Received: 19 February 2021 | Revised: 28 October 2021 | Accepted: 5 December 2021

DOI: 10.1002/pne2.12067

Paediatric & Neonatal Pain WILEY

ORIGINAL ARTICLE

Presence and predictors of pain after orthopedic surgery and associated orthopedic outcomes in children with cerebral palsy

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Funding information
This study was funded, in part, by Eunice Kennedy Shriver NICHD [Grant No. 73126 & 94581] and the Endowed Fund for Research in Cerebral Palsy Treatment of Gillette Children's Specialty Healthcare

Abstract

While children with cerebral palsy (CP) may undergo 8-22 orthopedic surgeries in their lifetime, little is known about the associated pain. We aimed to assess the pain presence before and one year after lower extremity orthopedic surgery, predictors of pain presence at follow-up, and the association between pain and orthopedic outcomes related to surgery. This retrospective study included 86 children with CP (M age = 10.0 years, SD = 3.2; range = 4.1-17.3 years, Gross Motor Functional Classification System (GMFCS) level I-III) who underwent orthopedic surgery and had completed questionnaires at gait analyses before (M = 2.7 months; range = 0.0-5.7) and after surgery (M = 11.8 months; range = 9.0-14.9). Pain presence, location, and Pediatric Outcomes Data Collection Instrument (PODCI) scores were documented before and after surgery at gait analyses. Pain prevalence was 60% at baseline and 56% at follow-up. Significant predictors of pain presence at follow-up included (1) pain presence at baseline (range of odds ratios [OR] across any/all locations = 3.22 to 15.54), (2) older age (range of OR for any pain, back, knee, and foot pain = 1.24-1.26), (3) female sex (decreased OR for males for ankle pain = 0.12), (4) having hip surgery (decreased OR for foot pain = 0.20), and (5) lower GMFCS level (OR for foot pain = 0.41). Changes in PODCI Sports and Physical Function scores were associated with changes in hip and knee pain ($P < .03$); PODCI scores worsened for patients who had pain at both time points and improved for patients who had pain at baseline but not follow-up. Pain was present for over half of the participants before and after orthopedic surgery. Pain presence at follow-up was predicted by pain presence at baseline. Pain and functional outcomes were correlated at follow-up. Prospective studies examining perioperative pain experience and factors predicting pain outcomes are warranted.

KEYWORDS
cerebral palsy, developmental disability, orthopedic outcomes, orthopedic surgery, pain, pediatric

1 | INTRODUCTION

Cerebral palsy (CP) is the most common cause of physical disability in children, affecting 1.5-2.5 out of every 1000 live births and resulting in impaired postural and motor development and a sequela of musculoskeletal impairments and often co-occurring with impairments in sensation, cognition, and communication.[1,2] Prevalence estimates of orthopedic surgery in children with CP vary based on differences in CP severity sampled and different treatment practices across institutions and countries. In the United States individuals with CP may undergo 8-22 orthopedic surgeries in their lifetime.[3-6] Population estimates in Denmark suggest approximately 41%, 54%, and 62% of the children aged 8-15 years with CP in Gross Motor Function Classification System (GMFCS) levels I, II, and III-V, respectively, undergo orthopedic surgery.[7] Orthopedic surgeries continue to be frequent into adulthood; Horstmann et al reported 94% of adult participants with CP (n = 105) had experienced at least one lower extremity orthopedic surgery over a 5-year span.[8] Orthopedic surgeries aim to improve posture and limb alignment, normalize range of motion, or transfer muscle attachments to make muscles more functional—with intent to have a positive impact on function and pain, with greater emphasis placed on mobility for those in GMFCS level I–III and hip preservation and comfort in GMFCS levels IV–V.

While pain reduction may be a goal of orthopedic surgery in CP,[9] there is a dearth of research specific to pain outcomes from this treatment, possibly due to the challenges of obtaining self-reported pain among the approximate 25%-50% of individuals with cognitive or communication impairments (Novak 2012). Surprisingly, only 5% of 229 orthopedic outcome studies assessed pain prevalence.[10] The quality and level of evidence for these studies was low, predictive factors were not explored, and about half of the available studies were conducted with sample sizes of less than 25 participants. In several cases, preoperative pain was not quantified limiting the opportunity to understand pain outcomes following surgery.[11-13] Of the studies with larger sample sizes (n ≥ 25) and with pain assessments conducted before and after surgery, the majority found pain reduced following surgery or trended in that direction.[14-16] Pelrine et al[17] found that pain did not change significantly and Lauder et al[18] described the development of neuropathic pain for six participants (15%) which resolved after targeted treatment. A clear understanding of the typical trajectory of perioperative pain in CP, its prevalence and severity, associated opioid use, and predictive factors related to chronic pain presence after surgery is lacking.

