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Development and Validation of a Daily Pain Catastrophizing Scale

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Abstract

To date, there is no validated measure for pain catastrophizing at the daily level. The Pain Catastrophizing Scale (PCS) is widely used to measure trait pain catastrophizing. We sought to develop and validate a brief, daily version of the PCS for use in daily diary studies to facilitate research on mechanisms of catastrophizing treatment, individual differences in self-regulation, and to reveal the nuanced relationships between catastrophizing, correlates, and pain outcomes. After adapting the PCS for daily use, we evaluated the resulting 14 items using 3 rounds of cognitive interviews with 30 adults with chronic pain. We refined and tested the final daily PCS in 3 independent, prospective, cross-sectional, observational validation studies conducted in a combined total of 519 adults with chronic pain who completed online measures daily for 14 consecutive days. For study 1 (N = 131), exploratory factor analysis revealed adequate fit and—unexpectedly—unidimensionality for item responses to the daily PCS. Study 2 (N = 177) correlations indicated adequate association with related constructs (anger, anxiety, pain intensity, depression). Similarly, results for study 3 (N = 211) revealed expected correlations for daily PCS and measures of daily constructs including physical activity, sleep, energy level, and positive affect. Results from complex/multilevel confirmatory factor analysis confirmed good fit to a unidimensional model. Scores on the daily PCS were statistically comparable with and more parsimonious than the full 14-item version. Next steps include evaluation of score validity in populations with medical diagnoses, greater demographic diversity, and in patients with acute pain.

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Perspective—This article describes the development and validation of a daily PCS. This daily measure may facilitate research that aims to characterize pain mechanisms, individual differences in self-regulation, adaptation, and nuanced relationships between catastrophizing, correlates, and pain outcomes.

Keywords

Pain; catastrophizing; daily; measurement; psychosocial; psychology

Pain catastrophizing, a negative mental set brought to bear on actual or anticipated pain,³⁰ is widely shown to be associated with poor pain treatment response in patients with chronic pain. Results from several observational and treatment outcome studies have suggested that pain catastrophizing holds superior prognostic value for chronic pain incidence and outcomes compared with many other variables, thus elevating its importance in experimental research, and in clinical research and care.^{1,3,20,21,29,34}

The Pain Catastrophizing Scale (PCS)³¹ is a 13-item self-report measure of catastrophizing in the context of actual or anticipated pain. The PCS measures catastrophizing as a multifaceted construct with 3 subscales: rumination (eg, “I can’t stop thinking about how much it hurts”), magnification (eg, “I worry that something serious may happen”), and helplessness (eg, “There is nothing I can do to reduce the intensity of the pain”). Support for a 3-factor structure for PCS scores has accumulated.^{19,31,32} PCS instructions direct respondents to consider how they tend to respond to painful circumstances and to indicate the degree to which they experience each of 13 thoughts or feelings when experiencing pain. Theoretically, the PCS measures pain catastrophizing as a stable ‘trait’ variable, although it is malleable and responsive to treatment.^{8,12}

For example, numerous investigations have provided evidence of contextual influences on catastrophizing.^{23,25,33} Levels of catastrophic thinking have been shown to vary in relation to exposure to a wide range of experimental or clinical pain stimuli.^{4,16,23} Furthermore, these ‘situation-specific’ indices of catastrophizing have been shown to predict future pain and distress responses, independent of levels of ‘trait’ catastrophizing.^{4,7,9}

It is likely that the experience of catastrophic thoughts varies as a result of day to day fluctuations in symptom severity and other pain-related contextual features. At present, little is known about the symptom-related, stress-related, or psychosocial factors that influence the elicitation or activation of catastrophic thoughts. From a clinical perspective, increased knowledge about the stimulus features that elicit catastrophic thinking, and knowledge about time-dependent or context-dependent influences on catastrophic thinking might point to new avenues of intervention for chronic pain. From a theoretical perspective, increased knowledge about the contextual determinants of catastrophic thinking will provide important information relevant to elaboration or modification of biopsychosocial models of chronic pain.

Research on the contextual determinants of catastrophic thinking would be facilitated by the development of a daily measure of catastrophic thinking. Concurrent assessment of time-dependent changes in pain-related stimulus features and the experience of catastrophic

thoughts would provide a rich data pool from which to address questions about the interrelations among psychological, physical, and social dimensions of the chronic pain experience. Currently, there exists no validated measure that can be used for the daily assessment of catastrophizing. To characterize mechanisms of chronic pain, treatment response, and how adaptation and change occurs for pain catastrophizing, mood, and pain, a daily measure is needed that will provide scores with proven validity for quantifying pain catastrophizing over the previous 24 hours. Such a measure would allow researchers to deconstruct how catastrophizing fluidly relates to other daily experiences and develop prediction models that characterize therapeutic targets and antecedents for patient improvement. Such a measure also would facilitate the conduct of cross-lagged analytics, allowing researchers to observe the mechanics of catastrophizing as a process variable,^{2,28,29} as well as facilitate comparison across studies that use daily diary data. Accordingly, our primary goal was to develop and evaluate the validity of scores from a brief, daily version of the PCS; our secondary goal was to preserve in the daily PCS, the 3-factor structure of the original PCS.

Methods

Study methods involved 4 steps: 1) developing candidate items by modifying PCS items to ensure suitability for daily administration,¹⁵ 2) conducting 3 rounds of cognitive interviews and refining the daily PCS candidate items after each round, 3) selecting and administering final candidate items for the daily PCS in a prospective study, then using results of exploratory factor analysis to winnow items and derive a statistically sound, brief daily PCS, 4) administering the brief daily PCS in 3 separate prospective cohort studies and using confirmatory factor analyses to validate the final brief daily PCS (Fig 1), and to assess daily relationships with measures of pain and emotional experience.

