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Psychosocial predictors of acute and chronic pain in adolescents undergoing major musculoskeletal surgery

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Abstract

Acute and chronic pain delay recovery and impair outcomes after major pediatric surgery. Understanding unique risk factors for acute and chronic pain is critical to developing effective treatments for youth at risk. We aimed to identify adolescent and family psychosocial predictors of acute and chronic postsurgical pain following major surgery in adolescents. Participants included 119 youth age 10–18 years (M_{age}=14.9;78.2% white) undergoing major musculoskeletal surgery and their parents. Participants completed pre-surgery baseline questionnaires, with youth reporting on baseline pain, anxiety, depression, insomnia and sleep quality, and parents reporting on parental catastrophizing and family functioning. At baseline, 2-weeks, and 4-months post-surgery, youth completed 7-days of daily pain diaries and reported on health-related quality of life. Sequential logistic regression models examined pre-surgery predictors of acute and chronic postsurgical pain, defined as significant pain with impairment in health-related quality of life. Acute pain was experienced by 27.2% of youth at 2-weeks, while 19.8% of youth met criteria for chronic pain at 4-months. Baseline pain predicted acute pain (OR=1.96; 95%CI=1.32–2.90), while depressive symptoms (OR=1.22; 95%CI=1.01–1.47) and sleep quality (OR=0.26; 95%CI=0.08–0.83) predicted chronic pain. Tailored interventions need to be developed and incorporated into perioperative care to address risk factors for acute and chronic pain.

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Keywords

adolescent; chronic postsurgical pain; spinal fusion; depression; insomnia

Introduction

Acute and chronic pain are common experiences after major surgery. Compared to younger children, adolescents are at elevated risk for both acute and chronic pain following surgery[22,46]. Negative consequences include delayed recovery and impaired health-related quality of life (HRQOL)[45,47,49], making effective pain management a high priority. Despite high prevalence of acute pain (>50%)[37,45] and chronic pain (20%)[19,26,38,47,53], risk factors for postsurgical pain in youth remain largely unknown[51]. Given the influence of a large range of biopsychosocial factors on development of chronic pain[14], it is possible that a different set of risk factors may predict acute versus chronic pain. It is important to understand the transition from acute to chronic postsurgical pain (CPSP) to develop effective treatments for youth at risk[60].

Elman and Borsook's model of the mechanisms of chronic pain and addiction[14] highlights the roles of sensory (pain processing), psychological (emotions, cognitions), behavioral, and social (interpersonal) domains in the evolution of pain, from inciting tissue damage to chronification of pain. Although biopsychosocial models are often applied to pediatric chronic pain, much less attention has been directed toward understanding pediatric postsurgical pain[51,60]. Emerging research suggests that psychosocial factors play a role in persistence of pain after major surgery[10,37,38,47,53,60]. However, a recent systematic review examining risk factors for CPSP in youth identified a gap in well-designed studies that examine comprehensive risk factors in this population[51]. For example, several studies have examined adolescent anxiety (e.g., general anxiety, pain catastrophizing)[4,3,6,50] but other emotional factors important in chronic pain (e.g., depressive symptoms)[24] have not been assessed. Similarly, a few studies examined sleep quality as a predictive factor[45,52], but more comprehensive assessment of sleep disturbances has not been conducted. Further, there has been minimal consideration of the social context, including parent and family factors[27], in pediatric CPSP studies. Additional weaknesses in the literature include small sample sizes, inconsistency in measurement of both acute and CPSP to understand risk for transition, and differing definitions of CPSP based on presence of pain without consideration of severity and impact[51], limiting conclusions that can be drawn.

To address these gaps, we conducted a prospective longitudinal cohort study in youth undergoing major musculoskeletal surgery. We aimed to examine adolescent psychological (emotional, cognitive) and behavioral factors (sleep quality, insomnia symptoms), and parent and family factors as predictors of risk for acute postsurgical pain (APSP) at 2-weeks and CPSP at 4-months following surgery. To begin to understand the sensory component of postoperative pain, we assessed pre-operative pain intensity and distribution. We defined postsurgical pain as pain that is associated with impairment in HRQOL[59], and chose 2-weeks for the acute outcome period based on research demonstrating differentiation of recovery trajectories at 2-weeks post-surgery[47]. Based on prior perioperative as well as

broader pediatric pain literature[24,27,41,51], we expected baseline pain, adolescent emotional and behavioral factors, and parent and family factors to predict acute and CPSP. We hypothesized that higher baseline pain intensity[6,10,45], wider pain extent[48], higher levels of anxiety and depressive symptoms[10,17,24,45], higher insomnia severity, poorer sleep quality[52], higher parent pain catastrophizing[37,47], and poor family functioning[27], would significantly predict APSP, and subsequent CPSP.

