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Original Reports

The Pediatric Pain Screening Tool (PPST) can Rapidly Identify Elevated Pain and Psychosocial Symptomatology in Treatment-Seeking Youth with Acute Musculoskeletal Pain

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Abstract: **This cross-sectional study examines the utility of the Pediatric Pain Screening Tool (PPST) for rapidly assessing pain and psychosocial symptomatology in treatment-seeking youth with acute musculoskeletal pain. Participants were 166 youth (10-18 years, 53.6% female) participating in one of two larger cohort studies of youth with acute musculoskeletal pain. Youth completed the PPST and measures of pain, pain-related fear, pain catastrophizing, pain-related disability, and sleep quality. Participants were categorized into PPST risk groups using published cut-offs. ANOVA and chi-square examined associations between PPST risk groups and self-report measures; receiver operating characteristic (ROC) analyses examined associations among PPST scores and clinical reference cut-offs. The PPST classified 28.3% of youth as high, 23.5% as moderate, and 48.2% as low-risk. Females were more likely to be high-risk. ANOVAs revealed differences in clinical factors by PPST risk group particularly differences among youth labeled high versus low-risk. ROC analyses showed the PPST is effective in discriminating "cases" versus "non-cases" on pain-related disability, pain-fear and catastrophizing. Results reveal the PPST is effective for rapidly screening youth with acute pain for pain and psychosocial symptomatology. An important next step will be to examine the validity of the PPST in predicting recovery outcomes of acute pain samples.**

Perspective: ***This article presents the Pediatric Pain Screening Tool (PPST) as a measure for rapidly screening youth with acute pain for pain and psychosocial symptomatology. The tool categorizes youth into low, moderate or high-risk groups and discriminates among those with versus without clinically significant levels of disability, pain-related fear and catastrophizing.***

Key Words: *acute pain, pediatric, musculoskeletal, screening, risk.*

Acute musculoskeletal pain is common during childhood and adolescence.[1,2] While many youth with acute pain recover from symptoms, data suggest 30% develop persistent musculoskeletal pain.[3] Given data showing factors such as sleep disturbances, depressive symptoms, and pain-related fear are associated with pain-related disability and quality of life in the acute pain period,[4,5] screening for elevated pain and psychosocial symptomatology in the acute care setting is important. While preventive interventions for youth with acute musculoskeletal pain have not been developed, data gathered in the acute care setting can inform provider anticipatory guidance (e.g., education about known associations among pain, mood and sleep; recommendations for activity engagement, use of evidence-based biobehavioral pain management strategies). Moreover, if screening reveals clinically significant symptoms or elevated risk, recommendations for closer follow-up or referrals for additional psychosocial assessment can be given.

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The Pediatric Pain Screening Tool (PPST) was developed to efficiently assess physical and psychosocial symptomatology in youth with chronic pain.[6] Physical and psychosocial domains assessed include sleep, pain-related disability, school attendance, pain-related anxiety, and depression. Adapted from Keele's Start Back Screening Tool,[7] the brief 9-item PPST classifies youth into low, moderate or high-risk groups, with greater endorsement of items leading to higher risk classification. A validation study in youth with chronic pain revealed PPST risk classification was concurrently associated with pain-related disability, pain anxiety, pain-related fear, anxiety and depression.[6] Moreover, PPST scores predicted pain outcomes over time, with youth classified at baseline as either moderate or high-risk having greater disability and more psychological symptoms 4 months later.

Recently the utility of the PPST screener was examined in pediatric headache and sickle cell populations. In youth with headache, Heathcote and colleagues found PPST scores effectively discriminated youth with high versus low levels of disability and emotional distress (pain catastrophizing, fear of pain, anxiety, and depressive symptoms). Furthermore, the PPST discriminated references cases for pain-related disability at a two-month follow-up showing its ability to predict outcomes over time.[8] In youth with sickle cell disease, Sil and colleagues found youth classified as high-risk on the PPST had significantly higher pain intensity, greater pain frequency, higher pain-related disability and more depressive symptoms than youth classified as low or medium-risk. PPST total and psychosocial subscale scores discriminated youth who met clinical cut-offs on key measures of (e.g., pain interference, pain frequency, inpatient admissions, catastrophizing and fear).[9]