Language Adaptation

To adapt the PCS for daily use we first modified the instructions to ask respondents to consider only the previous 24 hours when considering each question. Additionally, because of the retrospective referent to the previous 24-hour timeframe, we revised instructions and item verbiage to past tense (eg, “During the past 24 hours while I was in pain...I wondered whether something serious might happen.”). The most notable substantive content change from the original scale was the decoupling of a double-barreled item (original PCS item 4: “It’s awful and I feel that it overwhelms me”), thereby creating 2 separate items (“I felt that my pain overwhelmed me,” and “I felt my pain was awful,”) thereby increasing the total daily PCS item count to 14. We decoupled a second double-barreled item (item 3: “It’s terrible and I think it’s never going to get any better.”) and determined that after decoupling item 4, additional decoupling of item 3 would yield 2 virtually indistinguishable items (“I felt my pain was awful,” and “I felt my pain was terrible”). To avoid this duplication of items the team opted to simply reword item 3 to: “I thought my pain was never going to get any better.” Finally, we changed the scale’s upper anchor from “all the time” to “to a constant degree” to make it consistent with the other scale labels, which were all in terms of degree.

Cognitive Interviews

We conducted 3 rounds of cognitive interviews with 10 individuals with chronic pain (30 total). All procedures were conducted in compliance with the Stanford University institutional review board; no compensation was offered to participants. Inclusion criteria included age 18 years or older and reporting chronic pain. The cognitive interviews were conducted via telephone with a licensed clinical psychologist and pain specialist (B.D.D.). In each round and across all 30 individual interviews, we applied cognitive interviewing methods recommended for questionnaire design.¹⁷ Participants were e-mailed the 14 candidate daily PCS items in advance of the interview and were told that the purpose of the interview was to collect information that would allow the team to create a simple and easy to understand questionnaire for individuals with pain.

During their interview, participants instructed to read aloud the instructions and each of the 14 daily PCS candidate items. They were asked to narrate their thought processes in real time as they verbally completed the measure (ie, think aloud protocol). This aspect of cognitive interviewing allows researchers to identify opportunities to clarify language in the instructions and individual items. After verbal completion of the measure, participants were asked to describe their overall responses to the instructions, the items, and whether they recommended any additional modifications. Each cognitive interview was approximately 25 minutes in duration.

Qualitative data were collated for the 10 participant interviews in a cognitive interview round. Participant comments on individual items and scale instructions were categorized according to theme. Results were discussed at a research team meeting comprised of 3 to 4 research team members, including 2 licensed clinical pain psychologists, a master's level pain researcher, and a pain physician. There was general agreement among participants regarding recommended changes, and these changes served to enhance clarity of the measure while retaining the meanings of individual items. We adopted suggested changes in cases when multiple participants recommended a specific refinement, and, in general, rejected recommendations made by a single participant. Changes suggested in 1 round of cognitive interviews were incorporated into the items used in the next round. This process was repeated through all 3 rounds.

We adopted a modified Delphi process to finalize scale content and instructions. The resulting revised 14-item measure was circulated to the broader research team for consideration and discussion. The result of team consensus after round 1 of cognitive interviews was labeled, "daily PCS version 2." In this version, mention of chronic pain in the instructions was changed from degree to frequency. The introductory stem was changed from "During the past 24 hours, while I was in pain..." to "During the past 24 hours..." Additionally, all instances of "the pain" were replaced with "my pain" and all instances of "it" referring to pain were replaced with "my pain" for clarity. Small wording modifications were made to the items to enhance clarity.

Using the daily PCS version 2, the aforementioned methods were repeated, in full, for a second round of cognitive interviews conducted with a unique cohort of 10 individuals with chronic pain. After round 2 feedback, "During the past 24 hours" was added to the

beginning of every item and the instructions were modified to be as they are in the final version of the daily PCS. The revised version, daily PCS version 3, was used in a final round of cognitive interviews with a third unique cohort of 10 individuals with chronic pain. Minor wording changes were suggested and made after round 3 of cognitive interviews. Results from this final round yielded the final daily PCS version 4 (Table 1), which was used in 3 subsequent validation studies. To allow for the fact that individuals may experience no pain in the previous 24 hours or for another reason would skip an item, we added the option “I decline to answer” to the daily PCS response scale.

Daily PCS Validation Study

Next, we used the daily PCS version 4 to conduct 3 prospective, observational, daily diary-based, online validation studies using 3 independent samples of adults with chronic pain. The studies were approved by the Human Subjects Committee of the Stanford University institutional review board. Participants were recruited through in-house listservs of individuals with chronic pain and/or through a national chronic pain media outlet (National Pain Report). Inclusion criteria for both studies were age 18 years or older, English-literate, current chronic pain, and ability to complete 14 days of daily measures online. Informed consent was obtained online, and participants reported demographic information for age, sex, highest education attained, level of household income, race, and ethnicity. Additionally, we collected average pain intensity ratings for the previous 30 days (0–10; with “0” being no pain and “10” being worst pain imaginable), and duration of chronic pain. Participants received e-mail reminders for their daily surveys.

Study 1

Study 1 involved daily administration of the revised final 14-item daily PCS (Table 1) for 14 days via an emailed REDCap¹⁰ link sent to participants every 24 hours, starting 24 hours after they completed the first daily PCS. Participants were allowed 24 hours from the time the survey invitation was sent to them to complete the daily PCS. Participants were offered a possible total of \$15 compensation in the form of an [Amazon.com](https://www.amazon.com) gift card; compensation was scaled to reward higher rates of survey completion. The purpose of this first study was to pare our number of daily items to the minimum necessary with a secondary goal of retaining items that represented each of the 3 subscales of the original PCS. The final, winnowed or “brief” version of the daily PCS was planned for use in the second validation study.