Materials and Methods

Participants:

Participants included 119 youth undergoing major musculoskeletal surgery and their parent or guardian, recruited from a tertiary pediatric hospital in the Northwest United States between October 2014 and June 2018.

Youth were eligible for participation if they were 1) 10–18 years of age, 2) scheduled to undergo major musculoskeletal surgery (spinal fusion for idiopathic spinal deformity, Nuss procedure for pectus deformity, or hip or femur osteotomy), and 3) able to read and understand English. Youth were excluded from the study for 1) developmental delay affecting ability to complete study measures independently, 2) chronic medical condition (e.g. neuromuscular scoliosis, diabetes, cancer), 3) diagnosed chronic pain condition requiring treatment, or 4) prior major surgery (e.g. spine surgery, open thoracic or abdominal surgery). Eligible procedures were chosen as the most common major musculoskeletal procedures in adolescents without significant comorbidity.

Procedures:

The Institutional Review Board approved all study procedures. Potentially eligible youth were identified using an electronic screening tool selecting patients based on patient age and scheduled procedure type and indication from the electronic medical record. An informational study packet was mailed to potential participants, following which research assistants approached youth and their parents by phone, or in person at their pre-operative appointments. Of the 213 potentially eligible families approached, 88 declined, 6 were not eligible, and 119 enrolled into the study. Primary reasons for non-participation included not interested in research or not enough time. Five enrolled families dropped out of the study prior to the 4-month assessment, and 114 families completed the study through 4-month follow up. Long-term follow up of health outcomes in this sample is ongoing.

Eligible and interested families completed written consent (parents and youth≥18 years) and assent (youth<18 years). Youth completed 3 assessment timepoints: the week before surgery (pre-surgery baseline), 2-weeks after surgery (acute post-surgery outcomes), and 4-months post-surgery (chronic post-surgery outcomes) (Figure 1). Youth and their parents completed validated self-report questionnaire measures assessing pre-surgery psychosocial risk factors, once during the baseline assessment (the week before surgery). Youth reported on daily pain intensity using an online diary for 7 days at each timepoint, and completed additional pain and health outcomes measures once during each timepoint. Diaries and measures were collected using the Research Electronic Data Capture (REDCap) system which sends out an

email to participants containing a link for completing measures online. Measures were sent separately to parents and youth, and entries were time-stamped. Youth and parents received a small gift card incentive ($20 and $10 respectively) on completion of each assessment.

This is the first manuscript to report primary outcomes of this study. To date, a qualitative interview study with a small subset of participants has been published from this cohort[49], and pain and quality of life data from the baseline assessment were used in a measure validation study[13]. Results from the long-term follow up will be reported on study completion.

Measures:

Youth measures

Pain intensity.: At each assessment, youth rated their daily pain intensity for seven days. They were prompted at the end of each day to respond on an 11-point numeric rating scale with anchors 0="no pain" and 10="worst pain possible". Youth also self-reported daily medication use, indicating whether medication was taken (Yes/No) and listing the medication in a free text field. Self-report numeric rating scales are recommended for acute and chronic pain assessment in youth of this age range[4,57] and have shown adequate validity and sensitivity to change in youth following surgery[35].

Pediatric Quality of Life Inventory (PedsQL short form, acute version).: Youth completed the 15-item short form of the Pediatric Quality of Life Inventory assessing school, emotional, psychological, and physical functioning over the preceding 7 days[5]. The sum of items is transformed to yield a total score ranging from 0–100 reflecting both psychosocial and physical health, with lower scores indicating poorer HRQOL. The PedsQL has been extensively validated and is broadly used in youth of this age range[5,12,30,54,55], and has demonstrated sensitivity to acute changes in HRQOL[12]. Values one standard deviation below the population mean, based on normative data from healthy populations, are an established as a cutoff indicating impairment in HRQOL[5,55].

Pain characteristics.: Youth reported on extent to which pain limited activities in the prior 7 days on a 0–100 visual analogue scale, with anchors 0="does not limit any activity" and 100="limits all activities"[40]. Evidence of construct validity was shown in this sample through expected cross-sectional associations with pain intensity ($r=0.4$, $p<0.001$ at 2-weeks, $r=0.5$, $p<0.001$ at 4-months) and the physical health subscale of the PedsQL ($r=-0.4$, $P<0.001$ at 2-weeks, and $r=-0.6$, $p<0.001$). Youth rate level of emotional upset due to pain during the preceding 7 days on a 5-point Likert scale with response options ranging from "not at all" to "very much", which are assigned values from 1 to 5.

Widespread Pain Index (WPI).: Youth indicate any locations where they have experienced pain or tenderness during the past 7 days from 19 pain locations. The number of pain locations is summed to describe pain distribution or pain extent, reflecting the degree to which pain is widespread. The WPI has shown good construct validity to assess pain distribution in youth of this age range, with both acute and chronic pain[13].

