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Child and Parent Risk and Resilience Factors as Predictors of Long-term Recovery in Youth Undergoing Spinal Fusion Surgery

Jenny Thorsell Cederberg, PhD,† Sara Laureen Bartels, PhD,**
Måns Thulin, PhD,‡ Melanie Beeckman, PhD,§
Rikard K. Wicksell, PhD, and Liesbet Goubert, PhD‖*

Objectives: Undertreated pediatric postsurgical pain negatively affects health-related quality of life (HRQOL) and functioning and may lead to chronic postsurgical pain (CPSP). Predictors of recovery have been identified but more research is needed, particularly regarding resilience, social factors, and long-term effects. The aim of the present study was to investigate child and parent risk and resilience factors as predictors of long-term postsurgical recovery for adolescents.

Methods: Participants were patients with Adolescent Idiopathic Scoliosis (AIS), 12 to 18 years old, undergoing spinal fusion, and their parents. Recruitment occurred at the orthopedic units at 4 hospitals in Belgium. Data were collected before surgery (T0), at 3 (T1) and 6 weeks (T2), 6 months (T3), and 1 year (T4) post surgery. Multiple regression models were used to evaluate the predictive effect of pain intensity, pain catastrophizing, psychological flexibility, and pain acceptance on long-term functioning, HRQOL, and pain.

Results: The sample comprised 100 adolescents and 61 parents. Pain at T0, T1, and T3 and adolescent pain catastrophizing (T0) predicted health-related quality of life, functioning, and pain at T4 (while pain at T2 predicted HRQOL and pain). Parent pain catastrophizing predicted pain at T4. Adolescent and parental psychological flexibility predicted HRQOL, and parent psychological flexibility also predicted pain at T4. Adolescent acceptance at T1 predicted pain, and acceptance at T2 predicted HRQOL, at T4.

Discussion: The study identified pain and adolescent pain catastrophizing as risk factors, and adolescent and parental psychological flexibility and adolescent pain acceptance as resilience factors, for long-term recovery in youths undergoing spinal fusion. Postsurgical pain management targeting these factors may therefore promote recovery for these adolescents.

Key Words: long-term postsurgical recovery, adolescents, psychological flexibility, pain acceptance, health-related quality of life

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Adequate postoperative pain treatment ameliorates pain, improves recovery, and decreases the costs for health care systems,[1,2] yet a substantial proportion of pediatric patients receive inadequate postoperative pain management.[3] Undertreated postoperative pain may, aside from unnecessary pain, result in delayed remobilization, increased opioid use, and reduced health-related quality of life (HRQOL) including anxiety, eating difficulties, sleep disturbances, and poorer social and school functioning.[4–8] Moreover, ineffectively reduced postoperative pain may also increase the risk of developing chronic pain.[9]

Chronic postsurgical pain (CPSP) is defined as pain that persists longer than the usual period of healing, typically more than 3 months after surgery.[10,11] Approximately 20% of children and adolescents undergoing major surgery develop CPSP. The condition is associated with higher functional disability and poorer health.[12,13] Spinal fusion surgery is one of the most invasive pediatric procedures, used for correction of adolescent idiopathic scoliosis (AIS), which may lead to persistent pain, longstanding problems in functioning, and reduced HRQOL.[5,14,15]

Psychological mechanisms are increasingly recognized in understanding and treating acute pain in general and anxiety, pain coping, and parental pain catastrophizing have been identified as predictors of pediatric postoperative pain, including CPSP, in systematic reviews.[12,16] A conceptual model of biopsychosocial mechanisms for the transition from acute to chronic pain in youth undergoing surgery has been proposed by Rabbitts et al.[17] This model highlights the need to consider premorbid, sensory, biological, and psychosocial factors. The psychosocial domain includes emotional, cognitive, behavioral, as well as parental factors. With regard to parental factors, both parents' emotional and behavioral reactions have been shown to affect child pain and functioning in the context of pediatric chronic pain.[18] In the context of pediatric CPSP, however, the literature is scarce and studies examining the impact of parents on their child's recovery after surgery are needed.

Traditionally, research has focused on risk factors for poorer postsurgical recovery but resilience factors are increasingly emphasized as additional possible predictors

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From the *Department of Clinical Neuroscience, Karolinska Institutet, Stockholm; Departments of †Psychology; ‡Mathematics, Uppsala University, Uppsala, Sweden; Departments of §Movement and Sports Sciences; and ‖Experimental-Clinical and Health Psychology, Ghent University, Ghent, Belgium.

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Reprints: Jenny Thorsell Cederberg, PhD, Department of Clinical Neuroscience, Karolinska Institutet, Administration, Tomtebodavägen 18A, 5th floor, Stockholm 171 77, Sweden (e-mail: jenny.thorsell.cederberg@ki.se).

