



Preliminary Validation of a Diary Approach to Monitor Daily Adolescent and Parental Predictors of Postoperative Recovery—A Longitudinal Diary Study in Adolescents Undergoing Spinal Fusion Surgery

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■ **BACKGROUND:** About 1 in 5 adolescents undergoing major surgery develops chronic postsurgical pain. Various risk and resilience factors for recovery and chronic postsurgical pain have been identified, including parental characteristics. However, research commonly relies on nomothetic data, whereas psychometric properties of diaries assessing pediatric postsurgical recovery in everyday life are understudied. This study aimed to evaluate preliminary reliability, validity, and variability of diary data in adolescents and their parents after spinal fusion surgery.

■ **METHODS:** Adolescents with idiopathic scoliosis undergoing spinal fusion surgery and their parents were asked to complete daily diaries for 7 consecutive days at 5 time points: before surgery and 3 weeks, 6 weeks, 6 months, and 12 months after surgery. Diaries were developed based on validated questionnaires measuring relevant constructs of pediatric postsurgical recovery. Internal consistency; test-retest reliability; convergent, divergent, and concurrent criterion validity; and variability were examined.

■ **RESULTS:** The sample comprised 95 adolescents and 95 parents. Overall compliance rate was approximately 80% in both adolescents and parents, with a total of 5282 diary entries analyzed. Internal consistency for multi-item variables ranged from good to excellent ($\alpha = 0.82\text{--}0.93$) for

adolescent data and acceptable to excellent ($\alpha = 0.74\text{--}0.93$) for parent data. All test-retest correlations were significant—large ($\rho = 0.60\text{--}0.76$) for adolescent data and medium to large for parent data ($\rho = 0.57\text{--}0.80$). Regarding validity, all but 3 correlations between diary variables were significant. Diary variables generally correlated significantly with corresponding questionnaire data. Variability was low in some variables.

■ **CONCLUSIONS:** These results provide evidence for psychometric properties regarding reliability, validity, and variability of diaries monitoring processes of postsurgical recovery in everyday life in adolescents undergoing spinal fusion surgery. Replication is suggested for refinement and further validation, with particular attention to variability and evaluation of sensitivity to change.

INTRODUCTION

Chronic postsurgical pain (CPSP), defined as pain lasting for >3 months following surgery,¹ affects about 20% of children and adolescents undergoing major surgery.² Living with CPSP can negatively impact an individual's quality of life, functioning, and well-being.³ Moreover, increased health care costs are associated with CPSP,⁴ making pediatric CPSP a public health priority.^{5,6}

Key words

- Adolescents
- Chronic postsurgical pain (CPSP)
- Diary
- Predictors
- Recovery
- Surgery
- Validation

Abbreviations and Acronyms

CPSP: Chronic postsurgical pain
IQR: Interquartile range

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Various studies have identified risk and resilience factors for pediatric CPSP to understand its overall etiology and identify treatment targets. Research shows, for instance, that anxiety, pain catastrophizing, psychological flexibility, and pain acceptance,⁷ as well as depressive symptoms and sleep quality⁸ represent potentially modifiable risk and resilience factors. Additionally, parental characteristics, such as anxiety sensitivity, pain anxiety,⁹ pain catastrophizing, and parental psychological flexibility, are also associated with pediatric postsurgical recovery.^{10,11} Overall, an interpersonal fear-avoidance model is proposed for CPSP,^{12,13} in which the child's behavioral responses (i.e., confront/accept pain while continuing to engage in meaningful activities vs. fear pain and increase avoidance behaviors) is central to the transition from acute to chronic pain and thus recovery.

To understand CPSP and related factors, research in the field has mainly relied on group-level questionnaire data from fixed time points. Although this approach is common in behavioral sciences, and instruments used demonstrate overall good psychometric properties, the insights into dynamic, daily patterns of recovery remain limited. To improve treatments for patients experiencing pain, the importance of understanding the complex needs of the individual has been highlighted, and a greater focus on process-based research and treatments has been recommended.^{14,15} To assess recovery in everyday life, and the predictors thereof, diary approaches are suggested.¹⁶ Diary methodology, with daily assessments, enables the detailed investigation of dynamic microlevel processes, complementing existing more macrolevel data.¹⁷ It allows the investigation of events and experiences in their natural context and is particularly suitable for studying change processes during major events and transitions,¹⁸ such as during surgery and postsurgical recovery. However, the psychometric properties of this assessment format are generally understudied, especially in the context of CPSP. Therefore, the aim of the present study was to evaluate preliminary reliability, validity, and variability of diary data collected from adolescents undergoing spinal fusion surgery and their parents.