Study 2

The second validation study differed from the first in 2 important ways. First, in study 2 the brief daily PCS that was modified on the basis of study 1 was evaluated. Second, in addition to administering the brief daily PCS measure, additional measures were administered at days 1, 7, and 14. This coadministration allowed for correlational analyses between daily PCS scores and scores on measures of psychological symptoms known to correlate with scores on the original PCS.

Study 2 Measures—Short form versions of Patient Reported Outcomes Information System (PROMIS) item banks also were administered with a referent time frame of the previous 7 days.

PROMIS Pain Intensity uses a 0 to 10 numeric rating scale that is anchored with “0” = no pain and “10” = the worst pain imaginable.⁹ The numeric rating scale has been validated for specificity and use in chronic pain research.^{9,10}

Eight-item short forms of the PROMIS Depression, Anger, and Anxiety measures were used to measure psychological symptoms known to correlate with the original PCS. Respondents rate the frequency of feelings of and reactions to depression, anger, or anxiety experienced over the previous 7 days using a 5-point scale (eg, I was irritated more than people knew; 1 = never, 5 = always).²² PROMIS Depression, Anger, and Anxiety measures have been used in chronic pain research.^{5,26,27} High internal consistency has been observed for item scores of PROMIS short form scales of depression (Cronbach α = .909), anxiety (Cronbach α = .885), and anger (Cronbach α = .894). Summed item raw scores were converted to their associated T scores.

Study 3

Similar to the second study, the third and final validation study evaluated the brief daily PCS modified on the basis of study 1. However, the third study differed from the second in one important way: in addition to administering the brief daily PCS and additional measures at days 1, 7, and 14, assessments of pain, mood, activity, sleep, energy level, and positive affect were administered daily for the 14-day period. This procedure allowed for replication of confirmatory factor analyses, as well as correlational analyses between daily PCS scores and scores on measures of psychological constructs known to correlate with the original PCS. Adaptations of PROMIS items to a daily format have shown acceptable psychometric properties in previous research.²⁴

Study 3 Measures—Short form versions of PROMIS item banks were administered with a referent time frame of the previous 7 days. These PROMIS measures were identical to those in study 2, previously mentioned.

Key daily constructs included measurement of pain intensity, pain interference, sleep quality, energy level, activity level, depression, anxiety, anger, and positive affect (described in the next paragraph). To measure these constructs, item content was adapted from PROMIS measures. The time frame was “within the past 24 hours” or “today”; and responses were scaled on a 0 to 10 scale where 0 = “No pain at all/Not at all/Very poor” and 10 = “Worst Imaginable Pain/All the time/Very good.”

Pain intensity: Rate your average level of pain for the past 24 hours.

Pain interference: Rate how much pain interfered with your sleep last night.

Sleep quality: Rate your sleep quality last night.

Energy level: Rate your energy level for the past 24 hours.

Activity level: Rate your activity level for the past 24 hours.

Depression: In the past 24 hours, to what extent did you feel depressed?

Anxiety: In the past 24 hours, to what extent did you feel anxious?

Anger: In the past 24 hours, to what extent did you feel angry?

Analyses—For all 3 studies, data from participants who completed at least 50% of daily surveys (7 days) were included in the analyses; the decision to include participant data with at least 50% of complete days was on the basis of previous studies demonstrating suitable use of hierarchical data analysis on 7 days of daily diary data.^{11,35} As a test of the robustness of this selection, analyses also were conducted restricting analyses to data from participants who completed 80%, 90%, and 100% of diaries. Results were highly similar across approaches, and only the results on the basis of the 50% criterion are included in the current report. Analyses were performed in Mplus version 6.12 (Muthén & Muthén, Los Angeles, CA) and included Pearson correlations and multilevel (to account for multiple observations) exploratory and confirmatory factor analyses. In sample 1, multilevel exploratory factor analyses were conducted using 1-factor, 2-factor, and 3-factor models using the TYPE = COMPLEX command. Optimal factor structure was determined via examination of model fit indices. After identifying the optimal factor structure for the scale, an iterative process was used in which the item with the lowest factor loading was removed from the analysis, and the remaining items were then reanalyzed in a subsequent multilevel exploratory factor analysis. This process was repeated until a suitably small item pool was reached (3 items per identified factor, in accordance with psychometric standards for reliable factor structures). All factor loadings from the multilevel exploratory factor analyses are presented after a Geomin (oblique) factor rotation. In study 2 and study 3, confirmatory factor analyses were performed on data derived from a second, independent sample to verify the factor structure identified in study 1. Adequacy of model fit was estimated using the root mean square error of approximation (RMSEA), conditional fit index (CFI), Tucker-Lewis index (TLI), and standardized root mean square residual (SRMR). Means were aggregated for the PROMIS item banks at each of the time points and used to conduct Pearson correlations with the daily PCS measure.

As an additional assessment of validity, known group comparisons were conducted in study 2 and study 3. Participants were divided into groups on the basis of their aggregated scores on the 7-day PROMIS Depression scores according to published crosswalks between PROMIS Depression and the Patient Health Questionnaire-9 (PHQ-9).⁶ These crosswalks indicated that participants who met criteria for clinically significant symptoms of depression had a PROMIS Depression t score >59.9. Independent sample t-tests were then conducted to determine whether participants who reported comparatively higher levels of depressive symptoms in each sample varied in their average levels of daily pain catastrophizing.

To determine whether participant responses on daily PCS items changed as a result of participation in the study (ie, increasing pain catastrophizing levels across the 14-day period due to completing the daily PCS), we also conducted an analysis that assessed significance

of changes in daily PCS scores across time. If this effect was found to be nonsignificant, we interpreted this finding as evidence that participants were not experiencing elevated levels of daily pain catastrophizing simply by reporting on catastrophizing levels each day.

