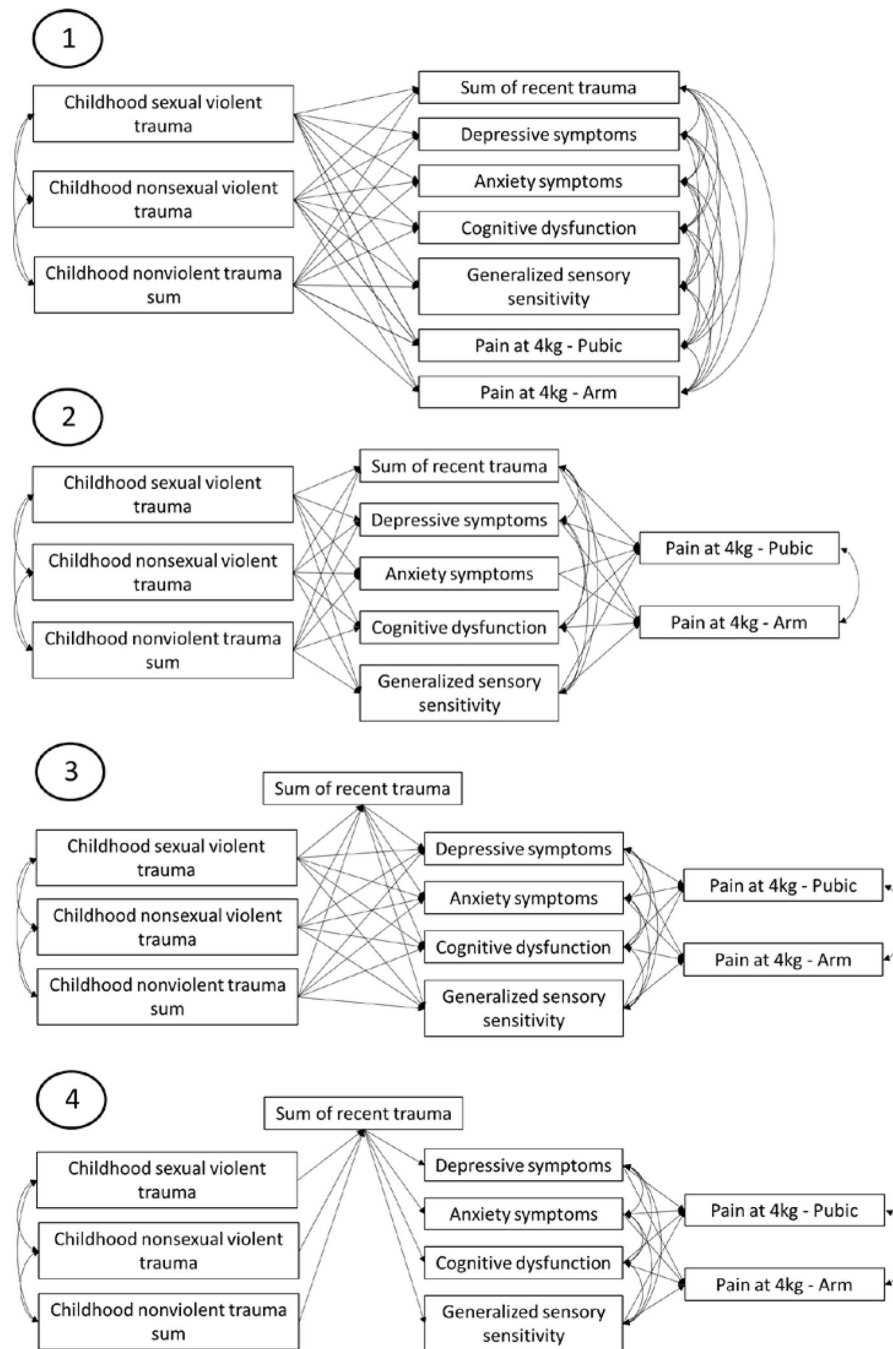


Figure 1. Models for comparison. Model 1 was designed to treat childhood trauma as causal and all adult variables as outcomes at the same level. Model 2 was designed to treat childhood trauma as causal, recent trauma and self-reported adult symptoms as mediators, and pain sensitivity as outcomes. Model 3 was designed to treat childhood trauma as causal, recent trauma as a partial distal mediator, self-reported adult symptoms as proximal mediators, and pain sensitivity as outcomes. Model 4 was designed to treat childhood trauma as causal, recent trauma as a full distal mediator, self-reported adult symptoms as proximal mediators,