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of pediatric CPSP.[17] Resilience is defined as effective functioning despite exposure to stressful circumstances and/or internal distress and is considered an important aspect of adaptive functioning in the presence of pain.[19,20] Psychological flexibility is one such potential resilience factor, that is, a factor that may predict resilient functioning in the face of pain. Psychological flexibility (and its theoretically related constructs *acceptance* and *experiential avoidance*) has been thoroughly studied in pain research, displaying predictive effects in the development and maintenance of persistent pain.[21,22] Due to the theoretical and conceptual overlap, the terms psychological flexibility and acceptance are used interchangeably in the literature. In this study, we use the term psychological flexibility in a broader sense (referring to how we relate to discomfort in general) and the term acceptance in relation to pain. Both child and parental psychological flexibility and pain acceptance have been found to predict better psychosocial functioning, less negative affect, and lower levels of disability in children with chronic pain.[23–25] With regard to CPSP, psychological flexibility and pain acceptance were recently identified as resilience factors in a study by Beeckman et al[26] evaluating risk and resilience factors of recovery at 6 months for adolescents undergoing spinal fusion surgery. Further evaluation of the impact of psychological flexibility in the context of pediatric CPSP is therefore of great interest.

With regard to follow-up, the need for long-term evaluation of predictors of pediatric CPSP has been stressed.[17] The majority of previous studies in the field have applied a fairly short time span for evaluation focusing on the acute (up to 4 wks) or subacute (between 4 and 12 wks) postoperative phase.[27] In addition, preliminary evidence suggests that the predictors of the development of pediatric CPSP in the first 6 months after surgery may actually be different from the predictors maintaining it beyond 6 up to 12 months.[9] This finding warrants further investigation of long-term effects beyond 6 months' follow-up and also indicates the importance of long-term evaluation of predictors of pediatric postsurgical recovery.

Moreover, functional outcomes, such as HRQOL and functioning, are highly relevant to evaluate as the main outcome variables of postoperative recovery since they may or may not be associated with the level of pain intensity.[28]

Taken together, 3 gaps in the literature require further attention to better understand the process of postsurgical recovery in youth. First, the parental dimension remains understudied as a critical social factor influencing adolescent recovery. Second, it is important to evaluate both risk and resilience factors as predictors of recovery. Psychological flexibility is an empirically supported and plausible resilience factor to investigate further. Third and finally, long-term follow-up, that is, beyond 6 months up to 1 year post surgery, is essential to understand the process of (sustained or delayed) recovery better and the predictors thereof, particularly with regard to CPSP.

Based on these 3 considerations, the aim of the present study was to evaluate risk and resilience factors as predictors of long-term recovery in youth undergoing spinal fusion surgery and their parents. The study focused on presurgical adolescent and parent pain catastrophizing and psychological flexibility, postsurgical adolescent and parent pain acceptance, and pain intensity as predictors of HRQOL, functioning, and pain intensity at 1 year after surgery.

The primary research questions of the study were: (1) does presurgical psychological flexibility, in adolescents and parents respectively, predict long-term postsurgical recovery at 1 year?; and (2) does postsurgical pain acceptance, in adolescents and parents respectively, predict long-term recovery at 1-year post surgery? Presurgical psychological flexibility and postsurgical pain acceptance, in both adolescents and parents, were hypothesized to predict lower pain intensity, higher level of functioning, and greater HRQOL at 1-year post surgery. Secondary research questions were: (3) do presurgical pain and/or pain catastrophizing, in adolescents and parents respectively, predict long-term postsurgical recovery at 1 year?; and (4) does postsurgical pain predict long-term recovery at 1 year post surgery? Presurgical and postsurgical pain in adolescents, as well as presurgical pain catastrophizing in adolescents and parents, were hypothesized to predict higher pain intensity, lower level of functioning, and lower HRQOL at 1-year post surgery.

MATERIALS AND METHODS

The present study is part of the larger project Postoperative Recovery after Spinal Fusion Surgery (PR-SF), from which Beeckman et al[26] previously reported 6 months' follow-up adolescent questionnaire data. The present study reports on adolescent and parent 12 months' follow-up questionnaire data. The project has been implemented according to the guidelines for Good Clinical Practice (ICH/GCP) and the Helsinki Declaration and the protocol for the project can be found at http://biblio.ugent.be/publication/8578153. The data sets generated and analyzed during the current study are not publicly available but are available from the corresponding author on reasonable request.

Participants

Participants were recruited from the orthopedic units at 4 hospitals (3 university hospitals and 1 general) in Flanders, Belgium (UZ Ghent, UZ Antwerp, UZ Leuven, and Saint-Jan Hospital in Bruges). Recruitment took place over 2 years between 2016 and 2018. Participants with adolescent idiopathic scoliosis (AIS) aged 12 to 18 years who were scheduled for spinal fusion surgery, and their parents, were offered participation in the study. Exclusion criteria included insufficient language skills in Dutch, prior spinal fusion surgery, and severe comorbidity due to neurological, developmental, or other health conditions. Informed consent was obtained from both adolescents and parents. Adolescents and parents were recruited in dyads. One hundred forty-four adolescents and parents respectively were eligible for inclusion, of whom 5 were unable to reach and 139 were invited to participate in the study. Of these, 33 declined and 106 accepted, of whom 6 dropped out before the start of the study. The main reason for declining was expected workload, either time-wise or mentally. The study was approved by the Medical Ethical Committee of Ghent University, with extended approval from all local ethical committees to collect data at their respective units.