Pain Catastrophizing Scale- Child version (PCS-C).: This 13-item measure assesses extent to which youth endorse thoughts and feelings of magnification, rumination, and helplessness in response to pain[11]. Response options range from 0 (“not at all”) to 4 (“extremely”), and are summed to yield a total score ranging from 0 to 52, with higher values indicating higher levels of pain catastrophizing. The measure is valid in this age range, and has been broadly used in youth undergoing major surgery[17,36,45,47].

Revised Child Anxiety and Depression Scale (RCADS).: This 47-item self-report questionnaire assesses adolescent symptoms of anxiety and depression. The measure comprises 5 scales of anxiety (social phobia, panic disorder, separation anxiety, generalized anxiety, obsessive-compulsive), and 1 scale for major depression. Response options range from 0 (never) to 3 (always), and corresponding items are summed to yield subscale scores, with higher scores indicating greater anxiety and depressive symptoms. The total anxiety scale score (sum of the 5 anxiety subscales) ranges from 0 to 111, and the depression subscale score ranges from 0 to 30. This measure is valid, reliable, and sensitive to change in youth[7,31,44], and has been broadly used in adolescents with pain[8,21]. Normative data (mean and SD) based on grade and sex can be used to calculate a T-score for subscale and total scores[58] to aid interpretation of individual scores. A T-score > 65 is considered borderline symptoms, and a T score > 70 is above clinical threshold.

Insomnia Severity Index (ISI).: Youth provided self-report of insomnia severity and impact in the preceding 2 weeks on this 7-item measure with responses on a 5-point Likert scale. Items (range 0–4) are summed to yield a total score which can be classified into 4 levels of insomnia symptom severity: 1) as absence of insomnia (0–7), 2) sub-threshold insomnia (8–14), 3) moderate insomnia (15–21), or 4) severe insomnia (22–28). This valid and reliable measure[2] has been used in research with adolescents[9] including youth with pain[43].

Adolescent Sleep Wake Scale (ASWS).: Youth completed the 10-item short form version of this measure assessing adolescent sleep quality in the preceding month, including going to bed, falling asleep, reinitiating sleep, and returning to wakefulness. Items are scored on a 6-point Likert scale ranging from 1 (always) to 6 (never), and are averaged to create a total score with higher scores indicating better sleep quality. The 10-item scale total score has shown adequate internal consistency and construct validity in adolescents with chronic pain[16].

Parent Measures

Pain Catastrophizing Scale-Parent version (PCS-P).: The parent version of this measure contains 13 items assessing parent’s cognitive and emotional responses to their child experiencing pain[20], using response options ranging from 0 (“not at all”) to 4 (“extremely”). Items are summed to yield a total score ranging from 0 to 52, with higher values indicating higher levels of pain catastrophizing. This measure is valid and reliable, and has been used with parents of adolescents in the perioperative setting[6,37,45].

Family Assessment Device (FAD)- general functioning subscale.: Parents completed the 12-item general family functioning subscale of the McMaster Family Assessment Device[15].

Parents endorse items by selecting one of 4 response options: ‘strongly disagree’, ‘disagree’, ‘agree’, or ‘strongly agree’. The mean of item scores (range 1–4) is computed. Scores can be interpreted using an established cutoff score of 2.0 or greater to indicate unhealthy family functioning. The FAD has demonstrated adequate internal reliability, discriminant validity, concurrent validity, and predictive validity[1,15,32,33] and has been used in parents of youth with pain[27,33].

Demographic questionnaire.: Parents report on child race, ethnicity, and sex, and parent education and income.

Statistical Analysis:

Sample size calculations were performed using a target sample size for multivariable regression modeling, based on guidelines to include at least 10 subjects per degree of freedom to obtain reasonable estimates of regression coefficients[23]. Based on 95% retention rates in our prior studies, we aimed to enroll 120 participants to obtain a final sample size of over 110 participants, which was adequate for including the 11 continuous or binary baseline predictor variables of interest.

Bivariate analyses comparing study completers (n=114) versus study dropouts (n=5) did not identify any significant differences on participant demographic factors (age and sex) or baseline pain intensity or distribution (number of pain locations) (p’s>0.05). All available data from participants were included in the analyses.

Daily diary data were cleaned by deleting all entries with timestamps outside of the valid date and time frame of 7 pm on the same day to 5 am the following morning. On average, youth completed 5.4 valid days over the 7 day diary monitoring period at baseline, 2-week, and 4-month time points. Thus a total of 1,811 days of diary data were generated by the participants. Pre-surgery daily pain data were averaged for each participant to calculate a mean baseline pain intensity score. Post-surgery daily pain data at 2-weeks and 4-months after surgery were combined with HRQOL data to define binary outcome variables for APSP and CPSP. Daily medication use was manually coded into categories: over the counter analgesics (acetaminophen, non-steroidal anti-inflammatory drugs), opioid, or other medication. Medication use at 2-weeks and 4-months were described as the proportion of days (over the 7 day monitoring period) that medication use was reported for each medication category.