and pain sensitivity as outcomes. Model fit statistics showed Model 3 as the preferred model.

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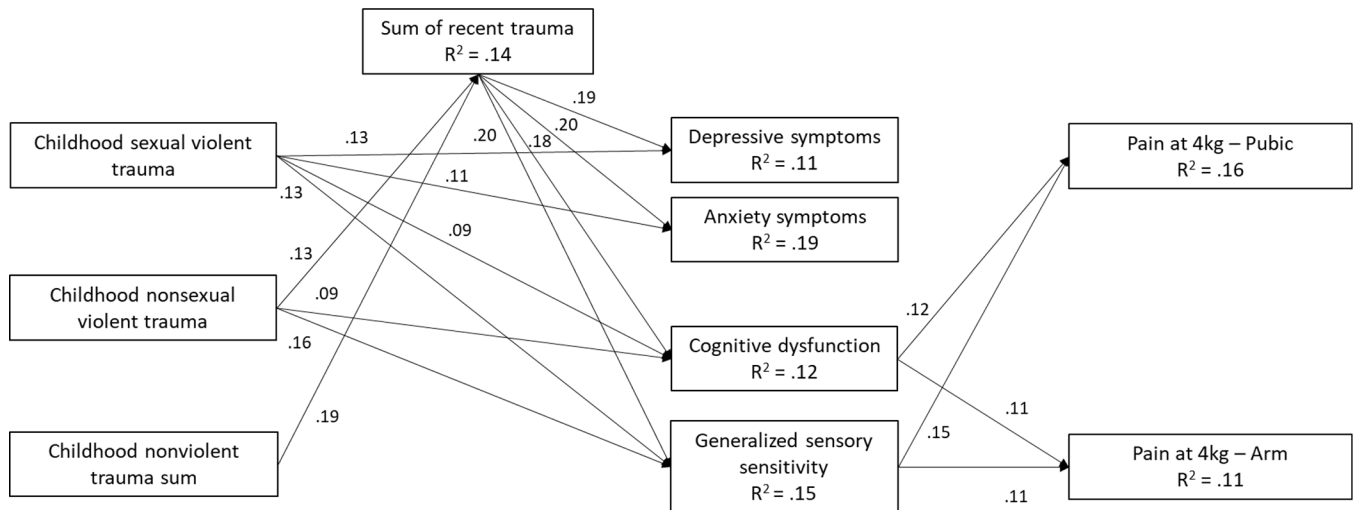


Figure 2. Path model predicting pain sensitivity. Standardized estimates are shown. Only significant paths are shown. Covariates (age, college graduate, and sex) were included with direct associations on study variables. Covariance among variables at the same levels were also included. Covariates and covariance estimates, however, are not included in the figure to ease interpretability. X^2 (df = 8) = 13.42, $p = .098$; RMSEA = .034 (90% CI [.000, .065]); CFI = .996; TLI = .965.

Table 1.