Procedure

All participants underwent the standard presurgical, perisurgical, and postsurgical procedures at their respective hospitals. Data were collected through self-report questionnaires at 5 different time points: before surgery (T0) and at 3 weeks (T1), 6 weeks (T2), 6 months (T3), and 12 months (T4) after surgery. Depending on the time point, the

questionnaires took ~25 to 45 minutes to complete. Participants were reminded via telephone of an upcoming time point 1 week before. The questionnaires were administered online via a secure survey platform (Limesurvey, 2.00), with a link to the survey and personal log-in details sent out via e-mail. Participants were asked to complete the questionnaires within 1 week, after which weekly reminders were sent out via e-mail up to 3 weeks after the initial link was sent out. Eventual data collected after these 3 weeks were considered invalid and excluded from further analyses. Biomedical data were collected from the participant's medical records. Participants were offered a movie ticket on completion of all assessments.

Measures

With regard to the adolescent data, the present study reports on sociodemographic information, biomedical data, pain intensity, pain catastrophizing, psychological flexibility, pain acceptance, HRQOL, and functioning. With regard to parent data, the study reports on sociodemographic information, parental pain catastrophizing, parental psychological flexibility, and parental pain acceptance. An overview of the variables measured at different time points is presented in Figure 1. The associated measures are described below. Pain intensity, pain catastrophizing, psychological flexibility, and pain acceptance were used as predictor variables, with particular focus in this study on the latter two. As such, pain and pain catastrophizing were operationalized as risk factors whereas psychological flexibility and pain acceptance were operationalized as resilience factors. Recovery was operationalized in terms of improvements in HRQOL and functioning. In addition, pain was also analyzed as a secondary outcome variable. Note that parental factors were only analyzed as predictors of recovery in adolescents (and no parental outcomes were hence measured).

Sociodemographic and Biomedical Data

Sociodemographic data were collected through a self-report questionnaire. The data included age, sex, and level of education for both adolescents and parents. In addition, information regarding nationality and hospital center for adolescents and relation to the child (ie, mother/father/other), marital status, and occupation for parents was gathered. The biomedical data collected from the adolescent's medical record were filled in by the medical staff at each respective unit. These data consisted of preoperative, perioperative, and postoperative data. The preoperative data included length, weight, body mass index (BMI), curve type, Cobb angle, skeletal maturation, treatment history, and other medical or nonmedical symptoms. The perioperative data included complications during and duration of hospital stay, pain treatment, pain measurements, and treatment history. The postoperative data included complications, pain treatment, and information about other treatments at home.

Pain Variables

The Graded Chronic Pain Scale Child Report (GCPS-C)[29,30] was used to assess the adolescents' pain. The GCPS consists of 8 items measuring pain intensity, disability, and type of pain. Current pain intensity and worst and average pain during the past 3 weeks were rated on an 11-point numerical rating scale (NRS) ranging from 0 (=no pain) to 10 (=worst possible pain). NRS scales have been found responsive and valid for use in children above 8 years of age.[31,32] The GCPS has been frequently used in clinical research settings, and its psychometric properties have been supported in pediatric samples.[30] Scores of 0 are considered *no pain*, 1 to 3 *mild pain*, 4 to 6 *moderate pain*, and 7 to 10 *severe pain*.[33] Pain was measured at all 5 time points (T0-T4).

Pain Catastrophizing

The Pain Catastrophizing Scale (PCS) is designed to measure catastrophizing thoughts in relation to pain.[34] The PCS for children (PCS-C)[35] was used to assess pain catastrophizing in adolescents and the PCS for parents (PCS-P)[36] for parental catastrophizing. Both the child and the parent scale consist of 13 items measuring catastrophizing thoughts in relation to the child's pain (such as "When I have pain, I get scared that the pain will get worse" for the child scale and "When my child is in pain, I keep thinking about how badly I want the pain to stop" for the parent scale), with which the respondent rate their agreement on a 5-point Likert scale. The score range is 0 to 52. Higher scores indicate higher levels of pain catastrophizing. The internal consistency of the PCS-C has previously been shown to be good ($\alpha = 0.87$) and it correlates with measures of depressed mood and anxiety.[35] Cronbach α for the study sample was excellent ($\alpha = 0.93$). Internal consistency for the PCS-P has previously been shown to be excellent ($\alpha = 0.93$); it correlates with measures of parental distress and child functioning[36] and Cronbach α for the sample was good ($\alpha = 0.89$). Pain catastrophizing was measured presurgically, at T0.

Psychological Flexibility

The Avoidance and Fusion Questionnaire for Youth (AFQ-Y) measures psychological inflexibility in adolescents[37–39] and was used to assess the adolescents' presurgical level of psychological flexibility. It consists of 17 items targeting experiential avoidance and cognitive fusion, such as "I am afraid of my feelings," with which the respondents rate their level of agreement on a 5-point Likert scale. The score range is 0 to 68. Items are reversed which means that higher scores indicate higher levels of psychological flexibility. The internal consistency