Models emphasizing the importance of prevention of pain in pediatric populations call for intervention in the acute pain period.[10,11] While some preventive interventions for chronic musculoskeletal pain in children have been developed and tested (e.g., exercise-based prevention for chronic back pain[12,13]), to our knowledge no programs have been developed to intervene during the acute phase of musculoskeletal pain problems. In fact, a key challenge is how identify youth with acute pain who may benefit from such interventions. To fill this gap, the current study examined the utility of the PPST in quickly and efficiently assessing pain and psychosocial symptomatology in youth with acute musculoskeletal pain. Data from two cohort studies that administered the PPST as part of the larger study protocols were included; PPST data from these cohorts has not previously been published. The first aim was to identify concurrent associations among PPST risk groups and measures of pain-related emotional and physical function in this sample. The second aim was to examine the ability of PSST total and psychosocial subscale scores to discriminate reference standard "cases" versus "non-cases" on measures of pain anxiety and disability. The third aim was to identify cut-offs for both the PPST total score and the PPST psychosocial subscale, that identified elevated symptomatology in an acute musculoskeletal pain sample.

Method

This study was conducted at two academic medical centers in the northwestern United States. Study procedures at both sites were approved by the respective Institutional Review Boards and all participants provided consent or assent prior to participating.

Participants were 166 youth ages 10-18 years (and one parent) participating in one of two longitudinal studies assessing how pain changes over time in youth with new-onset musculoskeletal pain. Study one assessed youth post-injury and at 4 month follow-up; study two assessed youth post-injury, four months later and again at 12 months. Participants were included in the current project if they completed the Pediatric Pain Screening Tool as part of data collection for either of the two research studies.

To be eligible for either of the two larger studies, adolescents must have recently sought treatment in the emergency department or outpatient clinic for an acute musculoskeletal pain complaint at one of two participating academic medical centers. Additional inclusion criteria were: a) a new musculoskeletal pain complaint was the primary reason the child was seeking medical care, b) pain duration was <1 month at time of completing study measures, c) no previous injury at the current musculoskeletal pain site in the past two years, and d) no history of surgery at the pain site or planned surgery at the pain location. Youth were excluded if: a) they had co-occurring major medical condition (e.g. diabetes, cancer), b) they were currently being treated for a co-occurring chronic musculoskeletal pain condition (e.g., fibromyalgia), c) the musculoskeletal pain was related to serious pathology (e.g., arthritis, cancer), d) they were currently pregnant, e) they could not read/write in English, f) they had a cognitive impairment or intellectual disability that impacted their ability to consent/prevented them from independently completing study tasks, g) they had a history of major surgeries or major hospitalizations (> 7 day length of stay), and/or h) they had been hospitalized for psychiatric care within the last year.

Data from only one of the included studies has been previously published.[3,4,5,14] None of the previously published manuscripts included the PPST measure and/or had aims/analyses related to screening because the PPST measure was published after study recruitment had started and the measure was added to the protocol during data collection.

Procedures

Potential participants were identified by research or clinical staff familiar with the study at the child's medical appointment/emergency department visit or via electronic medical record review following the visit. Families were then contacted by study staff via phone to undergo additional screening and if eligible, were invited to participate in the study. Youth and parent participants completed survey questionnaires either via paper (study one) or REDCap (study two) within one month of injury/pain onset date. Participants were

instructed to complete measures independently to reduce potential bias.

Questionnaire Measures

Demographics. Parents reported on their child's age, sex, race and ethnicity.

Pain intensity. Youth were asked to report on "usual pain intensity" over the past 7 days using a Numerical Rating Scale (11 point NRS 0-10).[15]

Pain location(s). Location of primary acute MSK pain complaint was reported verbally by participants at study enrollment and checked with the medical record. Responses were coded into 1 of 5 MSK pain location categories: leg/foot, arm/hand/shoulder, back/spine/neck, rib/chest, or hip.