Descriptive data for full sample and differences by history of violent childhood trauma

Variable	Overall M (SD) / n (%)	Childhood Traumatic Sexual Experience			Childhood Victim of Violence		
		No n = 440	Yes n = 129	p	No n = 463	Yes n = 107	p
Age	44.81 (15.68)	45.33 (15.96)	43.31 (14.71)	0.201	45.07 (16.18)	44.05 (13.48)	0.546
Female	384 (66.55)	269 (61.14)	108 (83.72)	< 0.001	298 (64.36)	80 (74.77)	0.040
College graduate	389 (67.42)	304 (69.09)	81 (62.79)	0.179	319 (68.90)	67 (62.62)	0.210
Race							
White/Caucasian	509 (88.21%)	387 (87.95)	114 (88.37)	0.587	408 (88.12)	95 (88.79)	0.302
Black/African-American	32 (5.55%)	22 (5.00)	10 (7.75)		26 (5.62)	6 (5.61)	
American Indian	3 (.52%)	3 (.68)	0 (.00)		3 (.65)	0 (.00)	
Native Hawaiian	1 (.17%)	1 (.23)	0 (.00)		1 (.22)	0 (.00)	
Asian	6 (1.04%)	6 (1.36)	0 (.00)		6 (1.30)	0 (.00)	
Multi-Race	18 (3.12%)	15 (3.41)	3 (2.33)		11 (2.38)	6 (5.61)	
Other	8 (1.39%)	6 (1.36)	2 (1.55)		8 (1.73)	0 (.00)	
Hispanic/Latino	37 (6.41%)	26 (5.92)	11 (8.53)	0.292	28 (6.06)	9 (8.41)	0.374
Sum of nonviolent childhood trauma	1.02 (0.87)	0.88 (0.82)	1.49 (0.87)	< 0.001	0.90 (0.84)	1.54 (0.80)	< 0.001
Sum of recent trauma	1.79 (1.25)	1.70 (1.23)	2.13 (1.28)	< 0.001	1.67 (1.23)	2.32 (1.19)	< 0.001
Depression	5.76 (4.50)	5.36 (4.35)	7.17 (4.76)	< 0.001	5.49 (4.40)	6.91 (4.77)	0.003
Anxiety	7.38 (4.73)	6.96 (4.59)	8.82 (4.97)	< 0.001	7.03 (4.68)	8.90 (4.72)	< 0.001
Cognitive dysfunction	78.61 (21.34)	76.86 (20.51)	84.58 (23.22)	< 0.001	77.13 (20.95)	84.98 (22.13)	< 0.001
Generalized sensory sensitivity	2.79 (2.28)	2.51 (2.12)	3.77 (2.59)	< 0.001	2.51 (2.14)	3.97 (2.52)	< 0.001
Pain at 4kg - Pubic	49.04 (25.09)	46.64 (24.95)	56.85 (23.62)	< 0.001	47.48 (24.85)	55.45 (24.94)	0.005
Pain at 4kg - Arm	37.18 (24.70)	36.37 (24.79)	39.26 (23.92)	0.245	36.94 (24.53)	37.26 (25.04)	0.906

Note. Boldfaced values are significant at $p < 0.05$.

Prevalence of childhood and adulthood trauma types in patients with urologic chronic pelvic pain syndrome (UCPPS) with history of violent childhood trauma

Table 2.

Trauma type	Overall		Childhood Sexual Violent Trauma		Childhood Nonsexual Violent Trauma		
	n (%)	No (n = 440) n (%)	Yes (n = 129) n (%)	p	No (n = 463) n (%)	Yes (n = 107) n (%)	p
Childhood experiences							
Death of friend or family member	256 (44.8)	178 (40.5)	77 (59.7)	<0.001	203 (43.8)	52 (48.6)	0.373
Parents' divorce or separation	202 (35.8)	136 (31.1)	66 (52.8)	<0.001	132 (28.8)	70 (66.7)	<0.001
Traumatic sexual experience	129 (22.7)	--	--		71 (15.4)	58 (54.2)	<0.001
Victim of violence	107 (18.8)	49 (11.2)	58 (45.0)	<0.001	--	--	
Extremely ill or injured	125 (22.0)	75 (17.1)	49 (38.0)	<0.001	82 (17.8)	43 (40.2)	<0.001
Other major upheaval	213 (37.4)	144 (32.8)	69 (53.5)	<0.001	157 (34.0)	56 (52.3)	<0.001
Recent experiences (past 3 years)							
Death of friend or family member	288 (50.7)	217 (49.5)	70 (54.7)	0.306	219 (47.6)	68 (63.6)	0.003
Divorce or separation	73 (13.0)	50 (11.6)	23 (18.1)	0.053	54 (11.8)	19 (17.9)	0.093
Traumatic sexual experience	26 (4.6)	21 (4.8)	5 (3.9)	0.662	20 (4.4)	6 (5.7)	0.567
Victim of violence	31 (5.5)	18 (4.1)	13 (10.2)	0.008	17 (3.7)	14 (13.1)	<0.001
Extremely ill or injured	164 (29.1)	114 (26.2)	50 (39.4)	0.004	115 (25.2)	48 (45.3)	<0.001
Major change in work	279 (49.5)	211 (48.5)	67 (52.8)	0.399	224 (49.1)	54 (50.5)	0.802
Other major upheaval	157 (27.7)	112 (25.7)	45 (35.2)	0.036	117 (25.6)	39 (36.5)	0.023