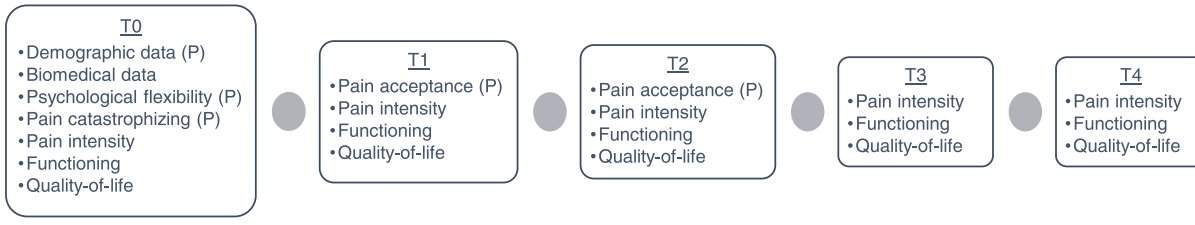

FIGURE 1. Variables measured at different time points. All variables are measured in adolescents. Variables with (P) are also measured in parents.

of the AFQ-Y has been shown to be good ($\alpha = 0.83$) and it correlates with measures of anxiety, physical symptoms, social functioning, and HRQOL.[38] Sample-specific Cronbach α was good ($\alpha = 0.89$). The Avoidance and Action Questionnaire (AAQ-II) is designed to measure a general level of experiential avoidance,[40,41] and was used to assess the level of psychological flexibility in the parents before surgery.[42] Respondents rate their level of agreement with statements such as "I worry about not being able to control my worries and feelings," on a 7-point Likert scale. The score range is 7 to 49. Higher scores indicate higher levels of psychological inflexibility, hence lower psychological flexibility. Internal consistency as well as test-retest reliability have been shown to be acceptable to good ($\alpha = 0.78$ to 0.88 and 0.81, respectively) and it correlates with a range of measures of mental health.[41] Cronbach α for the sample was excellent ($\alpha = 0.94$). Psychological flexibility was measured presurgically, at T0.

Pain Acceptance

The Chronic Pain Acceptance Questionnaire for Adolescents (CPAQ-A)[43] was used to measure pain acceptance in adolescents after surgery. The adolescent version is an adaptation of the well-established original CPAQ.[44] The scale comprises 2 subscales measuring engagement in daily activities in the presence of pain and willingness to experience pain. It consists of 20 items with which respondents rate their agreement on a 7-point Likert scale ranging from 0 (=never true) to 6 (=always true). The score range is 0 to 120. Higher scores indicate higher levels of pain acceptance. The psychometric properties of the adolescent scale have been supported in pediatric chronic pain samples.[43] For the current study, a Dutch translation, following a back-translation procedure, was used, and the internal consistency of the study sample was good ($\alpha = 0.83$). The Parent Psychological Flexibility Questionnaire (PPFQ)[45] was used to assess parental pain acceptance after surgery. The PPFQ measures psychological flexibility in parents in relation to their child's pain. It consists of 31 items pertaining to 3 subscales measuring *acceptance*, *cognitive defusion*, and *committed action*. Parents rate their agreement with statements such as "I suffer terribly from my adolescent's pain and need to make the suffering stop," on a 7-point Likert scale ranging from 0 (=never true) to 6 (=always true). The score range is 0 to 186. Higher scores indicate higher levels of psychological flexibility. The PPFQ has shown satisfactory psychometric properties.[45] For the current study, a Dutch translation, following a back-translation procedure, was used, and the internal consistency of the study sample was good ($\alpha = 0.87$). Pain acceptance was measured postsurgically, at T1-T2.

Health-related Quality of Life and Functioning

The Pediatric Quality of Life Inventory (PedsQL 4.0)[46] was used to assess HRQOL and functioning in adolescents. The child report was used for adolescents at the age of 12 and the adolescent report for 13- to 18-year-olds. The PedsQL measures HRQOL within the domains of physical, emotional, social, psychological, and school functioning (constituting 5 subscales). The scale consists of 23 items measuring health-related problems rated on a 5-point Likert scale ranging from 0 (=never) to 4 (=almost always). Items are reversed and higher scores indicate a better HRQOL. The PedsQL is well-established and has shown good reliability and validity in both healthy and clinical samples.[46–48] Internal consistency of the study sample was excellent ($\alpha = 0.92$). The Functional Disability Inventory (FDI)[49] was used to assess the adolescents' physical functioning and disability. The FDI consists of 15 items covering activity limitations during the past 2 weeks. The score range is 0 to 60. Higher scores indicate higher levels of disability, and hence lower levels of functioning. It has been found to have good reliability and validity.[50] The internal consistency of the study sample was excellent ($\alpha = 0.92$). HRQOL and functioning were measured at all 5 time points (T0-T4).