Pain-related disability

Either the Child Activity Limitations Interview (CALI-21)[16] or the Child Activity Limitations Interview Short Form (CALI-9)[17] was used to assess pain-related disability. On both versions of the measure, the five response options ask participants to rate difficulty of engaging in tasks from 0 'not difficult' to 4 'extremely difficult', higher scores indicate greater impairment due to pain. For those that completed the CALI-21 (n = 63) the 9 items that make up the short form were extracted to calculate the disability score to permit combining the samples from the 2 studies. The CALI-21 and CALI-9 have demonstrated reliability and validity in assessing pain-related disability in school aged children and adolescents with pain.[16,17]

Fear of pain

Youth reported on fear and avoidance related to pain using the Fear of Pain Questionnaire (FOPQ-C).[18] The 24 items on the scale are rated on a 5-point scale ranging from 0 'strongly disagree' to 4 'strongly agree' and items are summed for a total score, with higher scores indicating more pain-related fear. The FOPQ-C has excellent reliability and construct validity and the measure has been used to assess pain-related fear in diverse pain samples.[18-20] The original validation paper included youth with pain duration of one month[18] showing applicability for use who have not yet developed chronic pain. The clinical reference points for the measure are 0−34 (low); 35-50 (moderate); and ≥51 (high) fear symptoms. The clinical cut-off of ≥ 51 (indicating high fear) was used to categorize "cases" versus "non-cases" in ROC curve analyses.

Pain catastrophizing

The 13-item Pain Catastrophizing Scale for Children (PCS-C) was used to assess catastrophizing about pain symptoms in children and adolescents.[21] The measure prompts children to reflect on past painful experiences ("Below are some things that happen to you when you have pain") with response options on a 5-point scale (0-4) ranging from 0 'not at all' to 4 'extremely'. Higher scores reflect greater pain catastrophizing. The measure has demonstrated reliability in youth with pain.[21,22] The clinical reference points for the measure are 0−14 (low); 15- 25 (moderate); and 26 and greater (high) catastrophizing symptoms.[22] The clinical cut-off of ≥ 26 indicating high catastrophizing symptoms was used to categorize "cases" versus "non-cases" in ROC curve analyses.

Sleep quality

Either the Adolescent Sleep-Wake Scale (ASWS) 28 item version of ASWS Short-form (10-itmes) was used to assess children's perceptions of their sleep quality.[23,24] Youth reported on their sleep using a 6-point scale (range from 1 'always' to 6 'never') with higher scores indicating better sleep quality. For those that completed the full 28-item ASWS (n=63), the 10 items that make up the short form were extracted to calculate the total score to permit combining the samples from the 2 studies. The ASWS measures five behavioral dimensions of sleep (going to bed, falling asleep, maintaining sleep, reinitiating sleep, returning to wakefulness). The ASWS and ASWS short-form are a valid and reliable assessment tool that has been used extensively in both pain and non-pain populations.[23,24]

Pediatric Pain Symptomatology

The nine-item Pediatric Pain Screening Tool (PPST) was used to assess physical and psychosocial symptomatology.[6] Individual items assess pain, ambulation, school attendance, sleep, pain-catastrophizing, pain-related fear, anxiety, depression, and pain-related bother. The consists of two subscales, Physical and Psychosocial, and a total score can also be calculated. The measure has been shown to be reliable and valid is a variety of pediatric pain samples including: mixed chronic pain samples[6] and youth with headache[8] and sickle cell disease.[9]

Data analysis

Data were analyzed using SPSS v.27. Summary statistics were used to describe characteristics of the sample and are reported in Table 1. Means and standard deviations were used for continuous data, and categorical items were described using frequency statistics. ANOVA was used to examine differences among PPST risk groups and study measures (age, number of days between pain onset and survey completion, pain intensity, pain-related disability, sleep quality, pain catastrophizing, and fear of pain). Chi-square was used to examine differences among PPST risk groups and both demographic and clinical characteristics (e.g., gender, race, ethnicity, pain location, recruitment setting, and fracture status).

Receiver Operating Characteristics (ROC) curves were used to calculate the area under the curve (AUC) for the PPST total score and PPST psychosocial subscale scores comparing PPST scores against "cases" versus "non-cases" on established clinical cutoffs on both the Pain

Table 1. Demographic characteristics of the sample (n = 166).