MATERIALS AND METHODS

Participants

Adolescents diagnosed with adolescent idiopathic scoliosis (age range 12–18 years) scheduled for spinal fusion surgery and their parents were eligible for study participation. Participants were recruited from the orthopedic units at 4 hospitals in Belgium (3 university hospitals, UZ Ghent, UZ Antwerp, and UZ Leuven, and 1 general hospital, AZ Sint-Jan Bruges) between 2016 and 2018. Exclusion criteria included prior spinal fusion surgery, insufficient Dutch language skills, and severe comorbidities (neurological, developmental, or other health condition). Participants were recruited in dyads (with 1 parent per adolescent invited). Informed consent was collected from both adolescents and parents. Of 144 adolescents who met inclusion criteria, 5 were unreachable and 139 were invited to participate. Among those invited, 106 adolescents accepted and 33 declined participation. Before study start, 6 adolescents and 4 parents dropped out. Consequently, 100 adolescents and 102 parents were included in the study. The study was approved by the Medical Ethical Committee of Ghent University,

with an extended approval from all local ethical committees to collect data at their respective unit.

Design and Procedure

This study was part of a larger longitudinal project, the Post-operative Recovery After Spinal Fusion Surgery Study (<https://biblio.ugent.be/publication/8578153>). The project adhered to the guidelines for Good Clinical Practice (ICH/GCP) and the Declaration of Helsinki. The datasets of the study are not publicly available, but are available from the corresponding author on reasonable request. The diary data were collected 2 weeks before surgery (To) and at 3 weeks (T1), 6 weeks (T2), 6 months (T3), and 12 months (T4) after surgery. The postoperative follow-up intervals were chosen to capture both short-term and long-term recovery. Baseline sociodemographic and biomedical data were used to characterize the sample. Diaries were administered online through Limesurvey,¹⁹ a protected Web-based survey tool used to obtain research data. At each time point, participants were asked to complete a daily online diary in the evening for a period of 7 consecutive days. Commonly, participants started on Monday and completed their last diary on Sunday. Participants were reminded daily to complete the diary via automatically sent text messages (if they had previously agreed to receive these messages). A researcher checked daily in the morning to see if the diaries were completed and, if needed, reminded the participants using text messaging. At each upcoming time point, an e-mail reminder was also sent, and participants had access to their own diary via a personal code. Questionnaires were also collected in the larger project and administered at To–T4 (for the participants to fill in once per time point), used for validation purposes in the present study.

Measures

Diary Measure. Outcome measures assessing recovery are usually multidimensional²⁰ and relate to a health profile specific to the disease.²¹ In the present study, variables determining recovery included 3 common symptoms (pain intensity, fatigue, and physical complaints) and various elements of functioning that are relevant to patients after spinal fusion surgery. An adolescent diary and a parent diary were developed. Items were answered on a 7-point response scale (0 = not at all true; 6 = totally true) unless indicated otherwise. The adolescent diary measured pain intensity, fatigue, physical complaints, pain-related fear, pain catastrophizing, psychological flexibility, activity engagement, activity avoidance, positive and negative mood, general functioning, pain interference, parent presence/contact with parent, parent instructions to avoid or engage, and parent protective behavior. The parent diary measured parental variables including positive and negative mood, pain catastrophizing about child's pain, pain-related fear of child's pain, parent instructions to child to avoid or engage in activities, and parent protective behavior. The diary items were developed based on items of validated questionnaires measuring the constructs of interest and adjusted for daily use and/or parent report, and the discriminant content validity procedure was applied.²² Variables, number of items, items, response scales, score ranges, and sources for development are presented in **Table 1** for the adolescent diary and **Table 2** for the parent diary.

Table 1. Variables, Number of Items, Items, Response Scales, Score Ranges, and Sources for Adolescent Diary