Results

Study 1

Of the 186 adult participants with chronic pain, 131 (70.4%) completed 7 of the 14 days of surveys and were included in the analyses. Participants were predominantly Caucasian (93.1%), female (83.1%), with mean pain intensity in the severe range (6.69; SD = 1.83) for the past 30 days. Demographic and pain characteristics are reported in Table 2. Mean chronic pain duration = 1 year (range: 3 months to >1 year). Median age was 50 to 59 years (measured in decades). Median education level was the Associate's degree (2 years of university education; Table 2). Regarding pain diagnoses, 54.2% of the sample reported a diagnosis of complex regional pain syndrome, 45.8% a diagnosis of fibromyalgia, 31.3% chronic low back pain, 29.8% chronic migraines, 10.7% ongoing pain from a surgical procedure, 7.6% chronic pelvic pain, and 27.5% another type of chronic pain not listed in our questionnaires (categories were not mutually exclusive, and participants could endorse more than 1 pain condition). Because of an unusually high percentage of participants reporting complex regional pain syndrome ($N = 71$), we used χ^2 to test for differences in the baseline data of this group compared with participants reporting other types of pain. We found no statistically significant differences between pain diagnostic groups for age, sex, ethnic or racial makeup, educational level, or PCS scores. However, we did find that participants reporting complex regional pain syndrome had greater average pain intensity ($P = .016$). Intraclass correlations, reflecting the degree of stability in responding across 14 days, showed sufficient variability across all days to allow daily modeling (Intraclass Correlation [ICCs] ranging between .620 and .755 for all items). It should be noted that the magnitude of these ICCs did not suggest that clustering was so strong as to suggest that the daily PCS did not vary from day to day. Rather, these estimates indicated that the daily scores showed a sufficient degree of clustering at the person level across the data collection period to allow the use of multilevel modeling. Previous simulation studies have suggested that ICCs $<.1$ are more likely to yield biased estimates in multilevel models.^{13,14}

To investigate survey bias we compared characteristics between participants included in the analyses and those excluded because of a low survey response (<7 days). T tests were conducted to examine differences in baseline characteristics of those included and those excluded because of a low survey response. Low responders reported significantly higher levels of pain intensity at baseline ($t_{124.2} = 2.63$, $P = .010$), but did not vary in mean pain duration ($P > .15$). χ^2 Analyses indicated no statistically significant differences in age, ethnic or racial makeup, or educational level between included responders and those excluded because of low survey response.

Results from analysis of item characteristics and score distributions suggested that all 14 items were suitable for analysis (ie, no obvious indications of skewness or kurtosis, no items with an elevated frequency of “I don't know/Prefer not to answer” responses). Multilevel exploratory factor analysis results suggested that the 14 items of the daily PCS adequately fit

a unidimensional factor model, suggesting that the 3 subscales could be collapsed into a general scale (RMSEA = .063, CFI = .973, TLI = .968, SRMR = .047; Table 3). Using the criterion of choosing the items with the highest item factor loadings, 3 items of the rumination subscale showed the strongest item factor loadings and were thus retained.

Because our secondary aim was to create a tool that would maintain the 3-factor PCS structure, however, we also opted to include a representative item from past factor analyses that produced a 3-factor structure. Consequently, the single highest loading item from the previously-defined magnification and helplessness sub-scales were retained for study 2 (Table 4). Model fit for responses to this reduced item set was good (RMSEA=.054; CFI = .998; TLI = .995; SRMR = .010). Reliability was tested and found to be high in among a composite of the 5 retained items ($\alpha = .938$).

Sample 2

In study 2 the 5 remaining daily PCS items derived from study 1 (Table 4) were administered daily for 14 days to 209 adults with chronic pain. PROMIS short forms (Anger, Depression, Anxiety, Pain Intensity) were administered at days 1, 7, and 14. A total of 177 participants (84.7%) completed 7 days of surveys and were included in the analyses. Participants were primarily female (68.9%), Caucasian (91.0%), with average pain intensity over the previous 30 days in the severe range (6.45; SD = 1.90). Median pain duration was 1 year (range = 3 months to >1 year); median education level was the Bachelor's degree. Pain diagnoses in the second study sample were: chronic low back pain (32.0%), chronic migraines (20.1%), complex regional pain syndrome (18.5%), fibromyalgia (16.6%), chronic pelvic pain (7.5%), ongoing pain from a surgical procedure (7.2%), and other type of chronic pain not listed in our questionnaires (27.9%).

As with study 1, intraclass correlation estimates for all items indicated adequate variability across all days to allow for daily modeling (ICCs ranging between .558 and .640 for all items). Results of multilevel confirmatory factor analysis suggested that responses to the 5 retained items of the daily PCS had again showed adequate fit to a unidimensional factor model: RMSEA = .039; CFI = .999; TLI = .998; SRMR = .321 (Table 5). However, because we believed that 5 items may be considered excessively lengthy for a unidimensional daily assessment instrument, and because of concerns that the retained item pool was disproportionately skewed toward rumination (3 of the 5 retained items), we opted to test a model in which we retained only the highest loading items from each original subscale according to the study 1 factor analysis ("During the past 24 hours, I felt that my pain overwhelmed me," "During the past 24 hours, I was afraid that my pain would get worse," and "During the past 24 hours, I kept thinking about how much I hurt"). As the 3-item factor scale was fully saturated, all model fit indices suggested perfect fit. Means were aggregated for the PROMIS item banks at the 3 time points. Moderate and highly similar correlations were found between scores on the 3- and 5-item daily PCS composites and scores on PROMIS measures indicating reasonable convergence with related constructs (Pearson correlation coefficients ranged from .378 to .581; Table 6). Reliability was tested and found to be consistent with study 1 results for the 3-item daily PCS ($\alpha = .887$) as well as the 5-item daily PCS item sets ($\alpha = .941$).