Age in years (M, SD)	14.2	2.1
Gender (n, %)		
Male	77	46.4
Female	89	53.6
Ethnicity (n, %)[a]		
Hispanic/Latino	37	22.7
Not Hispanic/Latino	117	71.8
Unknown/Not reported	9	5.5
Race (n, %) [b]		
American Indian or Alaska Native	3	1.8
Asian	6	3.6
Biracial or Multiracial	34	20.5
Black or African American	10	6.0
White	96	57.8
Other	16	9.6
BMI Percentile (age corrected %)[c]		23.4
Referral Source (n, %)		
Emergency department	84	50.6
Outpatient Clinic	82	49.4
Fracture (n, %)		
Yes	47	28.3
No	118	71.1
Primary Pain Complaint (n, %)		
Leg/foot	114	68.7
Arm/hand/shoulder	21	12.7
Back/spine/neck	17	10.2
Hip	13	7.8
Rib/chest	1	0.6

[a]n = 163
[b]n=165
[c]n=159

Catastrophizing Scale (PCS-C; clinical cut-off ≥ 26 indicating high catastrophizing) and Fear of Pain Questionnaire (FOPQ; clinical cut-off ≥ 51 indicating high pain-related fear). Because the CALI-9 does not have a published clinical cut-off, "cases" were calculated using participant scores > 1 SD above the mean. Specifically, the youth who scored > 1 SD above the CALI-9 total score sample mean were labeled as "cases" and all other participants were labeled as "non-cases". For all AUC analyses, evaluation of discrimination was classified using published criteria: <.07 poor, ≥0.7 fair, ≥0.8 good, and ≥0.9 excellent.[25] ROC curves were also used to derive clinical cut-offs for the PPST total score and PPST psychosocial subscales for this acute musculoskeletal pain sample. Missingness was considered at random and sample size for all statistical analyses that did not include the full sample is presented in the tables.

Results

Participant demographic and descriptive statistics are located in Table 1. Participants were 166 youth ages 10-18 years (M = 14.17, SD = 2.07), were 53.6% female, and 70.5% non-Hispanic. 57.8% of youth identified race as White, with 20.5% identifying as biracial or multiracial. 50.6% of youth had sought pain treatment in the emergency department and 49.4% outpatient clinics (e.g., orthopedics, sports medicine). Most common pain location was leg/foot pain (68.7%) with 28.3% of youth experiencing a fracture as part of their injury. Usual pain intensity over the past 7 days was moderate, M = 3.97 (SD = 2.13).

Frequency of PPST item endorsement in this acute pain sample is located in Table 2. Findings show most commonly endorsed PPST items were: "It is not really safe for me to be physically active" (49.4%), "My pain is in more than one body part" (42.8%), and "In general I don't have as much fun as I used to" (38.0%). Item endorsement from the validation sample, and youth with headache and sickle cell disease[6,8,9] are included in Table 2 for comparison.

Total PPST scores in the acute pain sample ranged from 0-9 (M = 2.97, SD = 2.18) and PPST psychosocial subscale scores ranged from 0-5 (M = 1.61, SD = 1.43). Using published PPST cut-offs,[6] 28.3% of youth were classified as high-risk, 23.5% moderate risk, and 48.2% low risk. PPST risk groups differed significantly by

Table 2. Frequency of PPST Item Endorsement.

	% Agree			
PPST items	Acute Pain	Chronic Pain[a]	Headache[b]	Sickle Cell[c]
Physical subscale				
My pain is in more than one body part	42.8	69.4	40.9	83.6
I can only walk a short distance because of pain	34.9	56.8	25.6	50.7
It is difficult for me to be at school all day	27.7	73.1	76.9	52.1
It is difficult for me to fall and stay asleep at night	30.7	63.6	54.5	49.3
Psychosocial subscale				
It is not really safe for me to be physically active	49.4	45.9	19.4	30.1
I worry about my pain a lot	30.7	48.3	54.5	52.1
I feel my pain is terrible and it is never going to get any better	7.8	36.6	45.9	31.5
In general, I do not have as much fun as I used to	38.0	61.7	54.5	32.9
Overall, how much has pain been a problem in the past 2 weeks?[d]	21.7	79.2	73.1	32.8

[a]Data abstracted from Simons *et al.*[26]
[b]Data abstracted from Heathcote *et al.*[7]
[c]Data abstracted from Sil *et al.*[21]
[d]Based on PPST scoring instructions, item responses "a lot" and "a whole lot" are coded as "agree"

Table 3. Results of ANOVA comparing PPST risk groups on clinical characteristics.