APSP and CPSP were defined by applying the modified International Association for the Study of Pain (IASP) definition of CPSP as pain that affects HRQOL[59]. Thus, we defined APSP as a binary variable indicating presence of moderate-severe pain and impaired HRQOL. Participants were classed as having APSP if at 2-weeks they reported, 1) moderate-severe pain (pain intensity ≥ 5) on more than 50% of daily diary days, and 2) impaired HRQOL based on PedsQL™ total score < 74.9. The cutoff of 74.9 is based on the established cutpoint for impaired quality of life of 1 SD (11.2 points) below the population mean (86.1 points)[55] based on normative data for the PedsQL short form[5]. Participants were classed as having CPSP if at 4-months they experienced, 1) greater than minimal pain (pain intensity ≥ 3) on more than 50% of days during the daily monitoring period and 2)

impairment in HRQOL (PedsQL™ < 74.9). The daily intensity cutoffs for acute and chronic pain were selected based on prior data supporting that pain above these thresholds represent a departure from the average experience after surgery[10,37,38,47,51], as well as our own prior research demonstrating significant activity limitations and impairment in quality of life of acute postsurgical pain in the moderate-severe range[46,5] and of chronic pain in the mild range[47] after surgery. APSP and CPSP were defined independently, thus youth may meet criteria for CPSP even if they had not met criteria for APSP.

We conducted cross-sectional two-sided t-tests and Mann-Whitney U tests comparing pain characteristics (extent to which pain limits activities, and degree of emotional upset due to pain) at 2-weeks by APSP status. Similarly, we compared pain characteristics at 4-months by CPSP status. Further, for descriptive purposes, we applied two-sided t-tests and chi-squared tests to compare baseline demographic and psychosocial variables, with APSP status at 2-weeks, and with CPSP status at 4-months.

To examine psychosocial predictors of acute and chronic postsurgical pain, we took a sequential approach to examine 4 levels of a priori identified domains with the following ordering: demographic factors, baseline pain, adolescent psychological (emotional and behavioral), and parent/family risk factors. We conducted a sequence of multivariable logistic regression models to examine the associations between the domain factors and APSP or CPSP status. The base model (Model 1) included baseline demographic variables only. Then baseline pain intensity and pain distribution (Model 2), adolescent emotional and behavioral factors (Model 3), and parent and family factors (Model 4) were added into the models sequentially, leading to four nested regression models. The nested models were compared by Akaike's Information Criterion (AIC) and likelihood ratio tests (LRTs). AIC is penalized log-likelihood statistic commonly used for model selection with smaller values indicating better model fit. Likelihood ratio tests comparing each successive model to the previous step (i.e. M2 vs. M1, M3 vs M2, and M4 vs. M3) were used to assess whether the domain specific factors as a whole had significant associations with APSP or CPSP status. All analyses were conducted using Stata version 14 (StataCorp, College Station, TX).

Results

Descriptive data

119 youth (75 girls, 44 boys), with a mean age of 14.9 years (range, 10.0–18.9 years), 78.2% white enrolled into the study (Table 1). APSP, as defined by moderate-severe pain on the majority of days and impaired HRQOL at 2-weeks, was experienced by 27.2% of youth. Youth who met criteria for APSP reported significantly higher pain interference on activities (73.5 vs. 53.7, $p<0.001$) and emotional upset from pain (3.5 vs. 2.6 vs., $p<0.001$) at 2-weeks as compared to those without APSP. On average, over the 7 day monitoring period, youth used an opioid on 21.4% of days at the 2-week post-surgery assessment. Use of over the counter analgesics was reported on 54.4% of days. Table 2 presents bivariate analyses for differences in baseline variables by APSP status.

At 4-months after surgery, 19.8% of youth met criteria for CPSP, as defined by more than minimal pain on the majority of diary days and impaired HRQOL at 4-months post-surgery.

Youth with CPSP reported higher pain interference on activities (51.7 vs. 21.4, p<0.001) and emotional upset from pain (3.0 vs. 2.1, p<0.001) at 4-months as compared to those who did not have CPSP (i.e., minimal pain or normal HRQOL). The rate of CPSP was significantly higher amongst youth who met criteria for APSP as compared to those who did not (50.0% vs. 9.1%, p<0.001). No participants reported any opioid use over the 7 day diary monitoring period at 4-months; over the counter analgesic use was reported on 7.3% of days over the 7 day monitoring period at 4-months after surgery. Bivariate analyses comparing baseline variables by CPSP status are presented in Table 3.