Note. Boldfaced values are significant at $p < 0.05$.

Table 3.

Bivariate correlations among study variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1 Childhood sexual violent trauma	--											
2 Childhood nonsexual violent trauma	0.36	--										
3 Age	-0.05	-0.03	--									
4 Female	0.20	0.09	-0.17	--								
5 College graduate	-0.06	-0.05	0.05	-0.02	--							
6 Childhood nonviolent trauma sum	0.29	0.29	-0.06	0.14	-0.12	--						
7 Sum of recent trauma	0.15	0.20	-0.19	0.23	-0.06	0.26	--					
8 Depressive symptoms	0.17	0.12	-0.16	0.04	-0.16	0.11	0.24	--				
9 Anxiety symptoms	0.16	0.15	-0.34	0.08	-0.12	0.08	0.27	0.57	--			
10 Cognitive dysfunction	0.15	0.14	-0.13	0.11	-0.21	0.05	0.22	0.55	0.48	--		
11 Generalized sensory sensitivity	0.23	0.25	0.02	0.18	-0.08	0.14	0.26	0.38	0.36	0.43	--	
12 Pain at 4kg - Pubic	0.17	0.12	-0.09	0.30	-0.002	0.09	0.12	0.16	0.14	0.20	0.24	--
13 Pain at 4kg - Arm	0.05	0.01	0.09	0.23	0.09	0.04	0.07	0.07	0.002	0.12	0.18	0.66

Note. Pearson correlations are reported. Boldfaced values are significant at $p < 0.05$. Complete case analyses was used. Thus, sample sizes vary.

Table 4.

Model comparison for model building

Model	χ^2	df	p	χ^2	df	RMSEA	RMSEA 90% CI			CFI	TLI	AIC	BIC
							LL	UL	UL				
Saturated model													
(Model 1)	--	--	--	--	--	--	--	--	--	--	--	33532.06	33745.60
Model 2	12.92	6	0.044	--	--	0.045	0.007	0.079	0.995	0.941	33544.98	33758.52	
Model 3	13.42	8	0.098	0.50	2	0.034	0.000	0.065	0.996	0.965	33545.49	33759.02	
Model 4	58.69	20	<0.001	45.27	12	0.058	0.041	0.075	0.974	0.901	33590.76	33804.29	

Note. Boldfaced values indicate the preferred model. RMSEA=Root Mean Square Error of Approximation. 90% CI=90% Confidence Interval; LL=Lower Limit; UL=Upper Limit; CFI=Comparative Fit Index. TLI=Tucker-Lewis Index. AIC=Akaike Information Criterion. BIC=Bayesian Information Criterion.

Table 5.