Variable	Number of Items	Items	Response Scale/Score Range	Source
Pain intensity	2	"How intense was your pain on average today?" "How intense was your worst pain today?"	0 = "No pain"; 6 = "Worst possible pain"/0–12	Characteristic Pain Intensity subscale of the Graded Chronic Pain Scale for Children ³⁹
Fatigue	1	"How tired were you on average today?"	0 = "Not tired"; 6 = "Worst possible tiredness"/0–6	Developed by the research team for the diary measure
Physical complaints	1	"Did you experience other physical complaints today?" Conditional item, if yes > "Which other physical complaints?"	0 = "No complaints"; 6 = "A lot of other complaints"/0–6	Developed by the research team for the diary measure
Pain-related fear	3	"Today, my pain caused my heart to beat fast or race" "Today, feelings of pain were scary for me" "Today, I worried about my pain"	0 = "Not at all true"; 6 = "Totally true"/0–18	Fear of Pain Questionnaire ⁴⁰
Pain catastrophizing	3	"Today, I thought something serious might happen to me because of the pain" "Today, I kept thinking about how much pain I was experiencing" "Today, I felt I couldn't go on much longer because of the pain"	0 = "Not at all true"; 6 = "Totally true"/0–18	Pain Catastrophizing State items ⁴¹
Psychological flexibility	6	"Today, I was aware of and attentive to my feelings and thoughts" "Today, I was aware of and attentive to what happened around me" "Today, I allowed my negative feelings and thoughts to be there" "Today, I was able to let go of my negative feelings and thoughts" "Today, I did things which I find important" "Today, I'm satisfied with the things I have done"	0 = "Not at all true"; 6 = "Totally true"/0–36	Avoidance and Fusion Questionnaire for Youth ^{24,25} DNA-V model from the Thriving Adolescent, an Acceptance and Commitment Therapy and Positive Psychology program for emotion regulation in teens ⁴²
Activity engagement	3	"Today, I did my planned activities while I was in pain or had other physical complaints" "Today, it was important for me to (at least try) to do my activities while I was in pain or had other physical complaints" "Today, I did my best to do the activities that I find important or fun to do while I was in pain or had other physical complaints"	0 = "Not at all true"; 6 = "Totally true"/0–18	Activity Engagement subscale of the Chronic Pain Acceptance Questionnaire for Adolescents ²⁶
Activity avoidance	3	"Today, I skipped activities because I thought the pain or other physical complaints would worsen by doing so" "Today, I stopped with what I was doing because the pain or other physical complaints started or became worse" "Today, I took some rest instead of doing activities because of (potential) pain or other physical complaints"	0 = "Not at all true"; 6 = "Totally true"/0–18	Activity avoidance items from the Avoidance subscale of the Fear of Pain Questionnaire ⁴⁰
Mood	10	"Today I felt, ..." "... joyful; miserable; cheerful; down; happy; scared; lively; anxious; proud; sad"	0 = "Not at all true"; 6 = "Totally true"/0–60	10-item Positive and Negative Affect Schedule for Children ⁴³

Continues

Table 1. Continued

Variable	Number of Items	Items	Response Scale/Score Range	Source
General functioning	3	"Which activities did you plan to do today?" "Activities to do with ..." "... school; friends; family; hobbies; sports; household duties/chores; other"	Yes/no	Developed by the research team for the diary measure
		"Did you do fewer or more activities today than you had planned?"	-3 = "A lot less activities"; 0 = "Did what I planned"; +3 = "A lot more activities"/-3+3	
		"I've had difficulties doing activities today"	0 = "Not at all true"; 6 = "Totally true"/0-6	
Pain interference	1	"Today, I had difficulties doing my activities because of the pain or other physical complaints"	0 = "Not at all true"; 6 = "Totally true"/0-6	Disability subscale of the Graded Chronic Pain Scale for Children ³⁹
Presence parent/guardian	1	"Did you have contact with this person today?"	Yes/no "In real life; via telephone, sms or e-mail"	Control question, developed by the research team for the diary measure
Parent instructions (avoid-engage)	2	"This person told me today to stop or cancel activities because of the pain or other physical complaints"; "This person told me today to keep on doing fun or important activities (or other activities I usually do) while I was in pain or had other physical complaints"	0 = "Not at all true"; 6 = "Totally true"/0-6	Activity avoidance items from the Avoidance subscale of the Fear of Pain Questionnaire ⁴⁰ Activity Engagement subscale of the Chronic Pain Acceptance Questionnaire for Adolescents ²⁶ Adjusted to parent instruction items
Parent protective behavior	2	"This person has made sure I did not have to do certain activities (e.g., household chores, going to school or sports) because of the pain or other physical complaints" "This person canceled activities (e.g., job-related duties, household chores, or hobbies) to be with me"	0 = "Not at all true"; 6 = "Totally true"/0-12	Solicitous Behavior subscale of the Inventory of Parent/Caregiver Responses to the Children's Pain Experiences ⁴⁴