Before surgery, 5.1% of youth met the cutoff for clinical depression and 4.3% met the cutoff for clinical anxiety. 11.0% of youth had moderate to severe levels of insomnia before surgery, while the vast majority had absent or sub-threshold symptoms.

Predictors of APSP

A sequence of multivariable logistic regression models examined associations between demographic factors, baseline pain, adolescent psychological/behavioral, and parent/family factors before surgery with presence of APSP at 2-weeks post-surgery (Table 4). Results revealed that baseline pain variables were significantly associated with APSP, while psychological/behavioral and parent/family factors were not. Addition of baseline pain variables to the base model containing demographic factors significantly improved model fit (AIC reduced from 130 to 115), and increased the prediction of APSP (LR= 19.31 for M2 vs. M1, p<0.001). Sequential addition of psychological/behavioral factors and parent/family factors did not improve model fit (AIC=119 and 117 respectively) or increase prediction of APSP (LR= 5.81 for M3 vs. M2, and LR= 5.97 for M4 vs. M3, p's>0.05). Of the baseline pain variables, mean baseline pain intensity was the only consistently significant independent predictor of APSP status (M4: OR=1.96; 95% CI 1.32 – 2.90). Thus, for each 1 point higher mean pain intensity rating during the week preceding surgery, the odds of APSP was 96% higher at 2-weeks following surgery (p<0.001).

Predictors of CPSP

The same sequence of multivariable logistic regression models was used to examine the association between demographic factors, baseline pain, adolescent psychological/behavioral, and parent/family factors before surgery and CPSP status at 4-months after surgery. The 4 nested regression models are presented in Table 5. Only addition of adolescent psychological and behavioral factors increased model fit, as reflected by a reduction in AIC, and increased prediction of CPSP status (LR= 17.02, p=0.004). Addition of baseline pain variables, and of parent/family variables did not improve model fit, and was not associated with a significant increase in overall prediction of CPSP (LR=5.07 for M2 vs. M1, and LR=3.55 for M4 vs. M3, P's>0.05). In the final model (M4), adolescent depressive symptoms (OR=1.22, 95% CI= 1.01–1.47), and sleep quality (OR=0.26, 95% CI= 0.08–0.83) were significantly associated with CPSP status at 4-months post-surgery. Each point higher level of depressive symptoms on the RCADs before surgery was associated with a 22% higher odds of CPSP at 4-months (p=0.03). Each 1 point higher sleep quality score on the ASWS before surgery was associated with 74% lower odds of developing CPSP at 4-

months (p=0.02). Associations between these two factors and CPSP were also detected in Model 3.

Discussion

This study comprehensively examined psychosocial risk factors for acute and chronic postsurgical pain in adolescents undergoing major musculoskeletal surgery. We examined demographic factors, baseline pain, adolescent psychological/behavioral, and parent/family risk factors as predictors of APSP at 2-weeks and of CPSP at 4-months following surgery. Our findings revealed that distinct domains predicted acute and chronic postsurgical pain. Pre-surgery pain intensity was the only significant predictor of APSP at 2-weeks post-surgery, with odds of developing APSP almost doubling with each 1-point increase in mean pain intensity during the week prior to surgery. As expected, pre-surgery adolescent emotional and behavioral factors were significant predictors associated with chronic pain at 4-months. Both depressive symptoms and sleep quality had a significant effect on chronic pain after surgery, with each 1-point difference on the scales assessing depressive symptoms and sleep quality before surgery being associated with a 22% and 74% difference in the odds of CPSP at 4-months, respectively. However, adolescent pain catastrophizing, anxiety symptoms, and insomnia symptoms were not predictive of CPSP.

This study builds on prior literature through assessing a comprehensive set of emotional, behavioral, and parent/family factors, allowing us to differentiate predictors of significant acute pain at 2-weeks and chronic pain at 4-months. Consistent with findings in prior studies in youth[6,45] as well as adults[39], baseline (pre-surgery) pain was a significant predictor of APSP. In adults, baseline pain severity has been identified as predictive of acute pain trajectories following major musculoskeletal surgery[39]. In addition, studies employing quantitative sensory testing before surgery in adults have found higher pre-surgery pain intensity is associated with higher pain sensitivity before surgery[34]. This suggests that altered sensory pain processing may potentially be one factor underlying the relationship between higher pre-operative pain and APSP. Further research is needed in pediatric populations to understand potential sensory mechanisms involved in acute postoperative pain in youth.

Prior research has demonstrated that pain trajectories become established during the first 2 weeks of recovery and pain may persist over the year following surgery in a subgroup of youth[47]. Similarly, we found that 50% of youth with APSP went on to develop CPSP at 4-months. This underscores the importance of developing and implementing interventions to target mechanisms underlying APSP, to improve recovery during the acute phase and promote resolution of pain before a pattern of persistence is established.