Given the invasive nature of orthopedic surgeries and the frequency at which they typically occur in CP, it is reasonable to be concerned about the development of chronic postsurgical pain (CPSP) as an especially troubling outcome.[9,17,18] CPSP is defined as pain that develops or increases in intensity after a surgical procedure and persists beyond the healing process (≥3 months[19]). In typically developing children and adolescents, CPSP affects approximately 13-42% of those undergoing predominantly orthopedic procedures[20,21]; up to 69% experience some level of chronic pain after spinal fusions.[22] There is no reason to expect that individuals with CP would be spared incurring CPSP at similar rates, especially considering children with CP are typically exposed to repeated surgeries, including multilevel surgeries (SEMLS) involving multiple procedures performed during a single operation.[3]

It is also problematic when preexisting pain does not resolve as intended following orthopedic surgery. For individuals without disabilities, preoperative pain persists after surgery (persistent pain) approximately 26%-30% of the time in adult samples undergoing a variety of orthopedic and nonorthopedic surgeries.[23,24] In a cross-sectional study exploring general causes of pain in children with CP, Findlay et al[25] detected postsurgical pain in 14% of their convenience sample; however, the sample was not specific to those who had undergone surgery.

Both CPSP and persistent pain can have a deleterious impact on the expected functional outcomes of the surgery. Research in adults without disabilities has demonstrated that CPSP commonly interferes with activities of daily living, sleep, and quality of life[26] and impacts long-term functional outcomes such as mobility and range of motion.[27,28] Not surprisingly, little is known about the prevalence and characteristics of persistent pain after surgery or how pain impacts functional outcomes in children with CP. However, limited case series have demonstrated that pain following SEMLS procedures in patients with CP have negatively impacted their ability to comply with physiotherapy and their ability to bear weight.[18]

Individuals representing the full severity spectrum of CP have historically been excluded from pain research. Recent work has led to the important finding that pain is common, long-lasting, and can be debilitating in individuals with CP. Specifically, chronic pain is estimated to affect 40%-60% of children or adolescents with CP[29-37] compared with 10%-37% of typically developing peers.[34,38-42] Chronic pain has repeatedly been associated with decreased life satisfaction, physical function, self-care, sleep, involvement in social activities, and academics.[33,43-45] Factors predictive of nonsurgical chronic pain in CP include increased gross motor impairment,[46,47] bilateral involvement,[48] older age,[48] and female sex.[49]

As preexisting pain is arguably the strongest predictor of CPSP in populations without physical disability and given the high estimates of chronic pain in CP, it is imperative that preoperative pain be assessed in children with CP as a potential risk factor for development of CPSP.

To address the need for more information regarding pain before and after lower extremity orthopedic surgery in CP, we undertook a preliminary, retrospective approach. We aimed to (1) quantify the prevalence of back and lower extremity pain before and after orthopedic surgery, (2) identify preoperative factors associated with pain presence after orthopedic surgery (ie, presence of pain before surgery, CP severity, age, sex, type of surgery), and (3) examine relationships between pain presence before and after surgery and functional/mobility outcomes following surgery.

TABLE 1 Participant demographics, mean (standard deviation) [min–max], unless specified otherwise