As with the first sample, few differences were noted between those who responded at least 7 of 14 days and those who did not. These groups did not vary significantly in baseline pain intensity, pain duration, depression, anxiety, or anger, nor did they vary on age, sex, ethnic or racial makeup, or education ($P > .05$ in all cases).

When known group analyses were conducted using the 3-item and 5-item daily PCS composites, the results suggested that participants who reported clinically significant depression scores according to the PROMIS Depression/PHQ-9 crosswalk study median reported significantly higher levels of daily pain catastrophizing compared with those with depression scores below this cutoff for the 3-item ($t_{178} = 4.85$, $P < .001$) as well as 5-item measures ($t_{178} = 4.81$, $P < .001$).

As noted previously, we found no convincing evidence to support superiority of 5-item daily PCS over the 3-item daily PCS (Table 6). Because we did not note any obvious differences between the 3-item and 5-item daily PCS versions in terms of model fit or convergent validity, we opted to retain the 3-item daily PCS form for study 3.

Sample 3

In sample 3, the 3 retained items for the daily PCS from study 2 were administered daily for 14 days to 305 adults with chronic pain. Daily measures of key constructs were administered to estimate pain intensity, pain interference, sleep quality, energy level, activity level, depression, anxiety, anger, and positive affect. A total of 211 participants (69.2%) completed 7 days of surveys and were included in the analyses. Participants were primarily female (88.1%), Caucasian (92.9%), with average pain intensity over the previous 30 days in the severe range (6.75; $SD = 1.50$). Median pain duration was 1 year (range = 3 months to >1 year); median education level was vocational certificate. Pain diagnoses in the second study sample were: chronic low back pain (45.5%), chronic migraines (32.2%), complex regional pain syndrome (32.2%), fibromyalgia (38.9%), chronic pelvic pain (16.6%), ongoing pain from a surgical procedure (10.0%), and other type of chronic pain not listed in our questionnaires (49.3%). Some differences were noted between those who responded at least 7 of 14 days and those who did not. These groups did vary significantly in baseline pain intensity, pain interference, sleep quality, energy levels, and physical activity, suggesting more intense pain and pain interference and lower levels of sleep quality, energy, and physical activity in those participants who completed more diaries ($P > .05$ in all cases).

Intraclass correlation estimates showed adequate variability across all days (ICCs ranging between .519 and .600 for all items). Results of multilevel confirmatory factor analysis again indicated perfect fit because of model saturation (RMSEA = .000; CFI = 1.000; TLI = 1.000; SRMR = .001). Correlations between daily PCS scores and daily assessments were computed using nonaggregated (ie, daily) scores. Scores on both the daily PCS had moderate correlations scores on daily pain and mood measures, and small to moderate inverse correlations with activity, sleep, and energy level (Table 7). Internal consistency of the 3-item daily PCS composite was, once again found to be high ($\alpha = .892$).

For study 2 as well as study 3 (Table 8), trends in daily pain catastrophizing were assessed across time. We found no evidence of trend changes in daily PCS scores across the 14-day

period ($P > .53$ in study 2 and study 3). As a result, we concluded that participants did not appear to be experiencing increased levels of pain catastrophizing due to their participation in the daily surveys (eg, due to frustration, study fatigue, or other idiosyncratic responding patterns that could have emerged across time).

As with study 2, known group analyses were conducted using aggregated scores on the 7-day PROMIS Depression assessments using the crosswalk with the PHQ-9 scale. Participants reporting depression scores above the established cutoff reported significantly higher levels of daily pain catastrophizing compared with those with depression scores below the cutoff ($t_{207} = 7.22$, $P < .001$).

Discussion

The goal of this research was to develop and evaluate the validity of a brief, daily version of the PCS. We followed a rigorous protocol to adapt the original 13-item PCS for daily administration and conduct subsequent validation studies. Cognitive interviews ensured the communication validity of the instructions and item content of the daily PCS. The validity of the final, 3-item daily PCS was supported in follow-up analyses. We found reasonable associations between the daily PCS and related constructs at the weekly level (anxiety, depression, anger, pain intensity) and at the daily level (pain intensity, pain interference, mood, physical activity, energy level, and sleep quality). These results support the convergent validity of the daily PCS. Further, daily PCS scores discriminated as expected among participants with higher and lower levels of depressive symptoms. Finally, our intraclass correlations showed a significant degree of clustering across the data collection period. These findings suggested that although there are notable between person differences in pain catastrophizing that manifest at the daily level, these scores were not sufficiently high that it would indicate invariance of pain catastrophizing scores at the daily level.

A study goal that was not met was the development of a daily PCS with a 3-factor structure. Our factor analytic results from the full 14-item candidate PCS item pool supported unidimensionality, suggesting that pain catastrophizing items assessed at the daily level do not show great levels of discrimination between the previously established PCS subscales. Consequently, we opted to retain 1 item from each of the 3 subscales from the original PCS that showed the highest item factor loadings. We note, however, that our initial factor analysis results suggested that rumination items had the highest loadings with the unidimensional factor, which may have been due to the framing of our items in terms of endorsing frequency of catastrophic thoughts about pain. Nevertheless, we believe this finding may be notable because it may also implicate the frequency of catastrophic thoughts as a factor in daily mood and function in chronic pain, in addition to the intensity of these thoughts (as reflected in the original PCS).