Questionnaire Data. Questionnaire data were correlated with corresponding diary measures. The adolescent questionnaire data analyzed in the present study included pain catastrophizing, psychological flexibility, and pain acceptance. Pain catastrophizing was measured with the Pain Catastrophizing Scale for Children²³ at T₀, psychological flexibility was measured with the Avoidance and Fusion Questionnaire for Youth^{24,25} at T₀, and pain acceptance was measured with the 2 subscales Activity Engagement and Pain Willingness of the Chronic Pain Acceptance Questionnaire for Adolescents^{26,27} at T₁ and T₂. The parent questionnaire data included parental pain catastrophizing, measured with the Pain Catastrophizing Scale for Parents²⁸ at T₀, and pain acceptance, measured with the 2 subscales Activity Engagement and Acceptance of Pain-Related Thoughts and Feelings of the Parent Pain Acceptance Questionnaire²⁹ at T₁ and T₂. All questionnaires used are well established and have demonstrated good psychometric properties.

Sociodemographic and Biomedical Data. Sociodemographic data were collected at baseline and included age, sex, and level of education for both adolescents and parents. Additional information on nationality and hospital were collected for adolescents. For

parents, additional information included relation to child (i.e., mother/father/other), marital status, and occupation. Biomedical data were collected from medical records and included height; weight; body mass index; curve type; Cobb angle; skeletal maturation; treatment history; other medical or nonmedical complaints; complications during, and duration of, hospital stay; pain treatment; pain measurements; treatment history; and post-operative data including complications, pain treatment, and information about other treatments at home.

Analytic Approach

Data Preparation. According to the rule of thumb for momentary data, a cutoff of 33% compliance rate was applied.³⁰ Thus, participants who completed <12 diaries were excluded from analyses. Based on this criterion, 5 adolescents and 7 parents were excluded from analyses. Diary assessments were coded according to time point (T₀-T₄) and day (1-7). Missing data were not imputed. Descriptive statistics were used to assess participant characteristics and frequency of diary assessments. The completion rate was calculated by comparing valid diary assessments with the total number of assessments (35, i.e., 7 days with 5 time points/day). Statistical analyses were performed

Table 2. Variables, Number of Items, Items, Response Scales, Score Ranges, and Sources for Parent Diary

Variable	Number of Items	Items	Response Scale/Score Range	Source
Mood	10	"Today, I felt ..."; "... alert; inspired; determined; attentive; active; upset; hostile; ashamed; nervous; afraid"	0 = "Not at all true"; 6 = "Totally true"/0–60	Positive and Negative Affect Schedule—short form ⁴⁵
Pain catastrophizing (child's pain)	3	"Today, I thought something serious might happen to my child because of the pain" "Today, I kept thinking about how much pain my child was experiencing" "Today, I felt I couldn't go on much longer because of my child's pain"	0 = "Not at all true"; 6 = "Totally true"/0–18	Pain Catastrophizing Scale for Parents ²⁸
Pain-related fear (child's pain)	3	"Today, my child's pain caused my heart to beat fast or race" "Today, my child's feelings of pain were scary for me" "Today, I worried about my child's pain"	0 = "Not at all true"; 6 = "Totally true"/0–18	Fear of Pain Questionnaire ⁴⁰ Adjusted to parent report
Parent instructions (avoid-engage)	2	"Today, I told my child to stop or cancel activities because of the pain or other physical complaints" "Today, I told my child to keep on doing fun or important activities (or any other activities that he/she usually does) while he/she was in pain or had other physical complaints"	0 = "Not at all true"; 6 = "Totally true"/0–6	Activity avoidance items from the Avoidance subscale of the Fear of Pain Questionnaire ⁴⁰ Adjusted to parent instruction Activity Engagement subscale of the Chronic Pain Acceptance Questionnaire for Adolescents ²⁶ Adjusted to parent instruction
Parent protective behavior	2	"Today, I have made sure that my child did not have to do certain activities (e.g., household chores, going to school or sports) because of the pain or other physical complaints" "Today, I canceled my activities (job-related duties, household chores, and/or hobbies) to be with my child"	0 = "Not at all true"; 6 = "Totally true"/0–12	Solicitous Behavior subscale of the Inventory of Parent/Caregiver Responses to the Children's Pain Experiences ⁴⁴

using IBM SPSS version 28.0.³¹ Tests of normality showed that, for most variables, data were not normally distributed. Thus, for test-retest reliability and validity testing, Spearman ρ was mainly used, and Pearson r was used where applicable. Correlation coefficients were interpreted according to the guidelines provided by Cohen, where $r = 0.10$ – 0.29 was considered small, $r = 0.30$ – 0.49 was considered medium, and $r = 0.5$ – 1.0 was considered large.³²

Reliability Testing. Cronbach α was calculated to assess internal consistency for all multi-item diary variables. Cronbach α levels were interpreted according to accepted practice with ≥ 0.7 as acceptable, ≥ 0.8 as good, and ≥ 0.9 as excellent. Test-retest reliability was assessed by correlating multiple-item diary variable scores, on scale level, between T1 and T2, when contextual factors were expected to be relatively stable, and the time interval (3 weeks) for test-retest reliability was considered appropriate.