	PPST risk group						
	Low M(SD)	Moderate M(SD)	High M(SD)	F	P	η^2	η^2 95% CI (LL, UL)
Pain intensity	3.35 (1.94)[b]	4.13 (2.04)	4.87 (2.21)[b]	8.27	.000	.26	.02, .18
Activity limitations	21.69 (15.39)[a,b]	36.83 (15.07)[a]	44.92 (18.30) [b]	32.88	0.000	.29	.17, .39
Fear of pain*	16.06 (12.65) [a,b]	26.15 (15.32)[a, c]	37.56 (20.12) [b,c]	27.84	0.000	.26	.14, .35
Pain catastrophizing	8.69 (6.47)[b]	12.25 (6.99)[c]	18.79 (11.86) [b,c]	21.15	0.000	.24	.10, .30
Sleep quality	4.23 (.79) [a,b]	3.72 (.83)[a]	3.66 (.90)[b]	8.79	0.000	.10	.02, .18

Notes: i) superscripts represent group differences using Tukey post hoc comparisons;
*Fear of pain total score calculated for n = 165 (one participant missing data)
[a]= low versus moderate
[b]= low versus high
[c]= moderate versus high, ii)

gender, with females more likely to be identified as high-risk. There were no differences in PPST risk group on other clinical or demographic factors (race, ethnicity, age, BMI, pain location, fracture status, recruitment setting). Furthermore, there were no associations among PPST scores nor PPST risk group and the number of days between pain onset and survey completion.

Aim one examined associations among PPST risk groups and measures of pain-related emotional and physical function. Results of one-way ANOVAs revealed differences in pain, pain-related disability, pain-related fear, pain catastrophizing, and sleep quality by PPST risk group (see Table 3). Post-hoc conducted using Tukey's range test revealed all three groups were significantly different on pain-related fear with higher PPST risk categorization corresponding to higher FOPQ scores. Regarding pain and pain catastrophizing, youth categorized as high risk had significantly higher pain and more pain-catastrophizing than youth in the low risk group. In terms of pain-related disability, significant differences were found between the low risk and both moderate and high risk groups; differences between moderate and high risk groups approached significance (p=.058).

Aim two examined the ability of PSST total and psychosocial subscale scores in discriminating reference standard "cases" versus "non-cases" on measures of pain-related fear, pain catastrophizing and pain-related disability and are presented in Table 4. For the 9-item PPST total score, AUCs for reference cases for pain catastrophizing (≥ 26), fear of pain ≥ 51, and pain-related disability (> 1 SD above the mean) were fair to good with values ranging from .79 - .85 for discrimination among "cases" versus "non-cases". ROC curve analyses examining the 5 items PPST psychosocial subscale in discrimination "cases" versus "non-cases" for pain catastrophizing (≥ 26), fear of pain ≥ 51, and activity limitations (> 1 SD above the mean) were similarly fair to good with values ranging from .77 - .87.

Aim three identified clinical cut-offs for both the PPST total score and PPST psychosocial subscale. Results revealed a PPST total score of ≥ 4 was the best concurrent predictor of high pain-related disability (>1 SD above the mean) in youth with acute musculoskeletal pain. See Figure 1. Furthermore, a PPST psychosocial subscale score of ≥ 3 was the best concurrent predictor of reference standard psychosocial distress on the both the pain catastrophizing and fear of pain measures. See Figures 2i-ii.

Discussion

Findings from the current study revealed the utility of using the PPST for rapidly screening and assessing pain and psychosocial symptomatology in a sample of treatment-seeking youth with acute musculoskeletal pain. While previous work has demonstrated the utility of the PPST in identifying youth with elevated symptomatology and poor outcomes in chronic pain samples,[6,8,9] this is the first study to show the PPST can effectively discriminate youth with acute musculoskeletal pain who present with different levels of pain and psychosocial symptoms. Findings support the potential utility of screening symptomatology of youth with musculoskeletal pain in the acute care setting before pain becomes chronic. This information might be used to target youth who may

Table 4. AUC for PPST total score and PPST psychosocial subscale scores against reference standard cases.

Reference standards	Case definition	PPST total AUC (95% CI)	PPST psychosocial AUC (95% CI)
Pain-Related Disability	> 1 SD above CALI-9 sample mean	.81 (.72-.90)	.77 (.69-.86)
Fear of Pain[a]	FOPQ ≥ 51	.79 (.69-.89)	.82 (.72-.92)
Pain Catastrophizing	PCS-C ≥ 26	.85 (.76-.94)	.87 (.81-.94)

[a]Fear of pain cut score calculated for n = 165 (one participant missing data)