Statistical Analyses

Descriptive statistical analyses were performed using IBM SPSS Statistics version 25 and 28.[51,52] Multiple regression models were fitted using R 4.1.2[53] with the boot.pval package.[54]

Analytic Strategy

Descriptive statistics were carried out to assess the characteristics of the study sample and descriptive information of the study variables. For the main analyses, the study used multiple linear regression models to evaluate the predictive effect of the predictor variables (ie, psychological flexibility, pain acceptance, pain intensity, and pain catastrophizing) on the outcome variables (ie, health-related quality of life, functioning, and pain intensity) and cross-validation[55] to evaluate the predictive accuracy of the models. Since the focus of the evaluation was on recovery in adolescents, adolescent and parent predictors are included in the same model. First, pain at T0-T3 and pain catastrophizing at T0 were analyzed to investigate their predictive effect on HRQOL, functioning, and pain intensity at T4. Then, in the main models, psychological flexibility at T0 and pain acceptance at T1-T2 were adjusted for pain intensity and child pain catastrophizing when investigating their predictive effect on the outcome variables (ie, HRQOL, functioning, and pain intensity, at T4). Psychological flexibility, which was measured at T0, was adjusted for pain at T0. Pain acceptance, which was measured after surgery, was adjusted for pain at T1. Regarding other potential covariates, the study has considered the empirical data available[12] (showing no association between the variables age, sex, income, scoliosis severity, BMI, time since diagnosis, and CPSP) and also conducted bivariate correlations with the sociodemographic, biomedical, and clinical factors, and the outcome variables. Due to the data not being normally distributed, Spearman's rho was used. The correlations included age, sex, nationality, parent education, Cobb angle, BMI, height, weight, duration of hospital stay, and pain history. Sex and pain history were significantly correlated with the outcome variables, whereas the correlations for the other variables were nonsignificant. A simulation-based post hoc power analysis for the regression models showed 85% power, with the number of explanatory variables in the main models, which was considered sufficiently high. Adding 1 additional covariate into the models reduced the power to 61%, and adding 2 covariates further reduced the power to 42%, which was considered too low in both cases. Therefore, due to power restrictions, supplemental multiple linear regression models were run including sex and pain history as covariates instead, thus, excluding pain catastrophizing and pain intensity. In these models, sex did not predict any of the outcome variables. As expected, pain history did predict the outcomes but not beyond the predictive effects of pain intensity, which was already included as a covariate in the main models. The results of the predictive effects of psychological flexibility and pain

acceptance on the outcome variables were not significantly changed in these supplemental analyses controlling for sex (and pain history instead of pain intensity). Thus, the number of significant and nonsignificant results were unchanged. The data on some of the continuous variables did not show normality. All *P* values for the linear models were, however, computed using the bootstrap, which allows for data that do not follow a normal distribution.[55] In each model, observations with complete data for the variables included in that model were used. Missing data were handled using pairwise deletion.

RESULTS

Sample Characteristics

One hundred adolescents and 61 parents represent the sample of the study. The sociodemographic and biomedical characteristics of adolescents are summarized in Table 1. Sample characteristics of parents are summarized in Table 2. Fifty-nine adolescents reported current pain at the start of the study, of whom 21 reported mild, 19 moderate, and 10 severe pain (9 did not report intensity). The most frequent type of pain reported was back pain (73.7%), followed by neck (8.8%), headache (7%), abdominal (5.3%), joint (3.5%), and injury-related pain (1.8%). Means, standard deviations, and ranges of variables at the different time points are presented in Table 3.

Risk Factors: Pain Intensity and Pain Catastrophizing

The results on the predictive effects of pain intensity and pain catastrophizing on long-term recovery are presented in Table 4. Pain intensity at T0, T1, and T3 predicted level of functioning, HRQOL, and pain at T4. Pain intensity at T2 predicted quality of life and pain at T4 but not level of functioning. Adolescent pain catastrophizing at T0 predicted level of functioning, HrQOL, and pain at T4. Parent pain catastrophizing predicted pain at T4 but not HRQOL or level of functioning.

TABLE 1. Sample Characteristics Adolescents, N = 100

Characteristic	M (SD) or n (%)
Age	15.18 (1.56)
Sex	
Female	67 (67)
Male	21 (21)
Not reported	12 (12)
Level of education	
Primary school	2 (2)
High school	98 (98)
Nationality	
Belgian	80 (80)
Dutch	2 (2)
Bulgarian	1 (1)
Philippine	1 (1)
Not reported	16 (16)
Biomedical variables	
Cobb angle (degrees)	52.19 (10.66)
Height (cm)	165.88 (8.04)
Weight (kg)	55.05 (10.33)
BMI	20.00 (3.61)
Duration of hospital stay	
< 7 d	53 (53)
7-14 d	31 (31)
15-21 d	2 (2)
Not reported	14 (14)

TABLE 2. Sample Characteristics Parents, N = 61

Characteristic	M (SD) or n (%)
Age	47.02 (6.72)
Relation to child	
Mother	54 (88.5)
Father	5 (8.2)
Other	2 (3.2)
Level of education	
Primary school	7 (11.5)
High school	17 (27.9)
Higher education (not university)	26 (42.6)
University	11 (18.0)
Child's nationality	
Belgian	11 (18)
Not reported	50 (82)
Marital status	
Married or partner	41 (67.2)
Divorced	7 (11.5)
Widow(er)	1 (1.6)
Single parent/not married	3 (4.9)
Newly composed family	7 (11.5)
Not reported	2 (3.3)

Resilience Factors: Psychological Flexibility and Pain Acceptance

The results on the predictive effects of psychological flexibility and pain acceptance on long-term recovery are presented in Table 5. Adolescent psychological flexibility at T0 predicted quality of life but not level of functioning or pain at T4. Parental psychological flexibility at T0 predicted HRQOL and pain at T4 but not functioning. Adolescent pain acceptance at T1 predicted pain at T4 but not functioning or HRQOL. There was, however, a statistically significant effect on the emotional subscale of PedsQl ($\beta = 0.56$, CI = 0.07-1.05, $P = 0.022$), on HRQOL at T4. Adolescent pain acceptance at T2 predicted quality of life at T4 but not functioning or pain. Parent pain acceptance did not predict functioning, HRQOL, or pain at T4.