Direct effects derived from path analysis predicting pain sensitivity (n = 577)

Outcome	Predictor	Coef.	Bootstrap SE	Standardized Coef.	p	Bias-corrected Bootstrap 95% CI	
						LL	UL
<i>Direct Associations</i>							
→Childhood sexual violent trauma							
	Age	0.00	0.001	-0.02	0.632	-0.003	0.002
	College graduate	-0.05	0.04	-0.05	0.214	-0.123	0.027
	Female	0.17	0.03	0.19	<0.001	0.109	0.236
→Childhood nonsexual violent trauma							
	Age	0.00	0.001	-0.01	0.815	-0.002	0.002
	College graduate	-0.04	0.04	-0.05	0.237	-0.114	0.027
	Female	0.07	0.03	0.08	0.032	0.004	0.130
→Childhood nonviolent trauma sum							
	Age	-0.002	0.002	-0.03	0.414	-0.007	0.003
	College graduate	-0.22	0.08	-0.12	0.006	-0.377	0.068
	Female	0.24	0.08	0.13	0.002	0.087	0.386
→Sum of recent trauma							
	Childhood sexual violent trauma	0.002	0.13	0.00	0.988	-0.250	0.258
	Childhood nonsexual violent trauma	0.42	0.14	0.13	0.002	0.149	0.687
	Childhood nonviolent trauma sum	0.27	0.06	0.19	<0.001	0.152	0.388
	Age	-0.01	0.003	-0.14	<0.001	-0.017	-0.006
	College graduate	-0.06	0.10	-0.02	0.524	-0.256	0.134
	Female	0.43	0.11	0.16	<0.001	0.226	0.642
→Depressive symptoms							
	Childhood sexual violent trauma	1.37	0.48	0.13	0.004	0.456	2.333
	Childhood nonsexual violent trauma	0.40	0.53	0.04	0.448	-0.638	1.436
	Childhood nonviolent trauma sum	-0.03	0.24	-0.01	0.884	-0.485	0.438
	Sum of recent trauma	0.69	0.17	0.19	<0.001	0.360	1.012
	Age	-0.03	0.01	-0.12	0.002	-0.055	-0.013
	College graduate	-1.27	0.39	-0.13	0.001	-2.031	-0.499
	Female	-0.50	0.41	-0.05	0.213	-1.329	0.267
→Anxiety symptoms							
	Childhood sexual violent trauma	1.20	0.50	0.11	0.018	0.198	2.172
	Childhood nonsexual violent trauma	0.97	0.52	0.08	0.061	-0.028	1.968
	Childhood nonviolent trauma sum	-0.24	0.25	-0.04	0.326	-0.718	0.239
	Sum of recent trauma	0.75	0.17	0.20	<0.001	0.421	1.071
	Age	-0.09	0.01	-0.30	<0.001	-0.114	-0.069
	College graduate	-0.87	0.40	-0.09	0.030	-1.648	-0.097
	Female	-0.38	0.38	-0.04	0.320	-1.126	0.358
→Cognitive dysfunction							