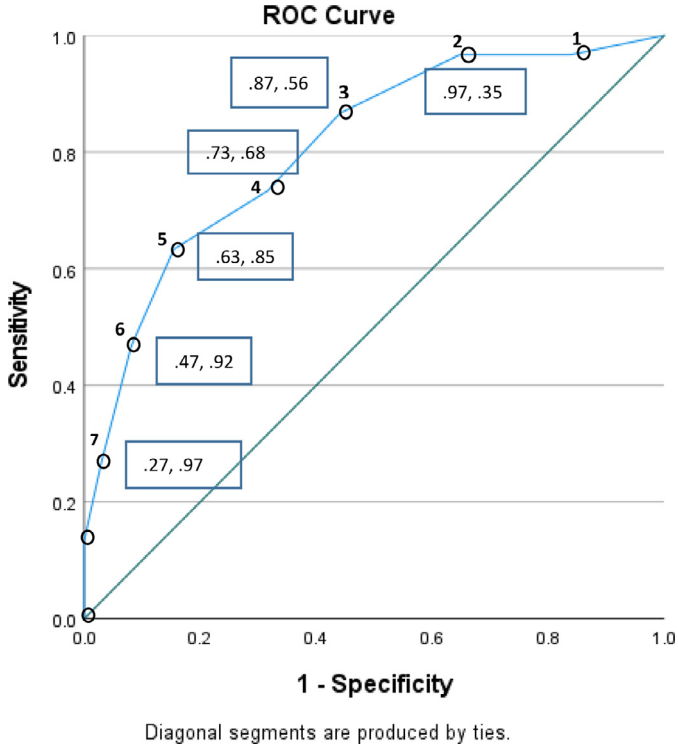

Figure 1. Receiver operating characteristics for the PPST total score against CALI-9 cases defined as > 1 SD above sample mean. Sensitivity and specificity notated in boxes on line.

benefit from ongoing monitoring, more intensive follow-up, and referrals for additional psychosocial assessment. Screening of youth acute pain is in line with recently proposed frameworks (e.g., The Integrated Prevention Model for pediatric pain;[11] the Developmental Model[10]) which emphasize the importance of expanding the focus of pediatric chronic pain treatment to include identification of vulnerabilities and pain prevention.

Similar to work in chronic pain samples, results of this study revealed that higher risk classification by the PPST was associated with higher levels of pain intensity, greater activity limitations, more pain-related fear,

i).

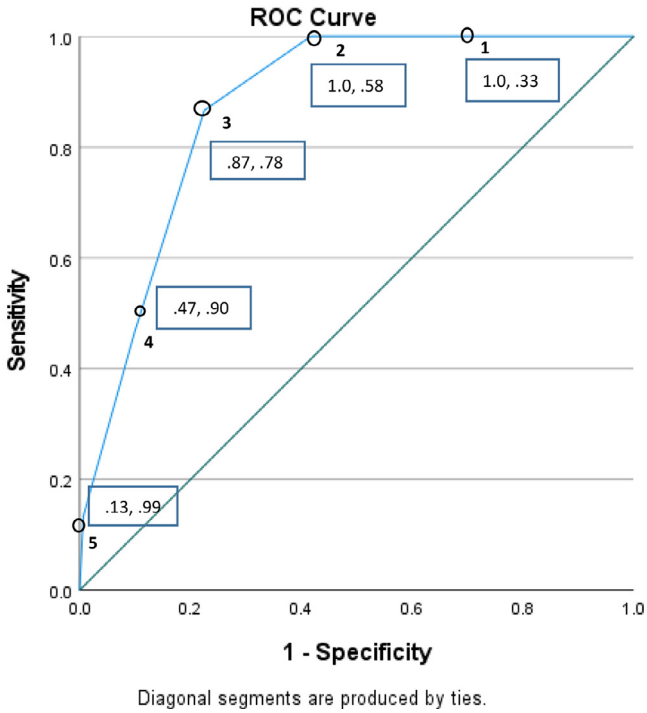

Figure 2. Receiver operating characteristics for the PPST Psychosocial subscale against i) Pain Catastrophizing Scale (PCS-C) cases defined as ≥ 26 and ii) Fear of Pain Questionnaire (FOPQ-C) cases as defined by ≥ 51. Sensitivity and specificity notated in boxes on line.

ii).