Validity Testing. Convergent and divergent validity was assessed by calculating correlations between diary variables expected to (convergent), or not to (divergent), correlate with each other. Generally, symptom and risk variables (pain intensity, fatigue,

physical complaints, pain catastrophizing, pain-related fear, negative mood, and activity avoidance) were hypothesized to correlate positively with each other and with pain interference and general functioning (reversely measured as function disability) and negatively with resilience variables (psychological flexibility, positive mood, and activity engagement). Furthermore, for some multi-item diary variables, questionnaire data were available, for which correlations were performed to assess concurrent criterion validity. The diary variables correlated with questionnaire data were pain catastrophizing, psychological flexibility, activity engagement, and activity avoidance for adolescents and pain catastrophizing, parent instructions to engage, and parent instructions to avoid for parents. Adolescent and parent data were calculated separately.

Variability

The variability of the diary variables used in the present study, with data on scale level, was assessed by calculating range, interquartile range (IQR), standard deviation, and variance. For adolescents, variability was assessed for pain catastrophizing, pain-related fear, psychological flexibility, activity engagement and avoidance,

Table 3. Sample Characteristics (N = 190)

Characteristic	Adolescents (n = 95)	Parents (n = 95)
Age, years, mean (SD)	15.14 (1.53)	47.02 (6.72)
Range	12–18	34–74
Sex, number (%)		
Male	21 (22.1)	12 (12.6)
Female	74 (77.9)	73 (76.8)
Not reported	-	10 (10.5)
Relation to child, number (%)	-	
Mother		71 (74.7)
Father		11 (11.6)
Stepmother		1 (1.1)
Stepfather		1 (1.1)
Grandmother		1 (1.1)
Not reported		10 (10.5)
Level of education, number (%)		
Primary school	2 (2.1)	7 (7.4)
High school	93 (97.9)	17 (17.9)
Higher education	-	26 (27.4)
University	-	11 (11.6)
Not reported	-	34 (35.8)
Ethnicity, number (%)		
Belgian or Dutch	81 (85.3)	
Other European	1 (1.5)	
Asian	1 (1.5)	
Not reported	12 (12.6)	
Biomedical variables, mean (SD)		
Height, cm	165.8 (7.73)	
Weight, kg	55.2 (10.50)	
BMI	20.0 (3.62)	
Cobb angle, °	52.1 (10.91)	
Duration of hospital stay, days		
<7	51 (53.7)	
7–14	29 (30.5)	
15–21	2 (2.1)	
Not reported	13 (13.7)	
Family situation, number (%)	-	
Married or cohabitating		56 (58.9)
Divorced		15 (15.8)
Widowed		1 (1.1)
Single parent		6 (6.3)
		Continues

Table 3. Continued

Characteristic	Adolescents (n = 95)	Parents (n = 95)
New family constellation		7 (7.4)
Not reported		10 (10.5)
BMI, body mass index.		

positive and negative mood, adolescent-reported parent instructions to engage and avoid, and parent protective behavior. For parents, variability was assessed for pain catastrophizing, pain-related fear, positive and negative mood, parent-reported instructions to engage and avoid, and parent protective behavior.

RESULTS

Sample Characteristics

Data from 95 adolescents and 95 parents were analyzed. Adolescents completed a total of 2623 diary entries, with an average completion of 27.6 entries and a completion rate of 79%. Parents completed a total of 2659 diary entries, with an average of 28.0 entries and a completion rate of 80%. Sociodemographic and biomedical data of the sample are presented in **Table 3**. Descriptive data for all continuous diary variables are presented in **Table 4**.

Reliability of Diary Variables

Internal Consistency. For adolescent data (2623 diary entries), the internal consistency of the multi-item variables was good to excellent, with Cronbach α levels ranging from 0.82 to 0.93, as follows: psychological flexibility (6 items), $\alpha = 0.82$; pain-related fear (3 items), $\alpha = 0.87$; pain catastrophizing (3 items), $\alpha = 0.88$; activity engagement (3 items), $\alpha = 0.91$; activity avoidance (3 items), $\alpha = 0.89$; negative mood (5 items), $\alpha = 0.91$; and positive mood (5 items), $\alpha = 0.93$. For parent data (2659 diary entries), internal consistency was acceptable to excellent, with Cronbach α levels ranging from 0.74 to 0.93, as follows: pain-related fear (3 items), $\alpha = 0.83$; pain catastrophizing (3 items), $\alpha = 0.80$; negative mood (5 items), $\alpha = 0.74$; and positive mood (5 items), $\alpha = 0.93$.