Our findings diverge from prior studies that identified psychosocial risk factors for acute postsurgical pain including pain catastrophizing[17], sleep disturbance, parent pain catastrophizing[45], and a cluster of high psychological symptoms[56] to be associated with higher acute pain intensity. We believe there are several reasons for this difference in findings. Most prior studies have only accounted for baseline pain with a single retrospective pain rating[17], while other studies did not assess pre-operative pain and only measured

psychosocial risk factors[28,36]. In contrast, our study included a robust daily assessment of baseline pain intensity over a 7 day period and included multivariable modelling. Using this approach, psychosocial factors did not emerge as independent predictors of APSP.

However, as expected, psychosocial factors did predict CPSP. We found that emotional and behavioral factors including higher depressive symptoms and poorer sleep quality predicted CPSP. These findings mirror research in other chronic pain populations. For example, depressive symptoms have also predicted risk for transition from acute to chronic musculoskeletal pain in youth after injury[24]. Similarly, strong associations between pain, depression, and sleep disturbances have been found in youth with established chronic musculoskeletal pain[25,29,42]. Indeed, sleep is proposed as a risk factor for development of chronic pain[18]. However, once chronic pain is established it is difficult to distinguish whether emotional and behavioral symptoms represent a risk factor, a comorbidity, or a consequence of chronic pain. By studying elective musculoskeletal surgery as a discrete event, we extend prior research findings showing that depressive symptoms and sleep quality prior to the inciting injury influence subsequent development of chronic pain.

Notably, while higher depressive symptoms and poorer sleep quality impacted CPSP outcomes, the majority of youth in this population had subclinical levels of these symptoms before surgery suggesting that even minor alterations in mood and sleep quality may be important to address. However, subclinical symptoms could go undetected during routine clinical care. Both depressive symptoms and poor sleep quality can be screened for and modified with cognitive-behavioral treatments. Further research is needed to test screening procedures before surgery to identify youth at elevated risk and/or to closely monitor youth for significant APSP for early intervention to reduce risk of transition to chronic pain. Interventions targeting depressive symptoms and sleep quality before or after surgery may reduce risk for CPSP.

In our comprehensive assessment of psychosocial factors in youth, we found some differences from previous studies of chronic postsurgical pain. Prior studies identified parent pain catastrophizing as associated with CPSP in youth[37,47,51]. In the present study, higher parent pain catastrophizing was associated with CPSP in univariate analyses, however when accounting for a more comprehensive set of psychosocial predictors, the association between parent/family factors and CPSP status weakened. In addition, prior studies found associations between youth's pre-surgery anxiety and pain catastrophizing with postsurgical pain[6,10,47], which we did not replicate in the current study. Few studies have assessed both anxiety and depressive symptoms as independent predictors in youth, and when these variables were placed in the same multivariate model we found that depressive symptoms were predictive of CPSP. Further work is needed in this population to more fully understand the influence of affective factors. Other potential reasons for differences in findings may include differences in study design (e.g. timing of follow-up), and use of a definition of CPSP which includes pain and HRQOL, compared to prior perioperative studies that defined CPSP status by presence of pain or pain intensity alone.

A strength of our study is the use of multi-dimensional definitions of APSP and CPSP to include not only pain intensity, but also the impact of pain on HRQOL. Supporting the

validity of this definition, we found large differences in activity interference and pain related bother in those who met our criteria for APSP and for CPSP. The prevalence of CPSP in the present study was similar to that described previously in the literature[51], but goes beyond by demonstrating that this subset of youth experience CPSP characterized by pain and physical and psychosocial impact. Identification of those with the highest impact pain increases the strength of findings from our predictive models. Discrepant definitions of CPSP have hindered progress in postoperative pain research[51]. Research is needed to validate a multidimensional definition for CPSP which can be applied consistently across research studies, to strengthen the literature and facilitate comparison and synthesis of findings across studies.

Limitations and future directions.

The findings of our study should be interpreted in light of several limitations. Because our sample lacked sociodemographic diversity, we were limited in our ability to examine sociodemographic risk factors. Further, we enrolled low numbers of some surgery types and were therefore unable to stratify findings by procedure type. In addition, procedure type may be confounded by sex, i.e. spinal fusion patients predominantly female while pectus predominantly male. Future studies designed to examine sex differences in postoperative pain mechanisms and outcomes are needed. Our study was also not designed to examine opioid use following surgery, and future studies may consider using technologies such as medication adherence monitoring to objectively assess postoperative medication use. While we comprehensively characterized psychosocial risk factors before surgery, we did not assess resilience factors, such as effective coping and self-efficacy. The perioperative period provides a distinct opportunity to examine risk and resilience mechanisms underlying transition of acute to chronic pain. While our study was designed to identify baseline psychosocial risk factors, future studies should evaluate change in psychosocial factors during short- and longer-term recovery to examine the mechanistic contribution to pain persistence.