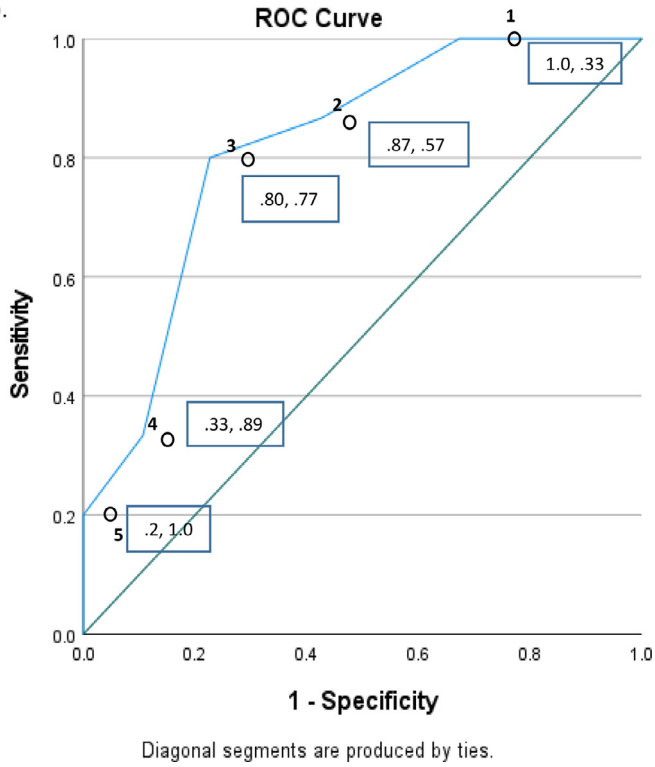

Figure 2. Continued

higher pain catastrophizing, and poorer sleep quality. This is important as it shows that a 9-item screening measure can quickly and efficiently identify concurrent symptomatology across a wide variety of domains. Moreover, in addition to effectively identifying risk groups, the ROC curve results revealed clinical cut-offs on both the PPST total score and PPST subscale that are appropriate for use with acute musculoskeletal pain samples. The recommended cut-off for the PPST total score in identifying concurrent high levels of pain-related disability in youth with acute musculoskeletal pain is ≥ 4. Importantly, this is different than the studies of youth with chronic pain which identified a PPST total score cut-off ≥ 5.[6,9] This difference in cut-offs is not surprising given the mean/standard deviation obtained for the PPST total score in this acute pain sample is lower than those in the pediatric chronic pain studies. This lower mean score in youth with acute musculoskeletal pain likely reflects that youth with new-onset pain problems may have less overall disruption in pain-related function than those who have established chronic pain conditions. Interestingly, the findings revealed a psychosocial subscale cut-off of ≥ 3 for this acute pain sample is the same cut-off as identified in previous pediatric chronic pain research.[6,8,9] This suggests that when youth with pain – either acute or chronic – endorse ≥ 3 psychosocial items on the PPST (e.g., "I worry about my pain a lot", "In general, I do not have as much fun as I used to") psychosocial risk is similar. This highlights that these cognitive-affective factors known to be associated with higher pain and disability in youth with chronic pain (e.g., pain catastrophizing, pain-related fear), are important even in the acute pain period.

It is also important to note that while findings from this acute pain sample show similar patterns in ROC analyses as previous studies (e.g., discrimination among "cases" versus "non-cases" on measures of disability, pain-related fear and pain catastrophizing), percent agreement on individual PPST items among pain samples differs (see Table 2). For example, endorsement of pain-related anxiety in item "I worry about my pain a lot" was 30.7% of youth with acute pain versus 48.8% of youth with chronic pain and 52.1% of youth with sickle cell disease. Similar differences emerged in perceptions about safety of physical activity with 49.4% of youth with acute pain endorsing "It is not safe for me to be physically active" versus 45.9% of youth with chronic pain, and 19.1% of youth with headache. While it could be argued that in context of acute pain the safety of physical activity may be different than for youth with chronic pain or headache, this does not make the item invalid. Rather, the screener gives the provider a brief tool for assessing cognitions about pain and function – including fear-avoidance. For example, while some activities may not be indicated in the context of an acute injury, it is likely that not all activity is "dangerous" and the patient/family many benefit from anticipatory guidance around safe movement.