Test-Retest Reliability. For adolescents, all test-retest correlation coefficients were significant and large for pain-related fear, $\rho = 0.63$; pain catastrophizing, $\rho = 0.62$; psychological flexibility, $\rho = 0.76$; activity engagement, $\rho = 0.63$; activity avoidance, $\rho = 0.68$; positive mood, $\rho = 0.60$; and negative mood, $\rho = 0.66$. For parents, all test-retest correlation coefficients were significant and medium for pain-related fear, $\rho = 0.59$, and pain catastrophizing, $\rho = .57$, and large for positive mood, $\rho = 0.80$, and negative mood, $\rho = 0.60$.

Validity of Diary Variables

Convergent and Divergent Validity. Correlation coefficients between diary variables are presented in **Table 5**. All correlations were significant, ranging from small to large, except for 3 correlations between psychological flexibility and physical complaints, parent

Table 4. Continuous Variables at Different Time Points

Variable	T0		T1		T2		T3		T4	
	A	P	A	P	A	P	A	P	A	P
Pain intensity	1.66 (1.65) [0–6]	-	1.70 (1.43) [0–6]	-	1.09 (1.23) [0–5]	-	0.83 (1.17) [0–6]	-	0.73 (1.02) [0–5]	-
Fatigue	2.34 (1.68) [0–6]	-	2.11 (1.49) [0–6]	-	1.52 (1.45) [0–6]	-	1.55 (1.53) [0–6]	-	1.43 (1.43) [0–6]	-
Physical complaints	0.59 (1.16) [0–6]	-	0.56 (1.11) [0–6]	-	0.35 (0.88) [0–6]	-	0.29 (0.81) [0–5]	-	0.26 (0.65) [0–5]	-
Pain-related fear	1.82 (3.29) [0–17]	1.83 (3.11) [0–18]	2.28 (3.54) [0–18]	2.41 (3.81) [0–18]	1.46 (2.97) [0–16]	1.21 (2.56) [0–16]	1.34 (2.85) [0–16]	0.52 (1.49) [0–12]	1.18 (2.74) [0–18]	0.62 (1.66) [0–16]
Pain catastrophizing	1.94 (3.43) [0–18]	1.31 (2.42) [0–12]	2.08 (3.29) [0–18]	1.90 (3.10) [0–15]	1.35 (2.90) [0–18]	0.88 (2.10) [0–15]	1.20 (2.56) [0–14]	0.41 (1.44) [0–14]	0.99 (2.44) [0–14]	0.40 (1.17) [0–11]
Psychological flexibility	19.66 (7.39) [0–36]	-	19.90 (8.60) [0–36]	-	20.63 (8.86) [0–36]	-	21.20 (8.56) [0–36]	-	20.74 (8.66) [0–36]	-
Activity engagement	10.31 (6.51) [0–18]	-	9.03 (5.85) [0–18]	-	8.81 (5.77) [0–18]	-	8.93 (6.16) [0–18]	-	8.56 (6.23) [0–18]	-
Activity avoidance	1.58 (3.31) [0–16]	-	3.86 (4.75) [0–18]	-	2.67 (4.14) [0–18]	-	1.43 (2.93) [0–18]	-	1.07 (2.49) [0–15]	-
Positive mood	18.68 (6.73) [0–30]	17.09 (7.11) [0–30]	17.77 (6.82) [0–30]	17.64 (7.45) [0–30]	19.04 (6.77) [0–30]	17.37 (8.15) [0–30]	19.87 (6.77) [0–30]	18.83 (7.84) [0–30]	19.56 (7.10) [0–30]	18.35 (7.80) [0–30]
Negative mood	3.97 (5.16) [0–30]	3.60 (4.10) [0–20]	3.04 (4.63) [0–23]	2.85 (4.06) [0–22]	2.84 (4.77) [0–30]	2.48 (3.91) [0–26]	3.05 (5.00) [0–30]	2.06 (3.34) [0–27]	2.94 (5.49) [0–30]	1.87 (3.46) [0–30]
Pain interference	1.17 (1.59) [0–6]	-	1.58 (1.66) [0–6]	-	1.63 (1.62) [0–6]	-	1.21 (1.39) [0–6]	-	0.98 (1.31) [0–6]	-
Parent instructions: avoid	0.33 (0.94) [0–6]	0.25 (0.83) [0–6]	1.09 (1.73) [0–6]	0.95 (1.69) [0–6]	0.80 (1.49) [0–6]	0.50 (1.26) [0–6]	0.34 (0.93) [0–5]	0.23 (0.85) [0–6]	0.17 (0.71) [0–5]	0.18 (0.81) [0–6]
Parent instructions: engage	0.65 (1.44) [0–6]	1.07 (1.94) [0–6]	1.23 (1.81) [0–6]	1.36 (2.00) [0–6]	1.16 (1.86) [0–6]	1.10 (1.95) [0–6]	0.90 (1.73) [0–6]	0.68 (1.64) [0–6]	0.49 (1.29) [0–6]	0.47 (1.34) [0–6]
Parent protective behavior	1.01 (2.01) [0–11]	0.82 (1.87) [0–11]	3.94 (4.14) [0–12]	3.38 (3.96) [0–12]	2.87 (3.70) [0–12]	2.02 (3.39) [0–12]	1.09 (2.03) [0–12]	0.54 (1.63) [0–12]	0.68 (1.64) [0–10]	0.43 (1.42) [0–12]