Conclusion.

In conclusion, a subgroup of adolescents undergoing major musculoskeletal surgery are at risk for experiencing acute and chronic postsurgical pain that reduces their HRQOL. Baseline pain predicted APSP, suggesting that altered sensory processing may play a role in acute pain. Emotional and behavioral factors including depressive symptoms and poor sleep predicted risk for chronic pain and impairment in quality of life, suggesting that after the acute phase, psychosocial processes influence development of chronic pain. Tailored intervention approaches need to be developed and incorporated into perioperative care to address risk for pain during the acute and chronic phases after surgery.

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Highlights

- 20% of youth experienced chronic pain at 4-months after major surgery
- Distinct psychosocial domains predicted acute and chronic postsurgical pain
- Higher baseline pain during the week before surgery predicted acute pain at 2-weeks
- Worse depressive symptoms and sleep quality before surgery predicted chronic pain
- Tailored interventions are needed address risk factors for acute and chronic pain

Perspective:

Longitudinal results demonstrate adolescents' pre-surgery pain severity predicts acute postsurgical pain, while depressive symptoms and poor sleep quality predict chronic postsurgical pain. Tailored interventions should address separate risk factors for acute and chronic pain after adolescent surgery.

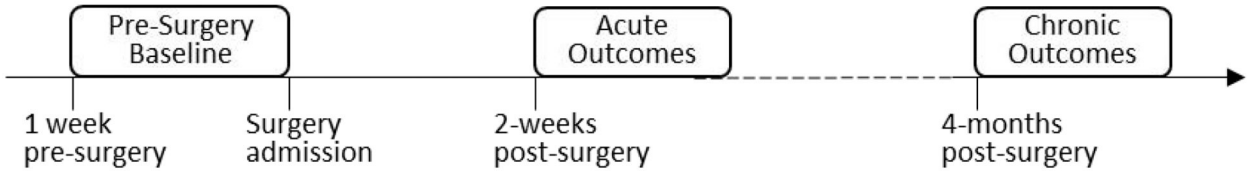

Figure 1.
Study design

Table 1.

Participant demographic and clinical characteristics

Demographics	Mean (Range) / N (%)
Age (years)	14.9 (10.0 – 18.9)
Sex	
Female	75 (63.0%)
Male	44 (37.0%)
Child Race	
White	93 (78.2%)
African American	5 (4.2%)
Asian	4 (3.4%)
Other/not reported	17 (14.3%)
Child Ethnicity	
Hispanic or Latino	10 (8.4%)
Non-Hispanic or Latino	103 (86.6%)
Not reported	6 (5.0%)
Annual household income	
< $29,999	8 (6.7%)
$30,000 – $69,999	30 (25.2%)
> $70,000	75 (63.0%)
Not reported	6 (5.0%)
Parental educational level	
High school or less	16 (13.4%)
Some college	31 (26.1%)
Bachelor's Degree or higher	69 (58.0%)
Not reported	3 (2.5%)
Caregiver relationship (n = 119)	
Biological Mother	104
Biological Father	7
Adoptive Mother	5
Adoptive Father	1
Stepmother	1
Grandmother	1
Surgery Type	
Posterior Spinal Fusion	81 (68.1%)
Anterior Spinal Fusion	3 (2.5%)
Pectus	31 (26.1%)
Femur/Hip	4 (3.4%)

Table 2.

Univariate analyses examining pre-surgery demographic and psychosocial variables by acute postsurgical pain (APSP) status at 2-weeks

	APSP-no	APSP-yes
	Mean (SD) or n (%)	**Mean (SD) or n (%)**
Age	14.8 (1.9)	15.0 (1.8)
Sex *		
male	34 (41.0%)	5 (16.1%)
female	49 (59.0%)	26 (83.9%)
Baseline pain **	1.8 (1.6)	3.5 (2.2)
Pain distribution	2.2 (2.1)	2.7 (2.2)
Pain catastrophizing	14.2 (10.2)	16.3 (9.4)
Anxiety symptoms	23.8 (17.8)	25.5 (15.9)
Depressive symptoms	5.8 (5.1)	7.9 (5.6)
Sleep quality *	4.3 (0.7)	3.9 (1.0)
Insomnia severity		
absence of symptoms	61 (74.4%)	16 (51.6%)
sub-threshold	15 (18.3%)	9 (29.0%)
moderate	5 (6.1%)	6 (19.4%)
severe	1 (1.2%)	0 (0%)
Parent pain catastrophizing	15.6 (10.1)	19.7 (12.7)
Family functioning		
healthy	63 (77.8%)	25 (83.3%)
unhealthy	18 (22.2%)	5 (16.7%)

* $P<0.05$;

** $P<0.001$

Table 3.