GMFCS level	I		II		III		All
Any baseline pain	Yes	No	Yes	No	Yes	No	All
n	14	7	24	15	14	12	86
Male, n (%)	8 (57%)	2 (29%)	11 (46%)	9 (60%)	10 (71%)	5 (42%)	45 (52%)
Age at baseline (years)	11.0 (2.7) [5.7-15.1]	8.2 (2.3) [5.2-12.6]	10.2 (3.5) [5.9-17.3]	9.2 (3.3) [4.1-14.3]	10.7 (3.2) [5.2-14.9]	9.4 (2.8) [5.2-13.8]	10.0 (3.2) [4.1-17.3]
Baseline to Surgery (months)	2.8 (2.3) [0.0-5.5]	2.1 (1.2) [0.1-4.0]	2.9 (2.1) [0.0-5.7]	3.0 (1.8) [0.1-5.5]	3.0 (2.1) [0.0-5.5]	2.0 (1.7) [0.0-5.0]	2.7 (2.0) [0.0-5.7]
Surgery to Follow-up (months)	12.4 (1.6) [9.7-14.9]	10.8 (0.7) [10.1-12.0]	11.9 (1.8) [9.0-14.7]	11.5 (1.5) [9.2-14.9]	11.5 (1.5) [9.4-14.4]	12.1 (1.5) [9.4-14.7]	11.8 (1.6) [9.0-14.9]
Tone type, n (%)							
Spastic	14 (100%)	7 (100%)	24 (100%)	14 (93%)	13 (93%)	9 (75%)	81 (94%)
Mixed	0 (0%)	0 (0%)	0 (0%)	1 (7%)	1 (7%)	3 (25%)	5 (6%)
CP Topography, n (%)							
Diplegic	10 (71%)	5 (71%)	20 (83%)	9 (60%)	10 (71%)	6 (50%)	60 (70%)
Triplegic	4 (29%)	2 (29%)	4 (17%)	5 (33%)	2 (14%)	5 (42%)	22 (26%)
Quadriplegic	0 (0%)	0 (0%)	0 (0%)	1 (7%)	2 (14%)	1 (8%)	4 (5%)

Note: Baseline to surgery = the time between the baseline gait analysis and orthopedic surgery; Surgery to follow-up = the time between orthopedic surgery and the follow-up gait analysis

Abbreviations: GMFCS = Gross Motor Function Classification System level; CP = cerebral palsy; CP topography = classifies which limbs are affected by CP.

2 | METHODS

This was a retrospective study for which the Institutional Review Board granted waiver of consent. Patient data from Gillette Children's Specialty Healthcare gait laboratory database were queried from January 1st, 2008 to November 30, 2020 to identify children who met the following inclusion criteria: (1) diagnosis of bilateral CP, (2) Gross Motor Functional Classification System (GMFCS[50]) level I-III, (3) spastic or mixed tone, (4) <18 years old, (5) two gait analyses (termed baseline and follow-up) at which a proxy-reported pain questionnaire was completed (standard of care at our institution), (6) not receiving intrathecal baclofen, and (7) lower extremity orthopedic surgery performed between the two gait analyses. If a child had bilateral surgery, only the right side was analyzed to ensure independence of observations. The baseline gait analysis occurred within 6 months prior to surgery; the follow-up gait analysis occurred 9-15 months after surgery.

Pain was assessed using a questionnaire provided to clinical patients at the time of gait analysis starting in 2008 (Figure S1). Retrospective pain findings using this questionnaire have been previously published.[17,51,52] The questionnaire only assessed pain presence by location (ie, back, hip, knee, ankle, foot, or other) and when pain was experienced (beginning/end of day, walking short distances, walking long distances, standing, navigating stairs or uneven terrain, constant/not activity related) at both the baseline and follow-up gait analyses. Pain described as "other" was included if it was described as back or lower extremity pain. We provided summary level pain information (termed "any pain") when patients had pain at one or more of the six locations.

Demographic information included age, sex, and CP severity. CP severity was defined using GMFCS levels (ranging from I-V) where higher GMFCS levels indicate greater motor impairment. Participants included in this study were GMFCS level I (ambulant without assistance), level II (ambulant without assistive devices, limitations in mobility outside the home), and level III (ambulant with assistive devices, wheelchair required outside the home). The location of orthopedic surgery was assigned (*hip*: psoas lengthening, adductor lengthening, femoral derotation osteotomy; *knee*: hamstring lengthening, patellar tendon advancement, rectus femoris transfer, distal femoral extension osteotomy, epiphysiodesis; *ankle/foot*: tibial derotation osteotomy, gastrocnemius or soleus lengthening, ankle/foot soft and bony procedures).