Findings from this study also revealed females were more likely to be categorized as high risk than males. Overall this is not surprising given that we know in the context of chronic pain, the prevalence of MSK pain is higher in females compared to males, particularly in adolescence.[26] These sex differences are also supported by our previous work that examined risk for transition from acute to chronic musculoskeletal pain which identified girls were more likely to develop chronic pain then

boys.[3] Additional research can further explore sex differences in youth with other types of acute pain complaints. Despite associations among gender and PPST scores in this acute pain sample, there were no associations among the PPST and other clinical or demographic factors (e.g., race, ethnicity, age, BMI, pain location, fracture status, recruitment setting). The lack of associations with individual level variables supports the use of the PPST in heterogeneous youth with acute MSK pain. Moreover, it parallels findings from other PPST studies in mixed chronic pain, headache and sickle cell samples which also did not show associations with clinical factors.

This study has several strengths that can be highlighted. First, participants were a relatively diverse sample (29.5% Hispanic, 20.5% biracial or multiracial) compared to previous pain studies and the sample was well balanced by gender (46.4% male). This increases confidence that findings can be applied to diverse groups. An additional strength is this was a clinical sample of treatment-seeking youth with acute musculoskeletal pain. The majority of pediatric pain research is conducted when pain is chronic, disabling and difficult to treat or is conducted in community setting (e.g., schools) via epidemiologic studies. By studying youth with acute pain soon after they experienced injury, we are able to capture the exact sample we seek to target with future preventive interventions.

There are also limitations to the study that need to be acknowledged. First, participants were exclusively an acute musculoskeletal pain sample. While musculoskeletal pain is highly prevalent in youth and is one of the most common reasons for seeking medical care, it is unknown how study findings apply to other acute pain samples. A key sample of interest for future research is youth with other pain locations/injuries such as concussions/mild traumatic brain injury (TBI). Like musculoskeletal pain, mild concussions are common in youth and a frequent reason for seeking care[27]. Moreover, data shows variability in recovery from concussions with some youth experiencing a remission of symptoms and others developing persistent pain and other problems.[28] Key next steps are to see how the PPST works in youth with TBI and a variety of other acute pain presentations to support providers in identifying at-risk youth to target with preventive interventions.

An additional limitation is that the only psychological measures included in the current study were the Pain Catastrophizing Scale and the Fear of Pain Questionnaire, as these were the only two psychological measures given in both studies. While these measures have been previously associated with pain outcomes in acute and chronic pain samples[29–32] and in the current study had clinical cut-offs used in ROC curve analyses for identification of "cases" versus "non-cases", it is unknown how other measures (e.g., anxiety, depression) are associated with PPST scores. Future research can explore associations among PPST risk groups and clinical cut-offs for other standard measures in youth with acute musculoskeletal pain. This future research can also explore associations among PPST scores and strategies youth are using to manage their acute pain, as this could data was not available for participants in both studies.

Additional research will explore the effectiveness of the PPST for predicting pain outcomes over time, including the persistence of pain and pain-related disability. Longitudinal data collection is underway so examining associations among PPST scores and longitudinal pain outcomes is planned. Knowing if PPST scores can predict pain-related outcomes outside the acute pain period will be important for understanding if the utility of the screener extends beyond current assessment of risk classification in youth with acute musculoskeletal pain but also longitudinally predicts recovery.

An additional direction for research will be to evaluate best practices and procedures for administering the PPST in clinical settings. While youth in this study had sought care in either the emergency department or outpatient clinics (e.g., orthopedics, sports medicine), participants in these studies completed the PPST as part of a research project when they had already left the acute care setting. Clinical cut-offs supporting the feasibility of using this tool in a busy clinical environment and future implementation studies will help provide guidance regarding processes and procedures for administering and scoring the PPST in the acute care setting.

In conclusion, findings from this study suggest the PPST is a promising tool for assessment of pain and psychosocial symptomatology in youth with acute musculoskeletal pain. The ROC analyses highlight the PPST total score can effectively discriminate "cases" versus "non-cases" on key measures of pain-related disability, pain catastrophizing and fear avoidance suggesting this measure can give providers immediate data that can inform their treatment recommendations and potentially referrals additional psychosocial assessment based on risk categorization. Using the PPST in the acute care setting also provides a unique opportunity to identify youth with elevated symptomatology before pain becomes chronic. It is hoped that ultimately point-of-care screening for youth with acute pain can play a key role in the prevention of chronic pain, as traditionally chronic pain treatment has occurred when pain and disability have already set in. As recently highlighted in other manuscripts calling for a focus on pain prevention[10,11] next steps will be the development of effective preventive interventions for use with acute pain samples.

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