Univariate analyses examining pre-surgery demographic and psychosocial variables by chronic postsurgical pain (CPSP) status at 4-months

	CPSP-no	CPSP-yes
	Mean (SD) or n (%)	Mean (SD) or n (%)
Age *	14.6 (1.9)	15.7 (1.8)
Sex		
male	31 (36.5%)	6 (28.6%)
female	54 (63.5%)	15 (71.4%)
Baseline pain *	2.0 (1.7)	3.2 (2.5)
Pain distribution *	2.0 (1.8)	3.1 (2.5)
Pain catastrophizing	14.4 (10.2)	17.8 (9.5)
Anxiety symptoms	23.6 (17.9)	31.7 (13.5)
Depressive symptoms **	5.4 (4.8)	10.8 (5.3)
Sleep quality **	4.3 (0.7)	3.6 (0.6)
Insomnia severity *		
absence of symptoms	63 (75%)	8 (38.1%)
sub-threshold	12 (14.3%)	10 (47.6%)
moderate	8 (9.5%)	3 (14.3%)
severe	1 (1.2%)	0 (0%)
Parent pain catastrophizing *	14.7 (9.8)	19.9 (12.0%)
Family functioning		
healthy	68 (81.0%)	16 (80%)
unhealthy	16 (19.0%)	4 (20%)

* P<0.05;

** P<0.001

Table 4.

Multi-variate logistic regression models examining pre-surgery risk factors for acute postsurgical pain at 2-weeks following surgery

	M1: Base model		M2: Clinical factors		M3: Emotional and behavioral factors		M4: FINAL MODEL Parent and family factors	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Age	1.21	(0.95 – 1.55)	1.14	(0.87 – 1.49)	1.12	(0.84 – 1.49)	1.17	(0.86 – 1.58)
Sex	4.75	(1.55 – 14.56) *	4.13	(1.12 – 15.32) *	3.79	(0.99 – 14.56)	3.86	(0.93 – 16.07)
Baseline pain intensity			1.81	(1.29 – 2.54) **	1.98	(1.35 – 2.91) **	1.96	(1.32 – 2.90) **
Pain distribution			0.77	(0.58 – 1.04)	0.71	(0.51 – 0.99) *	0.74	(0.53 – 1.04)
Pain catastrophizing					0.98	(0.92 – 1.04)	0.98	(0.92 – 1.05)
Anxiety symptoms					0.99	(0.96 – 1.03)	0.99	(0.96 – 1.03)
Depressive symptoms					0.95	(0.80 – 1.12)	0.94	(0.80 – 1.12)
Insomnia severity					1.39	(0.47 – 4.12)	1.46	(0.49 – 4.36)
Sleep quality					0.48	(0.21 – 1.09)	0.53	(0.22 – 1.25)
Parental pain catastrophizing							1.02	(0.97 – 1.07)
Family functioning							0.45	(0.10 – 2.01)
AIC	130		115		119		117	
LR			19.3 **		5.8		6.0	

AIC, Akaike Information Criterion; LR, Likelihood Ratio test statistic;

* P<0.05;

** P<0.001

Table 5.

Multi-variate logistic regression models examining pre-surgery risk factors for chronic postsurgical pain at 4-months following surgery

	M1: Base model		M2: Clinical factors		M3: Emotional and behavioral factors		M4: FINAL MODEL Parent and family factors	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Age	1.46	(1.10 – 1.94) *	1.34	(1.00 – 1.80)	1.15	(0.81 – 1.63)	1.18	(0.82 – 1.70)
Sex	2.31	(0.75 – 7.12)	1.22	(0.35 – 4.32)	1.22	(0.28 – 5.27)	1.29	(0.29 – 5.72)
Baseline pain intensity			1.26	(0.92 – 1.72)	1.18	(0.80 – 1.75)	1.31	(0.86 – 1.99)
Pain distribution			1.08	(0.80 – 1.46)	0.95	(0.67 – 1.34)	0.82	(0.54 – 1.24)
Pain catastrophizing					0.97	(0.90 – 1.04)	0.97	(0.90 – 1.05)
Anxiety symptoms					1.00	(0.95 – 1.04)	1.00	(0.96 – 1.04)
Depressive symptoms					1.24	(1.03 – 1.49) *	1.22	(1.01 – 1.47) *
Insomnia severity					0.32	(0.09 – 1.10)	0.31	(0.09 – 1.10)
Sleep quality					0.25	(0.08 – 0.76) *	0.26	(0.08 – 0.83) *
Parental pain catastrophizing							1.01	(0.96 – 1.08)
Family functioning							1.38	(0.32 – 6.03)
AIC	104		103		96		96	
LR			5.1		17.0 **		3.6	

AIC, Akaike Information Criterion; LR, Likelihood Ratio test statistic;

* P<0.05;

** P<0.01