Functional outcomes were collected at both the baseline and follow-up gait analyses using the Pediatric Outcomes Data Collection Instrument (PODCI; parent proxy due to patient age).[53] In particular, we were interested in performance on the Transfers and Basic Mobility and the Sports and Physical Function scales, which inquire about difficulty or ability to perform various mobility-related activities of daily living (eg, short distance walking, getting on or off chairs, toilets, vehicles) or more challenging skills (eg, running, biking, sports, prolonged walking, and prolonged stair climbing), respectively. Higher scores indicate greater mobility and functioning. The minimal clinically important difference for parent report is 4.0

and 4.3 points on the Transfers and Basic Mobility and Sports and Physical Function scales, respectively.[54]

2.1 | Statistical analyses

Multivariate logistic regression was used to detect factors predictive of the odds of pain present at follow-up. Factors included in the full model included five predictors: age (years), sex (male/female; reference: female), GMFCS level (level), location of orthopedic surgery (hip/knee/ankle; reference: no surgery at that location), and baseline pain presence (yes/no; reference: no). A reduced model was then performed in which GMFCS level and location of orthopedic surgery were excluded if they were not statistically significant predictors in the full model ($P < .05$). All analyses were performed in Matlab (R2018b Mathworks, Natick, Massachusetts, USA). Results are described in terms of statistical significance (95% confidence intervals [CI], P-values < .05) and effect sizes for chi-square tests using Cramer's V.[55,56] For one degree of freedom, small, medium, and large effects correspond to $V = 0.1$, 0.3, and 0.5, respectively. A Kruskal-Wallis test was performed with Dunn-Sidak post hoc correction for pairwise comparisons to assess if baseline/follow-up pain subgroup was related to PODCI outcomes. The following four pain subgroups were defined: (1) yes baseline pain, no follow-up pain, (2) no baseline pain, no follow-up pain, (3) no baseline pain, yes follow-up pain, and (4) yes baseline pain, yes follow-up pain.

3 | RESULTS

There were 86 participants who met the inclusion criteria (participant characteristics described in Table 1). Participants had various soft tissue or bony surgeries (Figure S2). The majority of children (87% at baseline, 93% at follow-up) reported participation in physical therapy and/or home exercise programs.

3.1 | Pain prevalence

Pain prevalence at any location was 60% at baseline and 56% at follow-up (Figure 1). Pain at individual locations ranged from 10% (hip) to 34% (foot) at baseline and 12% (ankle) to 33% (foot) at follow-up (Figure 1). The change in prevalence of any pain and location-specific pain was all trivial with the exception of hip pain showing a small-to-moderate increase (10%–19%; Cramer's $V = 0.16$; $P = .13$) and ankle pain showing a small-to-moderate decrease (21% to 12%; Cramer's $V = 0.18$; $P = .10$; Figure 1).

Among those who reported any pain at baseline, 79% reported any pain at follow-up (pain at individual locations at follow-up ranged from 33% [ankle] to 62% [foot]; Figure 1). Among those who reported no pain at baseline, 21% reported any pain at follow-up (pain at individual locations at follow-up ranged from 6% [ankle] to 24% [knee]; Figure 1). Pain at individual locations was experienced most often during prolonged walking for each pain except back pain, which was most often experienced at the beginning or end of the day (Table S1).

3.2 | Predictors of pain presence at follow-up

In the full models with all five predictors, the location of orthopedic surgery and GMFCS level were not statistically significant predictors for all but foot pain, so the reduced model (which excluded these two predictors) was used (Table 2). The presence of baseline pain was the strongest predictor of follow-up pain for all pain (any, back, hip, knee, ankle, foot; odds ratio range: 3.22-15.54). Older age was a significant predictor of follow-up pain for any, back, knee, and foot pain, increasing the odds of pain 24%-26%. Age was not a significant predictor of hip or ankle pain. Female sex was associated with increased odds of reporting follow-up ankle pain (odds ratio for male sex = 0.12) but was not significantly associated with the presence of other follow-up pain. Having hip surgery and being in higher GMFCS levels were associated with decreased odds of follow-up foot pain (odds ratios = 0.20 and 0.41, respectively; Table 2).

3.3 | Relationship between pain and functional outcomes

Change in PODCI Transfers and Basic Mobility scores were not significantly related to change in pain presence from baseline to follow-up (all $\chi^2 < 4.9$, $P > .18$). However, change in PODCI Sports and Physical Function scores were significantly related to change in hip and knee pain presence ($\chi^2 = 8.8$ and 10.1, respectively; $P = .03$ and 0.02, respectively). For both hip and knee pain, pairwise comparisons revealed that the difference in mean ranks differed only between the group that had pain at both time points (mean PODCI Sports and Physical Function score decreased (ie, worsened) 16 points [hip] or 9 points [knee]) compared with the group that had pain at baseline and then no pain at follow-up (mean PODCI SPF score increased (ie, improved) 3 points [hip] or 6 points [knee]; Figure 2).