DISCUSSION

The aim of the present study was to evaluate risk and resilience factors in adolescents undergoing spinal fusion surgery, and their parents, as predictors of long-term recovery at 1 year after surgery. The results showed that presurgical and postsurgical pain intensity at 3 weeks and 6 months after surgery, respectively, predicted both functioning, HRQOL, and pain, at 1-year follow-up. In addition, pain at 6 weeks after surgery predicted long-term HrQOL and pain. These findings are in line with previous research showing that pain intensity predicts recovery after surgery,[12,17] emphasizing the need for pain assessment and adequate postsurgical pain management. With regard to pain catastrophizing, the adolescent data predicted recovery 1-year post surgery with effects of adolescent pain catastrophizing on long-term functioning, HrQOL, and pain intensity. With regard to the parent data, parent pain catastrophizing predicted pain intensity at 1 year. These findings correspond with previous research identifying pain catastrophizing as a predictor of CPSP in youth.[12]

With regard to psychological flexibility before surgery, the results showed that adolescent presurgical psychological

TABLE 3. Means (M), SD, and Ranges (R) of Variables at Different Time Points

	T0			T1			T2			T3			T4		
Variable	**M**	**SD**	**R**	**M**	**SD**	**R**	**M**	**SD**	**R**	**M**	**SD**	**R**	**M**	**SD**	**R**
Adolescent															
Pain intensity															
Current	3.51	2.68	0-9	2.14	1.93	0-8	2.29	2.31	0-8	2.05	2.22	0-8	1.80	2.16	0-8
Worst during past 3 wks	6.67	2.16	1-10	7.11	2.33	2-10	5.39	2.31	1-10	5.45	2.47	2-10	5.00	2.32	1-10
Average past 3 wks	4.59	1.83	1-9	4.16	1.76	1-8	3.37	1.88	0-7	3.08	1.96	0-7	2.75	1.60	0-6
Pain catastrophizing	17.39	11.05	0-41	—	—	—	—	—	—	—	—	—	—	—	—
Psychological flexibility	48.88	11.80	18-68	—	—	—	—	—	—	—	—	—	—	—	—
Pain acceptance	—	—		43.35	10.41	21-67	45.43	10.60	11-70	—	—	—	—	—	—
Health-related HRQOL	74.65	16.13	37-100	58.54	15.61	25-89	65.84	16.04	33-90	74.93	15.76	28-100	79.93	13.80	39-100
Functioning	9.06	9.92	0-40	24.56	10.76	0-48	17.83	9.72	0-40	9.43	6.73	0-29	5.56	6.10	0-38
Parental															
Pain catastrophizing	18.50	8.65	0-37	—	—	—	—	—	—	—	—	—	—	—	—
Psychological flexibility	33.80	3.64	25-39	—	—	—	—	—	—	—	—	—	—	—	—
Pain acceptance	—	—	—	94.43	22.96	38-147	96.41	24.55	23-143	—	—	—	—	—	—

HRQOL indicates Health-related Quality of Life.

flexibility predicted HrQOL at 1 year after surgery. These findings imply that the way of relating to discomfort in general *before* surgery affects postoperative recovery for the adolescent at 1 year after surgery. This finding extends the results from Beeckman et al[26] showing that psychological flexibility before surgery predicts recovery at 6 months, displaying that this buffering effect of psychological flexibility sustains also beyond 6 months up to 1 year after surgery. This is an important finding given the need to follow up on the adolescents' postoperative recovery *long-term* and given the preliminary evidence that different predictors may be at play before and after 6 months post surgery.[9] Furthermore, parental psychological flexibility predicted adolescent HrQOL and lower pain intensity at 1-year follow-up. These findings suggest that parents' way of relating to discomfort in general before their child's surgery affects their child's postoperative recovery long term. Although parental psychological flexibility has previously been shown to have beneficial effects for children with chronic pain,[24,25] no previous study has, to our knowledge, reported its predictive effect on postsurgical recovery in youths.

With regard to postsurgical pain acceptance, the results showed that adolescent pain acceptance at 6 weeks post surgery predicted HRQOL at 1 year. These results are also in line with the previous study reported by Beeckman et al[26] showing that pain acceptance predicts postsurgical recovery in youths, yet extending the evidence to account for the level of recovery even long term, at 1 year post surgery. Although adolescent pain acceptance at 3 weeks post surgery did not predict HrQOL at 1 year post surgery, there was a statistically significant effect on the emotional subscale of PedsQl at 1 year, whereas the physical, social, and school subscales were nonsignificant. This suggests that adolescent pain acceptance at 3 weeks post surgery predicts some aspects of HRQOL at 1-year follow-up but not others. It seems intuitive that acceptance as an internal process would affect "internal" aspects of health, like emotional and psychological domains of HrQOL, more than "external" ones like physical, school, and social domains of quality of life, yet this is an empirical matter to be investigated further. However, adolescent pain acceptance at 6 weeks post surgery predicted general quality of life 1 year after surgery in this study. In addition, adolescent pain acceptance at 3 weeks post surgery also predicted pain intensity at 1 year. Regarding the lack of effects of adolescent pain acceptance on the level of functioning, it seems that both psychological flexibility before surgery and pain acceptance post surgery have more impact on other dimensions of recovery than functioning, which taps into the discussion of the nature of the concepts and their effect on different aspects of health. This finding is, however, incongruous with both previous research in pediatric chronic pain[23] and with the effects on overall HRQOL, which is conceptually constituted by different life domains including physical and school functioning. Thus, this empirical question needs to be investigated further. With regard to the lack of significant effects of parental pain acceptance on overall recovery (ie, HRQOL, functioning, and pain), these results are contradictory to the predictive effects of parental psychological flexibility shown and to previous research displaying beneficial effects of parental pain acceptance in children with chronic pain,[23,24] and needs to be investigated further.