Outcome	Predictor	Coef.	Bootstrap SE	Standardized Coef.	p	Bias-corrected Bootstrap 95% CI	
						LL	UL
	Childhood sexual violent trauma	4.66	2.37	0.09	0.049	0.207	9.444
	Childhood nonsexual violent trauma	4.70	2.40	0.09	0.050	0.044	9.429
	Childhood nonviolent trauma sum	-2.18	1.15	-0.09	0.057	-4.417	0.084
	Sum of recent trauma	3.09	0.82	0.18	<0.001	1.498	4.694
	Age	-0.10	0.06	-0.08	0.065	-0.213	0.005
	College graduate	-8.98	1.91	-0.20	<0.001	-12.656	-5.063
	Female	1.48	1.84	0.03	0.420	-2.128	5.129
	→Generalized sensory sensitivity						
	Childhood sexual violent trauma	0.71	0.27	0.13	0.008	0.189	1.236
	Childhood nonsexual violent trauma	0.96	0.29	0.16	0.001	0.421	1.543
	Childhood nonviolent trauma sum	-0.03	0.12	-0.01	0.783	-0.254	0.203
	Sum of recent trauma	0.37	0.08	0.20	<0.001	0.212	0.532
	Age	0.01	0.01	0.09	0.021	0.002	0.025
	College graduate	-0.32	0.20	-0.07	0.099	-0.710	0.066
	Female	0.52	0.19	0.11	0.006	0.147	0.892
	→Pain at 4kg - Pubic						
	Depressive symptoms	0.09	0.32	0.02	0.789	-0.539	0.705
	Anxiety symptoms	0.15	0.29	0.03	0.623	-0.438	0.720
	Cognitive dysfunction	0.15	0.06	0.12	0.024	0.020	0.273
	Generalized sensory sensitivity	1.71	0.52	0.15	0.001	0.674	2.720
	Age	-0.03	0.07	-0.02	0.692	-0.163	0.109
	College graduate	2.67	2.26	0.05	0.236	-1.683	7.134
	Female	14.29	2.28	0.26	<0.001	9.747	18.644
	→Pain at 4kg - Arm						
	Depressive symptoms	0.25	0.30	0.04	0.413	-0.353	0.834
	Anxiety symptoms	-0.45	0.28	-0.09	0.108	-0.991	0.123
	Cognitive dysfunction	0.13	0.06	0.11	0.045	0.003	0.247
	Generalized sensory sensitivity	1.19	0.54	0.11	0.028	0.121	2.250
	Age	0.18	0.07	0.11	0.011	0.042	0.318
	College graduate	6.09	2.13	0.12	0.004	1.907	10.163
	Female	11.89	2.13	0.23	<0.001	7.652	15.979
	<i>Covariance</i>						
	Childhood sexual violent trauma↔Childhood nonsexual violent trauma	0.06	0.01	0.35	<0.001	0.039	0.073
	Childhood sexual violent trauma↔Childhood nonviolent trauma sum	0.09	0.02	0.27	<0.001	0.064	0.125
	Childhood nonsexual violent trauma↔Childhood nonviolent trauma sum	0.09	0.01	0.28	<0.001	0.064	0.121

Outcome	Predictor	Coef.	Bootstrap SE	Standardized Coef.	<i>p</i>	Bias-corrected Bootstrap 95% CI	
						LL	UL
	Generalized sensory sensitivity↔Anxiety symptoms	2.91	0.43	0.33	<0.001	2.107	3.794
	Generalized sensory sensitivity↔Depressive symptoms	2.91	0.41	0.33	<0.001	2.137	3.761
	Generalized sensory sensitivity↔Cognitive dysfunction	16.68	1.94	0.39	<0.001	13.243	20.861
	Anxiety symptoms↔Depressive symptoms	9.41	0.89	0.52	<0.001	7.838	11.330
	Anxiety symptoms↔Cognitive dysfunction	36.43	4.09	0.42	<0.001	29.323	45.488
	Depressive symptoms↔Cognitive dysfunction	44.14	4.34	0.52	<0.001	36.293	53.368
	Pain at 4kg - Pubic↔Pain at 4kg - Arm	358.22	24.37	0.66	<0.001	316.690	414.432
	Age↔College graduate	0.33	0.32	0.05	0.302	-0.308	0.960
	Age↔Female	-1.25	0.30	-0.17	<0.001	-1.858	-0.660
	College graduate↔Female	-0.005	0.01	-0.02	0.581	-0.023	0.012

Note. SE = Standard Error. CI = Confidence Interval. Boldfaced values are significant coefficients in which the bias-corrected bootstrap 95% CI does not contain zero.

Table 6.