4 | DISCUSSION

The prevalence of pain before and after orthopedic surgery has rarely been reported for children with CP. In our sample, back or lower extremity pain prevalence remained unchanged from before to approximately 1 year after orthopedic surgery. Pain was reported in over half of the children. This is similar to the approximate 40%-60% reported by several other cross-sectional studies reporting pain prevalence in CP.[29,31-33,36,37,57,58] The rank order of common pain locations in this ambulatory sample (GMFCS I–III) aligns with previous reports, with foot and knee pain being most common.[35,49,59] It is concerning that the majority of children (79%) who had any pain at baseline also reported pain at follow-up. Approximately, half (48%–62%)

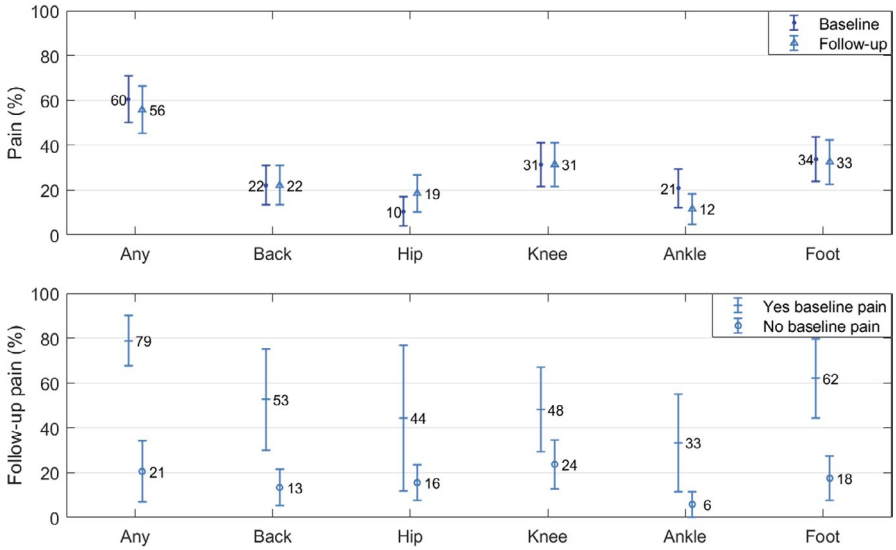

FIGURE 1 Pain prevalence with 95% confidence intervals for baseline and follow-up (top). Follow-up pain prevalence stratified on whether participants did or did not have baseline pain (bottom). The numbers in the figures are the point estimates for pain prevalence

of all children who had baseline back, knee, and foot pain reported that pain at follow-up, suggesting the importance of attending to these types of pain. For approximately one in five children who did not have any pain at baseline, new pain had emerged by the time of follow-up. In typically developing cohorts, CPSP has been estimated to occur in 22%-23% of those undergoing predominantly orthopedic procedures[20,21] and up to 69% experience mild-to-severe chronic pain after spinal fusions.[22] The prevalence of new pain at follow-up in the current sample is on par with CPSP estimates in orthopedic samples without physical disability, though because of the available data in this retrospective study, we cannot be sure if this new pain at follow-up is CPSP or acute pain.

In this preliminary retrospective study, we found that the strongest predictor of pain presence at follow-up was the existence of pain at baseline. This is consistent with other studies assessing surgical outcomes in both children and adult populations with or without CP.[17,60-63] The odds of each pain presence at follow-up either trended toward an increase (hip, ankle; both of which had the smallest sample sizes) or significantly increased (any, back, knee, foot) as age increased. This is consistent with previous findings that pain prevalence increases with age among those with CP.[48] Female sex was associated with the odds of ankle pain [95% CI odds ratio: 0.02-0.80]. While sex appeared to trend toward an association with other pain locations, none reached statistical significance. Some studies have documented that females reported pain more frequently[49] while others have not.[64]

CP severity and hip surgery were associated with foot pain outcomes. Those with lower GMFCS levels (ie, less severe CP, greater mobility/function) had an increased odds of foot pain at follow-up. As others have found, this is likely due to greater weightbearing and mobility activities by those in lower GMFCS levels who have greater motor abilities.[65] Accordingly, 72% of participants in the current sample reported that their foot pain occurred during prolonged walking. These activities might be something participants in higher GMFCS levels may not be able to do or they may be protected from because of using upper extremity assistive devices to offload lower extremity stresses. Also, in alignment with previous studies, greater GMFCS level appeared to be associated with increases in other types of pain (eg, hip pain[65]), but those analyses were likely underpowered given smaller sample sizes. Having hip surgery was associated with decreased foot pain at follow-up. We do not have a plausible explanation for why having hip surgery was associated with decreased ipsilateral foot pain at follow-up; it may be a spurious finding.