A secondary finding of the study was the significant bivariate correlation between sex and the study outcomes. This finding is surprising given the empirical evidence, showing a nonassociation between sex and CPSP.[12] Due to restrictions in power, the inclusion of additional covariates beyond pain and pain catastrophizing would result in insufficient power of the analyses. Therefore, supplemental regression analyses were carried out including pain and sex as covariates instead. In these models, sex did not predict any of the outcomes, and the predictive effect of psychological flexibility and pain acceptance on the outcomes were not substantially changed when controlling for sex (ie, the number of significant and nonsignificant effects were unchanged). This secondary finding implies, however, that sex warrants future attention when investigating predictors of pediatric postoperative recovery.

Study Limitations

There was a considerable amount of missing data in the study, particularly regarding parental data, which somewhat limits its power and the validity of the results. Possibly, some of the nonsignificant results would have reached statistical significance with a greater sample size (although this is an empirical matter to be investigated further).

TABLE 4. Coefficients, CIs, Bootstrap *P* Values and Adjusted R^2 From the Regression Models of Pain Intensity (at Baseline to 6 Months Post Surgery) and Pain Catastrophizing (at Baseline) and Their Effect on Functioning, Health-related Quality of Life, and Pain Intensity at 1-year Post Surgery

	FDI at T4					PedsQL at T4					Pain at T4				
Variable	Estimate	Lower bound	Upper bound	*P*	Adj. R^2	Estimate	Lower bound	Upper Bound	*P*	Adj. R^2	Estimate	Lower bound	Upper bound	*P*	Adj. R^2
Pain															
T0	0.718	0.226	1.258	***0.007***	0.085	−1.698	−2.862	−0.494	***0.004***	0.102	0.265	0.124	0.425	***0.000***	0.141
T1	0.813	0.159	1.456	***0.013***	0.072	−2.498	−4.137	−0.810	***0.004***	0.108	0.332	0.128	0.562	***0.000***	0.108
T2	0.598	−0.176	1.439	0.148	0.021	−1.732	−3.600	−0.090	***0.042***	0.055	0.248	0.020	0.494	***0.039***	0.060
T3	1.383	0.734	2.246	***0.000***	0.153	−3.240	−4.786	−1.562	***0.001***	0.175	0.505	0.324	0.717	***0.000***	0.235
PCS-C T0	0.207	0.073	0.345	***0.005***	0.109	−0.429	−0.710	−0.128	***0.009***	0.098	0.058	0.016	0.097	***0.004***	0.095
PSC-P T0	0.173	−0.076	0.430	0.143	0.025	−0.409	−0.868	0.063	0.098	0.040	0.066	0.002	0.131	***0.045***	0.069

FDI indicates Functional Disability Inventory; PCS-C, Pain Catastrophizing Scale for Children; PCS-P, Pain Catastrophizing Scale for Parents; PedsQL, Pediatric Quality of Life; T0, baseline before surgery; T1, 3 weeks post surgery; T2, 6 weeks post surgery; T3, 6 months post surgery; T4, 1 year post surgery.

P-values <0.05 are presented in bold/italics.

Furthermore, restrictions in power inferred limitations to the addition of more than 2 covariates to the regression models. Separate regression models were run due to this limitation, although it would have been preferable to include all potential covariates in the same model.

The study used different measures of psychological flexibility/acceptance pre- and post surgery. The reason for this was that pain acceptance was not considered relevant to measure before surgery because participants were not expected to experience pain at that time point. Therefore, a general measure of psychological flexibility was chosen at baseline. On the other hand, participants were expected to experience pain after surgery and a measure of psychological flexibility/acceptance in relation to pain was consequently critical post surgery. The general measure of psychological flexibility was not administered post surgery to reduce respondent burden. Given the fact that many participants did, in fact, experience pain before surgery, it would have been appropriate to include a measure of pain acceptance at baseline as well.

Future research will ideally include assessments during the first and second weeks after surgery, which will allow for opportunities to investigate the effect of postsurgical pain acceptance right after surgery when the pain intensity is likely to be higher and with more impact on functioning and quality of life, although respondent burden during the acute recovery phase needs to be carefully considered.