The results of this study should be viewed in light of several limitations. First, presence of chronic pain was self-reported and medical diagnoses were not confirmed. Future validation work is needed in medical populations and among individuals seeking care at tertiary referral pain clinics. Second, we highlight that our studies included a higher percentage of participants reporting complex regional pain syndrome than expected. This over-

representation may reflect participant misinterpretation of the category to mean “complex pain” versus a medical diagnostic label, or is the result of the Stanford Pain Management Clinic being a magnet center for patients with this diagnosis, or both. The lack of differences in baseline PCS scores between chronic pain diagnostic categories may serve to allay some concern regarding the sample characteristics. All 3 samples were also comprised of varying ratios of pain conditions. Although such heterogeneity may contribute to unwanted sources of measurement error in a chronic pain validation study, our results revealed consistency in the behavior of the measure across conditions. Nevertheless, there may be value in validating our findings in the future using more homogenous samples of people with chronic pain, as a means of articulating any potential differences in item response according to specific pain characteristics. Third, demographic characteristics for both studies revealed that both samples were predominantly female, college-educated, and Caucasian; results in this report may not be representative of populations with greater diversity and we highlight this as a necessary topic of future research. Fourth, results for 2 of the samples (1 and 3) revealed differences in the characteristics of participants who completed 7 days of surveys and were included in the analyses and those that did not. In sample 1, noncompleters had greater pain intensity than completers. For sample 3, noncompleters had lower pain intensity, pain interference, and better sleep, energy, and physical activity. Collectively, these findings suggest that participants who met our daily survey threshold for data analysis were more symptomatic than those who did not. We note that although it is likely impossible to perfectly align independent samples on all baseline characteristics, these sample discrepancies merit appreciation. Fifth, results from this work may not extend to settings involving acute pain and specific validation is needed for research involving such populations (eg, postsurgical studies).

Conclusions

Despite the aforementioned limitations, this research has several noteworthy strengths. First, we found strong evidence for the daily PCS, the first brief pain catastrophizing measure for daily use. The PCS is widely used in psychosocial and, increasingly, in biomedical research. Researchers have recommended that more granular, temporally focused measures of pain catastrophizing be used to examine the role of pain catastrophizing in pain and health outcomes research.¹⁸ The brief daily PCS may facilitate measurement of this important construct in surgical studies, pain registries, mHealth tools and platforms, and in psychosocial diary research that seeks to understand mechanisms of effective adaptation and change in the context of pain. Furthermore, the daily PCS may facilitate standardized measurement for future studies that examine pain catastrophizing at the daily level, thereby improving accuracy of analytics, interpretability, cross-study comparisons, and meta-analyses. Finally, the daily PCS may facilitate treatment outcome research and the conduct of multilevel modeling to characterize treatment effects on daily fluctuations in pain catastrophizing and the effect of these daily changes on trait pain catastrophizing.

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References

1. Abbott AD, Tyni-Lenne R, Hedlund R. Leg pain and psychological variables predict outcome 2-3 years after lumbar fusion surgery. *Eur Spine J.* 2011; 20:1626–1634. [PubMed: 21311916]
2. Burns JW, Day MA, Thorn BE. Is reduction in pain catastrophizing a therapeutic mechanism specific to cognitive-behavioral therapy for chronic pain? *Transl Behav Med.* 2012; 2:22–29. [PubMed: 24073095]
3. Burns JW, Kubilus A, Bruehl S, Harden RN, Lofland K. Do changes in cognitive factors influence outcome following multidisciplinary treatment for chronic pain? A cross-lagged panel analysis. *J Consult Clin Psychol.* 2003; 71:81–91. [PubMed: 12602428]
4. Campbell CM, Quartana PJ, Buenaver LF, Haythornthwaite JA, Edwards RR. Changes in situation-specific pain catastrophizing precede changes in pain report during capsaicin pain: A cross-lagged panel analysis among healthy, pain-free participants. *J Pain.* 2010; 11:876–884. [PubMed: 20488760]
5. Chapin HL, Darnall BD, Seppala EM, Doty JR, Hah JM, Mackey SC. Pilot study of a compassion meditation intervention in chronic pain. *J Compassionate Health Care.* 2014; 1:1–12.
6. Choi SW, Schalet B, Cook KF, Cella D. Establishing a common metric for depressive symptoms: Linking the BDI-II, CES-D, and PHQ-9 to PROMIS Depression. *Psychol Assess.* 2014; 26:513–527. [PubMed: 24548149]
7. Darnall BD, Aickin M, Zwick H. Pilot study of inflammatory responses following a negative imaginal focus in persons with chronic pain: Analysis by sex/gender. *Gend Med.* 2010; 7:247–260. [PubMed: 20638630]
8. Darnall BD, Sturgeon JA, Kao MC, Hah JM, Mackey SC. From catastrophizing to recovery: A pilot study of a single-session treatment for pain catastrophizing. *J Pain Res.* 2014; 14:219–226.
9. Edwards RR, Campbell CM, Fillingim RB. Catastrophizing and experimental pain sensitivity: Only in vivo reports of catastrophic cognitions correlate with pain responses. *J Pain.* 2005; 6:338–339. [PubMed: 15890636]
10. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform.* 2009; 42:377–381. [PubMed: 18929686]
11. Jamison RN, Raymond SA, Levine JG, Slawsky EA, Nedeljkovic SS, Katz NP. Electronic diaries for monitoring chronic pain: 1-Year validation study. *Pain.* 2001; 91:277–285. [PubMed: 11275385]
12. Jensen MP, Turner JA, Romano JM. Changes in beliefs, catastrophizing, and coping are associated with improvement in multidisciplinary pain treatment. *J Consult Clin Psychol.* 2001; 69:655–662. [PubMed: 11550731]
13. Maas CJ, Hox JJ. Robustness issues in multilevel regression analysis. *Stat Neerl.* 2004; 58:127–137.
14. Maas CJ, Hox JJ. Sufficient sample sizes for multilevel modeling. *Methodology.* 2005; 1:86–92.
15. Manchikanti L, Helm S 2nd, Fellows B, Janata JW, Pampati V, Grider JS, Boswell MV. Opioid epidemic in the United States. *Pain Phys.* 2012; 15:ES9–ES38.
16. Martel MO, Jamison RN, Wasan AD, Edwards RR. The association between catastrophizing and craving in patients with chronic pain prescribed opioid therapy: A preliminary analysis. *Pain Med.* 2014; 15:1757–1764. [PubMed: 24612286]
17. Miller, K., Chepp, MV., Willson, S., Padilla, JL. *Cognitive Interviewing Methodology.* Hoboken, NJ: John Wiley&Sons; 2014.
18. Mun CJ, Karoly P, Okun MA. Effects of daily pain intensity, positive affect, and individual differences in pain acceptance on work goal interference and progress. *Pain.* 2015; 156:2276–2285. [PubMed: 26469319]