We assessed proxy-reported functional outcomes in relation to preoperative pain presence. The subgroup that had hip or knee pain resolution at follow-up had substantially better PODCI Sports and Physical Function scores compared with children who experienced pain both before and after surgery. Notably, each of the four children who had hip pain at both time points reported decreased follow-up PODCI Sports and Physical Function scores. However, for the PODCI Transfers and Basic Mobility scale, there was no association of perioperative pain presence and change in scores. This finding suggests that successful management of hip and knee pain may have a significant impact on a patient's ability to improve on more challenging functional skills. Our finding that hip and knee pain most often occurred during prolonged walking corroborate this possible association.

This study has several notable limitations. First, pain queries were limited to the presence and location of pain. As such, we do not know the chronicity of the pain and cannot say that those who reported pain at baseline and follow-up had chronic pain. Similarly, the parameters of the pain (eg, intensity, frequency, duration, interference with function) are unknown. Second, the reliability and validity of the pain screening has not been fully established, although we have successfully used this assessment previously to quantify pain prevalence for research.[17,51,52] Despite these limitations, the overall and location-specific pain prevalence estimates align with other studies. Third, the retrospective design may be prone to sampling biases. First, not all ambulatory patients who undergo orthopedic surgery complete a preoperative clinical gait analysis, and most, but not all, patients return postoperatively for a gait analysis.

TABLE 2 Multivariate logistic regression models (full and reduced) for pain at follow-up pain, with 95% confidence intervals and p-values for the odds ratio

	Any	Back	Hip	Knee	Ankle	Foot
	OR [95% CI]	OR [95% CI]	OR [95% CI]	OR [95% CI]	OR [95% CI]	OR [95% CI]
Full Model						
Intercept	0.10 [0-3.06] *P* = .19	0.29 [0.01-9.61] *P* = .49	0.03 [0-1.15] *P* = .06	0.03 [0-0.76] *P* = .03	0.02 [0-1.69] *P* = .09	0.66 [0.02-26.58] *P* = .83
Yes Baseline Pain	12.19 [3.76-39.17] *P* < .01	5.11 [1.26-20.82] *P* = .02	5.79 [1.04-32.19] *P* = .04	2.92 [0.97-8.81] *P* = .06	14.20 [2.27-88.88] *P* < .01	15.09 [3.64-62.47] *P* < .01
Age	1.18 [0.92-1.18] *P* = .20	1.09 [0.84-1.09] *P* = .51	1.26 [0.99-1.60] *P* = .06	1.18 [0.96-1.46] *P* = .11	1.25 [0.91-1.72] *P* = .18	1.26 [0.96-1.66] *P* = .09
Male	1.63 [0.54-4.94] *P* = .39	0.55 [0.16-1.92] *P* = .35	0.48 [0.13-1.76] *P* = .27	0.73 [0.25-2.13] *P* = .56	0.12 [0.02-0.86] *P* = .04	0.72 [0.21-2.46] *P* = .60
Hip Surgery	0.73 [0.22-2.47] *P* = .61	0.75 [0.20-2.77] *P* = .67	2.47 [0.61-9.92] *P* = .20	1.06 [0.36-3.09] *P* = .91	1.01 [0.20-5.10] *P* = .99	0.14 [0.03-0.57] *P* = .01
Knee Surgery	1.80 [0.32-10.10] *P* = .51	4.67 [0.88-24.88] *P* = .07	0.33 [0.05-2.00] *P* = .23	2.25 [0.58-8.79] *P* = .24	1.86 [0.21-16.04] *P* = .57	0.68 [0.12-3.91] *P* = .67
Foot/Ankle Surgery	1.48 [0.42-5.22] *P* = .54	1.16 [0.30-4.53] *P* = .83	1.58 [0.40-6.30] *P* = .52	1.53 [0.49-4.85] *P* = .47	1.95 [0.27-13.88] *P* = .50	0.34 [0.08-1.40] *P* = .14
GMFCS level	0.61 [0.27-1.41] *P* = .25	0.42 [0.17-1.04] *P* = .06	0.61 [0.26-1.47] *P* = .27	1.00 [0.48-2.07] *P* = 1.00	0.48 [0.15-1.52] *P* = .21	0.40 [0.16-0.97] *P* = .04
Reduced Model						
Intercept	0.03 [0-0.22] *P* < .01	0.02 [0-0.22] *P* < .01	0.10 [0.01-0.76] *P* = .03	0.03 [0-0.21] *P* < .01	0.01 [0-0.25] *P* < .01	0.28 [0.01-6.28] *P* = .43
Yes Baseline Pain	13.06 [4.29-39.76] *P* < .01	4.80 [1.42-16.25] *P* = .01	5.14 [1.09-24.17] *P* = .04	3.22 [1.09-9.47] *P* = .03	15.54 [2.66-90.86] *P* < .01	11.37 [3.11-41.56] *P* < .01
Age	1.24 [1.03-1.50] *P* = .03	1.24 [1.01-1.51] *P* = .04	1.10 [0.91-1.32] *P* = .33	1.26 [1.07-1.49] *P* = .01	1.25 [0.96-1.65] *P* = .10	1.26 [1.01-1.57] *P* = .04
Male	1.59 [0.54-4.71] *P* = .40	0.66 [0.21-2.10] *P* = .48	0.46 [0.14-1.54] *P* = .21	0.78 [0.27-2.23] *P* = .64	0.12 [0.02-0.81] *P* = .03	0.65 [0.20-2.16] *P* = .49
Hip Surgery						0.20 [0.06-0.69] *P* =.01
GMFCS level						0.41 [0.18-0.95] *P* =.04