Implications and Future Research

Adolescent data up to 6 months post surgery from the main project to which the current study pertains has already been published.[26] The focus of the evaluation in the current study is *long-term* recovery at 1 year post surgery, which has been called for in previous research.[17] Long-term follow-up is also particularly important in the context of pediatric postsurgical pain given that previous preliminary evidence shows that the predictors of the development of CPSP up to 6 months after surgery may indeed be different from the predictors of the maintenance of CPSP up to 12 months. The current study showed that the preliminary buffering effect of psychological flexibility and pain acceptance seen earlier in the recovery process for these adolescents still remains relevant up to 1 year after surgery. The study also included the social domain, namely parental factors, as predictors of recovery, which has also been highlighted in previous research.[17] The study contributes to the knowledge of psychological mechanisms affecting long-term recovery, and the process of transition from postsurgical pain to CPSP, for adolescents undergoing surgery. Using outcome variables related to functioning, in addition to pain intensity, the analyses broaden the understanding of the sustained postsurgical recovery process. Pain intensity in the acute phase may be of limited value in the prediction of a person's daily functioning and well-being, especially long term. Instead, psychological flexibility and pain acceptance appear important aspects to consider in predicting and preventing CPSP among adolescents. Notably, both of these constructs are modifiable psychological processes and potential clinical targets in behavioral treatments (eg, Acceptance and Commitment Therapy) for adolescents undergoing major surgery. The results of the study also suggest the relevance of assessing parental psychological (in)flexibility before surgery to identify potential risk and resilience factors and promote recovery for adolescents through parental interventions.

TABLE 5. Coefficients, CIs, Bootstrap *P* Values and Adjusted R^2 From the Regression Models of Psychological Flexibility (at T = 0) and Pain Acceptance (at T1-T2) and Their Effect on Functioning, Health-related Quality of Life, and Pain Intensity at 1-year Post Surgery, Adjusted for Pain (at T0 and T1) and Child Pain Catastrophizing

	FDI at T4					PedsQL at T4					Pain at T4				
Predictor	Estimate	Lower bound	Upper bound	*P*	Adj. R^2	Estimate	Lower bound	Upper bound	*P*	Adj. R^2	Estimate	Lower bound	Upper bound	*P*	Adj. R^2
AFQ-Y T0	−0.138	−0.310	0.019	0.079	0.145	0.339	0.005	0.703	***0.049***	0.153	−0.021	−0.067	0.023	0.378	0.154
AAQ-II T0	−0.203	−0.775	0.340	0.457	0.136	1.154	0.103	2.312	***0.032***	0.184	−0.174	−0.329	−0.022	***0.027***	0.203
CPAQ-A															
T1	−0.052	−0.180	0.067	0.426	0.272	0.285	−0.012	0.621	0.059	0.261	−0.048	−0.092	−0.005	***0.029***	0.261
T2	−0.046	−0.162	0.067	0.447	0.271	0.286	0.007	0.581	***0.049***	0.269	−0.009	−0.050	0.031	0.616	0.198
PPFQ															
T1	−0.002	−0.065	0.051	0.923	0.255	0.011	−0.126	0.154	0.880	0.198	−0.003	−0.027	0.019	0.783	0.195
T2	−0.021	−0.073	0.038	0.394	0.271	0.027	−0.112	0.177	0.721	0.235	0.010	−0.009	0.029	0.312	0.224

AAQ-II indicates Acceptance and Action Questionnaire; AFQ-Y, Avoidance and Fusion Questionnaire for Youth; CI, Confidence Interval; CPAQ-A, Chronic Pain Acceptance Questionnaire for Adolescents; FDI, Functional Disability Inventory; PedsQL, Pediatric Quality of Life; PPFQ, Parent Psychological Flexibility Questionnaire; T0, baseline before surgery; T1, 3 weeks post surgery; T2, 6 weeks post surgery; T4, 1 year post surgery.

P-values <0.05 are presented in bold/italics.

More studies are, however, needed, ideally with bigger samples allowing subgroup analyses, focusing on long-term predictors of pediatric postsurgical recovery and their development from presurgery, through the acute, and subacute phases to 12 months' follow-up to build on and replicate the present findings. In addition to group-level evaluation, close monitoring of the individual trajectories using experience sampling methods and/or single case designs might provide relevant insights into dynamic and intrapersonal pain-related processes.[56] Aside from psychological flexibility, another resilience factor of interest for future investigation is self-efficacy, for which an association with CPSP has been demonstrated.[12] Finally, the social domain also needs to be examined in more detail and expanded to include other social factors influencing the child's postsurgical recovery beyond the parents, such as family systems, peer relations, or school contexts.

CONCLUSIONS

The study identified presurgical and postsurgical pain intensity and adolescent pain catastrophizing as risk factors, and adolescent and parental presurgical psychological flexibility, and adolescent pain acceptance as resilience factors for long-term recovery at 1-year follow-up for adolescents with idiopathic scoliosis undergoing spinal fusion surgery. These findings have important clinical implications given that pain catastrophizing, psychological flexibility, and pain acceptance are psychological mechanisms that are clinically modifiable in behavioral interventions for adolescents, as are parental processes through parent interventions. Based on these findings, supporting adolescents and their parents in managing these psychological processes, pre- and post surgery, may therefore promote long-term recovery and prevent the development of CPSP for these adolescents.

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