19. Osman A, Barrios FX, Kopper BA, Hauptmann W, Jones J, O'Neill E. Factor structure, reliability, and validity of the Pain Catastrophizing Scale. *J Behav Med.* 1997; 20:589–605. [PubMed: 9429990]
20. Pavlin DJ, Sullivan MJ, Freund PR, Roesen K. Catastrophizing: A risk factor for postsurgical pain. *Clin J Pain.* 2005; 21:83–90. [PubMed: 15599135]
21. Picavet HS, Vlaeyen JW, Schouten JS. Pain catastrophizing and kinesiophobia: Predictors of chronic low back pain. *Am J Epidemiol.* 2002; 156:1028–1034. [PubMed: 12446259]
22. Pilkonis PA, Choi SW, Reise SP, Stover AM, Riley WT, Cella D, Group PC. Item banks for measuring emotional distress from the Patient-Reported Outcomes Measurement Information System (PROMIS(R)): Depression, anxiety, and anger. *Assessment.* 2011; 18:263–283. [PubMed: 21697139]
23. Roh YH, Lee BK, Noh JH, Oh JH, Gong HS, Baek GH. Effect of anxiety and catastrophic pain ideation on early recovery after surgery for distal radius fractures. *J Hand Surg.* 2014; 39:2258–2264.e2.
24. Schneider S, Choi SW, Junghaenel DU, Schwartz JE, Stone AA. Psychometric characteristics of daily diaries for the Patient-Reported Outcomes Measurement Information System (PROMIS): A preliminary investigation. *Qual Life Res.* 2013; 22:1859–1869. [PubMed: 23180166]
25. Scott W, Wideman TH, Sullivan MJ. Clinically meaningful scores on pain catastrophizing before and after multidisciplinary rehabilitation: A prospective study of individuals with subacute pain after whiplash injury. *Clin J Pain.* 2014; 30:183–190. [PubMed: 23552561]
26. Sturgeon JA, Darnall BD, Kao MC, Mackey SC. Physical and psychological correlates of fatigue and physical function: A Collaborative Health Outcomes Information Registry (CHOIR) study. *J Pain.* 2015; 16:291–298.e1. [PubMed: 25536536]
27. Sturgeon JA, Dixon EA, Darnall BD, Mackey SC. Contributions of physical function and satisfaction with social roles to emotional distress in chronic pain: A Collaborative Health Outcomes Information Registry (CHOIR) Study. *Pain.* 2015; 156:2627–2633. [PubMed: 26230739]
28. Sturgeon JA, Zautra AJ. Psychological resilience, pain catastrophizing, and positive emotions: Perspectives on comprehensive modeling of individual pain adaptation. *Curr Pain Headache Rep.* 2013; 17:317. [PubMed: 23338769]
29. Sturgeon JA, Zautra AJ. State and trait pain catastrophizing and emotional health in rheumatoid arthritis. *Ann Behav Med.* 2013; 45:69–77. [PubMed: 22915012]
30. Sullivan, M. [Accessed September 15, 2016] The Pain Catastrophizing Scale. User Manual. Available at: http://sullivan-painresearch.mcgill.ca/pdf/pes/PCSMManual_English.pdf
31. Sullivan MJ, Bishop SR, Pivik J. The Pain Catastrophizing Scale: Development and validation. *Psychol Assess.* 1995; 7:524–532.
32. Van Damme S, Crombez G, Bijttebier P, Goubert L, Van Houdenhove B. A confirmatory factor analysis of the Pain Catastrophizing Scale: Invariant factor structure across clinical and non-clinical populations. *Pain.* 2002; 96:319–324. [PubMed: 11973004]
33. Vranceanu AM, Bachoura A, Weening A, Vrahas M, Smith RM, Ring D. Psychological factors predict disability and pain intensity after skeletal trauma. *J Bone Joint Surg Am.* 2014; 96:e20. [PubMed: 24500592]
34. Wertli MM, Burgstaller JM, Weiser S, Steurer J, Kofmehl R, Held U. The influence of catastrophizing on treatment outcome in patients with non-specific low back pain: A systematic review. *Spine (Phila Pa 1976).* 2014; 39:263–273. [PubMed: 24253796]
35. Zuroff DC, Sadikaj G, Kelly AC, Leybman MJ. Conceptualizing and measuring self-criticism as both a personality trait and a personality state. *J Pers Assess.* 2016; 98:14–21. [PubMed: 26046620]

Figure 1.
Study methodology for daily PCS validation.

Table 1
Full PCS Adapted for Daily Use in Individuals With Chronic Pain

Instructions: In chronic pain, one may have good days and bad days. Similarly, one's thoughts and feelings about pain may also change on a day-to-day basis.

We are interested in understanding your experience over the past 24 hours, bearing in mind that the past 24 hours may be different from your 'usual experience.'

Below are 14 items related to thoughts and feelings that can associate with pain. Using the following scale, indicate the degree to which you had these thoughts and feelings during the past 24 hours.