Abbreviations: GMFCS level, Gross Motor Functional Classification System level; OR, odds ratio; CI, confidence interval.

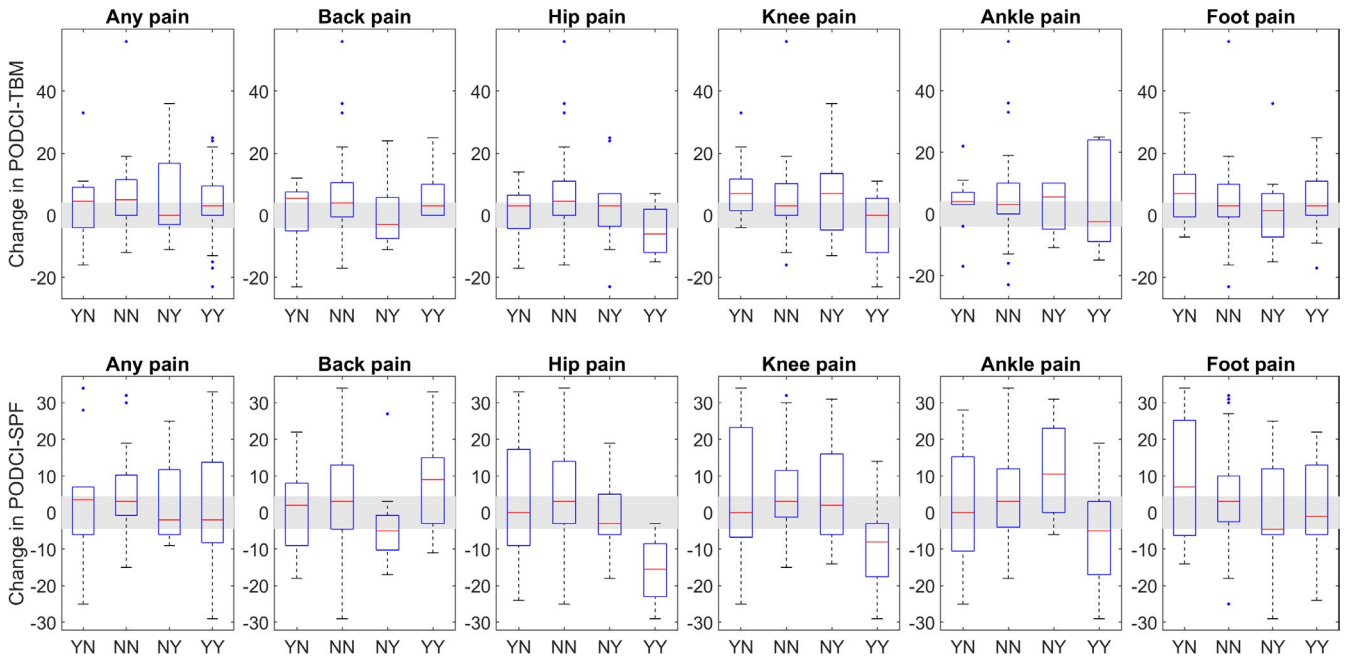

FIGURE 2 Change in Pediatric Outcomes Data Collection Instrument (PODCI) Transfers and Basic Mobility (TBM) and Sports and Physical Function (SPF) scales for the four baseline follow-up pain subgroups (YN, yes baseline pain, no follow-up pain; NN, no baseline pain, no follow-up pain; NY, no baseline pain, yes follow-up pain; and YY, yes baseline pain, yes follow-up pain). The horizontal gray rectangles represent the minimal clinically important difference for the respective scales

This is partially explained by provider referral practice, but some patients who do are being seen because of some concern of the family, limiting generalizability to the broader ambulatory CP population. Relatedly, results may not generalize outside our institution based on our general treatment philosophy and inclusion criteria, especially individuals with hemiplegia, in GMFCS levels IV–V, or on neuropathic pain and/or tone medications (eg, intrathecal baclofen). Future studies are needed to explore pre- and postoperative pain in these subpopulations. Fourth, the average baseline pain assessment occurred 2.7 months prior to surgery at the baseline gait analysis, so we cannot be sure if that pain still existed at the time of surgery. Fifth, sample sizes for those with location-specific pain ranged from 9 to 29 children. Therefore, this study was underpowered to analyze location-specific outcomes. Sixth, we cannot attribute change in pain or functional outcomes to orthopedic surgery because we lack a control group. Seventh, pain was assessed via proxy-report, which is not without issue, as parents/caregivers may over or underestimate pain prevalence.[66] However, proxy-report is the established method for pain research in young children and in samples where cognitive impairment may impede the ability to self-report. Finally, we cannot isolate the effects of one group of surgeries (eg, knee surgeries) on a given joint pain (eg, knee pain) because concomitant surgeries were often performed. This, however, represents standard of care.