Values are reported as mean (SD) [range].
T0, 2 weeks before surgery; T1, 3 weeks after surgery; T2, 6 weeks after surgery; T3, 6 months after surgery; T4, 12 months after surgery; A, adolescents; P, parents.

Table 5. Variable Matrix with Correlation Coefficients

Variable	1. Pain Intensity	2. Fatigue	3. Physical Complaints	4. Pain-Related Fear	5. Pain Catastrophizing	6. Psychological Flexibility	7. Activity Engagement	8. Activity Avoidance	9. Positive Mood	10. Negative Mood	11. Pain Interference	12. General Functioning	13. Parent Instructions: Avoid	14. Parent Instructions: Engage	15. Parent Protective behavior
1. Pain intensity	1.00*	0.64†	0.33§	0.64†	0.69†	-0.16#	-0.19#	0.63†	-0.39**	0.49‡	0.52‡	0.67†	0.36§	0.31§	0.36§
2. Fatigue		1.00*	0.31§	0.50‡	0.52‡	-0.14#	0.11	0.47‡	-0.34**	0.51‡	0.38§	0.57‡	0.30§	0.22§	0.27§
3. Physical complaints			1.00*	0.30§	0.30§	-0.02#	0.10	0.25§	-0.16#	0.25§	0.14	0.30§	0.19	0.16	0.17
4. Pain-related fear															
Adolescents				1.00*	0.81*	-0.13#	0.11	0.61†	-0.31**	0.55‡	0.51‡	0.54‡	0.39§	0.32§	0.38§
Parents				1.00*	0.83*				-0.08#	0.42‡			0.56‡	0.41‡	0.49‡
5. Pain catastrophizing															
Adolescents					1.00*	-0.12#	0.14	0.63†	-0.33**	0.55‡	0.57‡	0.57‡	0.38§	0.33§	0.37§
Parents					1.00*				-0.07#	0.38§			0.54‡	0.40§	0.47‡
6. Psychological flexibility						1.00*	0.34§	-0.10#	0.50‡	0.06	-0.09#	-0.13#	-0.11#		
7. Activity engagement							1.00*	0.13	0.11	0.07	0.24§	0.13	0.06	0.28§	0.14
8. Activity avoidance								1.00*	-0.28**	0.44‡	0.70†	0.64†	0.53‡	0.43‡	0.55‡
9. Positive mood															
Adolescents									1.00*	-0.42††	-0.24**	-0.28**	-0.16#	-0.08#	-0.13#
Parents									1.00*	-0.22**			-0.05#	0.13	0.02
10. Negative mood															
Adolescents										1.00*	0.38‡	0.44‡	0.27§	0.20	0.25§
Parents										1.00*			0.25§	0.19	0.30§
11. Pain interference											1.00*	0.69†	0.41‡	0.25§	0.40§
12. General functioning												1.00*	0.41‡	0.30§	0.40§
13. Parent instructions: avoid															
Adolescents													1.00*	0.47‡	0.59‡
Parents													1.00*	0.42‡	0.57‡