1-Notatall	2-A little of the time	3-Someofthe time
4-A lot of the time	5-All of the time	6-I decline to answer

- 1) During the past 24 hours, I worried about whether my pain would end.
- 2) During the past 24 hours, I felt I couldn't go on because of my pain.
- 3) During the past 24 hours, I thought my pain was never going to get any better.
- 4) During the past 24 hours, I felt that my pain overwhelmed me.
- 5) During the past 24 hours, I felt I couldn't stand my pain anymore.
- 6) During the past 24 hours, I was afraid that my pain would get worse.
- 7) During the past 24 hours, I kept thinking of other painful events.
- 8) During the past 24 hours, I anxiously wanted my pain to go away.
- 9) During the past 24 hours, I couldn't seem to keep my pain out of my mind.
- 10) During the past 24 hours, I kept thinking about how much I hurt.
- 11) During the past 24 hours, I kept thinking about how badly I wanted my pain to stop.
- 12) During the past 24 hours, I felt there was nothing I could do to reduce the intensity of my pain.
- 13) During the past 24 hours, I wondered whether something serious might happen.
- 14) During the past 24 hours, I felt my pain was awful.

Table 2

Participant Demographic and Pain Characteristics

	Female Sex	Median Age, Years	Caucasian, %	Median Education	Average Pain Intensity	Median Pain Duration	Pain Diagnosis *
Study 1	83.8	50 to 59	93.1	Associate's Degree (2-year university)	6.69 (SD = 1.83)	1 year	54.2% CRPS 45.8% Fibromyalgia 31.3% Chronic low back pain 29.8% Chronic migraines 10.7% Ongoing pain from a surgical procedure 7.6% Chronic pelvic pain 27.5% Another type of chronic pain not listed
Study 2	68.9	50 to 59	91.0	Bachelor's Degree (4-year university)	6.45 (SD = 1.90)	1 year	32% Chronic low back pain 20.1% Chronic migraines 18.5% CRPS 16.6% Fibromyalgia 7.5% Chronic pelvic pain 7.2% Ongoing pain from a surgical procedure 27.9% Other type of chronic pain not listed
Study 3	88.1	40 to 49	92.9	Vocational Certificate	6.75 (SD = 1.50)	1 year	45.5% Chronic low back pain 32.2% Chronic migraines 32.2% CRPS 38.9% Fibromyalgia 16.6% Chronic pelvic pain 10.0% Ongoing pain from a surgical procedure 49.3% Other type of chronic pain not listed

Abbreviation: CRPS, complex regional pain syndrome.

* Categories were not mutually exclusive, and participants could endorse more than 1 pain condition.

Table 3
Geomin-Rotated Factor Loadings for Exploratory Factor Analyses for All Daily PCS
Items in Study 1: Full Item Bank and Reduced 5-Item Measure

	Factor Loadings: All Daily PCS Items	Factor Loadings: Reduced 5-Item Measure
During the past 24 hours, I worried about whether my pain would end.	.870	
During the past 24 hours, I felt I couldn't go on because of my pain.	.843	
During the past 24 hours, I thought my pain was never going to get any better.	.870	
During the past 24 hours, I felt that my pain overwhelmed me.	.911	.878
During the past 24 hours, I felt I couldn't stand my pain anymore.	.925	
During the past 24 hours, I was afraid that my pain would get worse.	.820	.794
During the past 24 hours, I kept thinking of other painful events.	.754	
During the past 24 hours, I anxiously wanted my pain to go away.	.877	
During the past 24 hours, I couldn't seem to keep my pain out of my mind.	.927	.946
During the past 24 hours, I kept thinking about how much I hurt.	.938	.964
During the past 24 hours, I kept thinking about how badly I wanted my pain to stop.	.922	.913
During the past 24 hours, I felt there was nothing I could do to reduce the intensity of my pain.	.860	

Table 4
Results From Study 1: Validated 5-Item Daily PCS

1. During the past 24 hours	I couldn't seem to keep my pain out of my mind. (Rumination)
2. During the past 24 hours	I kept thinking about how much I hurt. (Rumination)
3. During the past 24 hours	I kept thinking about how badly I wanted my pain to stop. (Rumination)
4. During the past 24 hours	I felt my pain overwhelmed me. (Magnification)
5. During the past 24 hours	I was afraid that my pain would get worse. (Helplessness)

Table 5
Multilevel Confirmatory Factor Analysis Results for 3-Item and 5-Item Daily PCS

PCS Item	Study 2		Study 3
	Factor Loadings: 5-Item Model	Factor Loadings: 3-Item Model	Factor Loadings
During the past 24 hours, I couldn't seem to keep my pain out of my mind.	.932		
During the past 24 hours, I kept thinking about how much I hurt.	.960	.942	.906
During the past 24 hours, I kept thinking about how badly I wanted my pain to stop.	.919		
During the past 24 hours, I felt my pain overwhelmed me.	.873	.889	.870
During the past 24 hours, I was afraid that my pain would get worse.	.822	.818	.906

NOTE. All coefficients standardized.

Table 6
Study 2 Pearson Coefficients for the Daily PCS, Pain Intensity, and PROMIS Correlates

	PCS 3-Item Composite	PCS 5-Item Composite
PCS 3-item	1	.990
PCS 5-item	.990	1
Pain intensity	.573	.581
Depression	.450	.441
Anxiety	.403	.378
Anger	.554	.548

Table 7
Validated 3-Item Daily PCS

1. During the past 24 hours	I kept thinking about how much I hurt. (Rumination)
2. During the past 24 hours	I felt my pain overwhelmed me. (Magnification)
3. During the past 24 hours	I was afraid that my pain would get worse. (Helplessness)

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Table 8
Study 3 Pearson Coefficients for the Daily PCS, PROMIS Correlates, and Daily Constructs

	Daily PCS
Daily pain intensity	.528
Daily pain interference	.526
Daily sleep quality	-.360
Daily energy level	-.391
Daily activity level	-.311
Daily depression	.573
Daily anxiety	.518
Daily anger	.488
Daily positive affect	-.411