Specific indirect effects of the association between childhood trauma and pain sensitivity (n = 457)

Outcome	Indirect path	Coef.	Bootstrap SE	BCa Bootstrap 95% CI		Proportion of total indirect effect	Proportion of specific indirect effect
				LL	UL		
→Pain at 4kg - pubic							
	Total <i>childhood sexual violent trauma</i> via GSS, Depressive Symptoms, Anxiety Symptoms, and CD	1.946	0.93	0.326	3.944	0.414	
	via GSS	1.321	0.69	0.313	3.121		0.582
	via Depressive Symptoms	0.277	0.48	-0.381	1.658		0.122
	via Anxiety Symptoms	-0.162	0.36	-1.208	0.352		0.071
	via CD	0.510	0.48	-0.084	1.932		0.225
	Total <i>childhood nonsexual violent trauma</i> via GSS, Depressive Symptoms, Anxiety Symptoms, and CD	2.534	1.07	0.719	5.016	0.524	
	via GSS	1.936	0.85	0.645	4.081		0.674
	via Depressive Symptoms	0.142	0.33	-0.209	1.438		0.049
	via Anxiety Symptoms	-0.169	0.37	-1.250	0.375		0.059
	via CD	0.625	0.51	-0.014	2.150		0.218
	Total <i>childhood nonviolent trauma sum</i> via GSS, Depressive Symptoms, Anxiety Symptoms, and CD	0.067	0.39	-0.697	0.846	0.062	
	via GSS	0.130	0.23	-0.291	0.664		0.386
	via Depressive Symptoms	0.072	0.16	-0.099	0.613		0.214
	via Anxiety Symptoms	-0.011	0.10	-0.345	0.127		0.033
	via CD	-0.124	0.19	-0.666	0.141		0.368
	<i>Total indirect effect</i>	4.547	1.37	2.199	7.630		
→Pain at 4kg - arm							
	Total <i>childhood sexual violent trauma</i> via GSS, Depressive Symptoms, Anxiety Symptoms, and CD	1.025	0.78	-0.428	2.708	0.447	
	via GSS	0.904	0.53	0.139	2.360		0.335
	via Depressive Symptoms	0.588	0.52	-0.056	2.094		0.218
	via Anxiety Symptoms	-0.838	0.63	-2.579	-0.001		0.310
	via CD	0.370	0.38	-0.065	1.576		0.137
	Total <i>childhood nonsexual violent trauma</i> via GSS, Depressive Symptoms, Anxiety Symptoms, and CD	1.205	0.88	-0.328	3.166	0.489	
	via GSS	1.326	0.70	0.274	3.137		0.449
	via Depressive Symptoms	0.301	0.41	-0.185	1.639		0.102
	via Anxiety Symptoms	-0.874	0.60	-2.527	-0.028		0.296
	via CD	0.453	0.42	-0.049	1.760		0.153
	Total <i>childhood nonviolent trauma sum</i> via GSS, Depressive	0.093	0.32	-0.539	0.735	0.064	

Outcome	Indirect path	Coef.	Bootstrap SE	BCa Bootstrap 95% CI		Proportion of total indirect effect	Proportion of specific indirect effect
				LL	UL		
	Symptoms, Anxiety Symptoms, and CD						
	via GSS	0.089	0.17	-0.182	0.521		0.229
	via Depressive Symptoms	0.152	0.19	-0.063	0.778		0.391
	via Anxiety Symptoms	-0.058	0.25	-0.627	0.408		0.149
	via CD	-0.090	0.15	-0.557	0.087		0.231
	<i>Total indirect effect</i>	2.323	1.13	0.266	4.718		

Note. SE = Standard Error. BCa = Bias-corrected and Accelerated. CI = Confidence Interval. LL = Lower Limit. UL = Upper Limit. Boldfaced values are significant coefficients in which the bias-corrected and accelerated bootstrap 95% CI does not contain zero. Proportion of total and specific indirect effect is calculated by dividing the indirect effect by the sum of absolute values of coefficients included. Proportion of total indirect effect calculates the proportion of the total indirect effect by each distal predictor (childhood sexual violent trauma; childhood nonsexual violent trauma; childhood nonviolent trauma sum) regardless of mediator. Proportion of specific indirect effect calculates the proportion of the impact of each specific mediator for each distal predictor (childhood sexual violent trauma; childhood nonsexual violent trauma; childhood nonviolent trauma sum).

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