Further research is needed to explore the trajectory of perioperative pain to include thorough assessments of intensity, duration, interference, and quality of the pain. Such studies should include opioid use and factors that are associated with extended opioid use. It will be important to assess different classifications of perioperative pain, specifically preexisting chronic pain, incident pain (acute surgical pain), persistent chronic pain (present before surgery), and CPSP. Further work is needed to prospectively test the predictive factors identified in the current study, as well as additional factors, to confirm validity in predicting pain outcomes. It will be important to directly test the hypothesis that intervening on identified modifiable predictive factors will lead to improved pain outcomes. The ability to presurgically identify those with CP at greater risk for postoperative pain would provide the rationale to deploy the currently available clinical perioperative pain management strategies, preoperative mental health assessments/treatment, and facilitate informed decision-making around treatment options.

5 | CONCLUSIONS

This study documented that back or lower extremity pain was present in over half of ambulatory children with CP both before and after lower extremity orthopedic surgery. Having baseline pain increased the odds of having pain at follow-up by approximately 2-15 times, depending on the location of the pain. Clinicians should be aware of this risk factor in their patients, be diligent in longitudinally tracking those patients' pain, and consider involving a multidisciplinary pain management team preoperatively. Future prospective study is warranted to thoroughly assess pain experience, typical pain trajectories, and variables predictive of pain outcomes.

ACKNOWLEDGMENTS

The authors would like to thank Cole Hagen for his help with data extraction. This study was funded, in part, by Eunice Kennedy

Shriver NICHD [Grant No. 73126 & 94581] and the Long-Term Outcomes Research Fund of Gillette Children's Specialty Healthcare. Data are available upon reasonable request from the corresponding author.

CONFLICT OF INTEREST

None of the authors has a conflict of interest to declare.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

How to cite this article: Boyer ER, Novaczyk ZB, Novacheck TF, Symons FJ, Burkitt CC. Presence and predictors of pain after orthopedic surgery and associated orthopedic outcomes in children with cerebral palsy. *Paediatr Neonatal Pain*. 2022;4:43–51. doi:10.1002/pne2.12067