Table 6. Correlation Coefficients for Diary Variables and Questionnaire Data

Diary Variable	Questionnaire	Time Point	ρ
Pain catastrophizing			
Adolescents	PCS-C	T0	0.39
Parents	PCS-P	T0	0.38
Psychological flexibility (adolescents)	AFQ-Y	T0	0.14
Activity engagement			
Adolescents	CPAQ-A Activity Engagement		0.17
	Total score	T1	0.07
	CPAQ-A Activity Engagement		0.23
	Total score	T2	0.04
Parents	PPAQ Activity Engagement		0.07
	Total score	T1	0.05
	PPAQ Activity Engagement		0.12
	Total score	T2	0.11
Activity avoidance			
Adolescents	CPAQ-A Pain Willingness		-0.19
	Total score	T1	-0.29
	CPAQ-A Pain Willingness		-0.24
	Total score	T2	-0.38
Parents	PPAQ Pain Acceptance		-0.10
	Total score	T1	-0.11
	PPAQ Pain Acceptance		-0.07
	Total score	T2	-0.14

Correlations in bold are significant at $P < 0.01$ level (2-tailed).

PCS-C/P, Pain Catastrophizing State—Child/Parent; AFQ-Y, Avoidance and Fusion Questionnaire for Youth; CPAQ-A, Activity Engagement subscale of the Chronic Pain Acceptance Questionnaire for Adolescents; PPAQ, Parent Pain Acceptance Questionnaire; T0, 2 weeks before surgery; T1, 3 weeks after surgery; T2, 6 weeks after surgery; T3, 6 months after surgery; T4, 12 months after surgery.

variables, full range of scores was displayed for all variables except for pain catastrophizing, but IQR, standard deviation, and variance were relatively low.

DISCUSSION

The aim of the present study was to preliminarily evaluate the reliability, validity, and variability of adolescent and parental diary data in youth undergoing spinal fusion surgery. Overall, the results of the study showed that 1) participants' responses to multi-item variables were consistent, showing acceptable to excellent internal consistency for diary items and that diary variables assessed between 3 and 6 weeks after surgery showed a moderate to strong association, supporting the reliability of the diary measures; 2) diary measures correlated significantly overall in the expected directions and with varying strength with each other as well as questionnaire data, supporting the validity of the used diary approach; and 3) all diary measures showed some degree of

variability, suggesting dynamics of diary measures within and between individuals.

Associations of the Diary Measure with CPSP Relevant Variables and Questionnaire Data

Specifically regarding validity of the diary data, correlations were carried out for both single and multi-item variables. All correlations but 4 were significant, with the correlations ranging from small to large. Correlations between variables were also in the expected directions, for instance, with greater levels of pain correlating with lower levels of positive mood. The fact that pain intensity had the strongest correlations among the physical condition variables is not surprising given the central place of pain during the postsurgical period and the pain focus of the risk and resilience variables of the study, hence supporting the validity of these diary variables. The magnitude and directions of the correlations for pain-related fear and pain catastrophizing were as expected, and both adolescent and parent pain catastrophizing and pain-related fear correlated significantly with questionnaire data,

Table 7. Variability Parameters of Adolescent and Parent Diary Variables

Variable	Range [minimum-maximum]	Interquartile Range	SD	Variance (σ^2)
Adolescents				
Pain catastrophizing	18 [0–18]	2	3.02	9.14
Pain-related fear	18 [0–18]	2	3.14	9.88
Psychological flexibility	36 [0–36]	10	8.42	70.83
Activity engagement	18 [0–18]	11	6.12	37.41
Activity avoidance	18 [0–18]	3	3.84	14.78
Positive mood	30 [0–30]	9	6.86	47.06
Negative mood	30 [0–30]	5	5.00	25.03
Pain interference	6 [0–6]	2	1.58	2.48
General functioning	6 [0–6]	2	1.47	2.17
Parent instructions to engage	6 [0–6]	1	1.68	2.83
Parent instructions to avoid	6 [0–6]	0	1.31	1.71
Parent protective behavior	12 [0–12]	3	3.26	10.65
Parents				
Pain catastrophizing	15 [0–15]	1	2.29	5.24
Pain-related fear	18 [0–18]	1	2.84	8.04
Positive mood	30 [0–30]	11	7.69	59.16
Negative mood	30 [0–30]	4	3.86	14.89
Parent instructions to engage	6 [0–6]	1	1.84	3.39
Parent instructions to avoid	6 [0–6]	0	1.21	1.45
Parent protective behavior	12 [0–12]	2	2.97	8.84

with medium positive correlations. These results are in line with previous research indicating the role of pain catastrophizing and pain-related fear, also in parents, in adolescent postsurgical recovery,^{2,10} supporting the validity, both convergent and criterion, of these variables in a diary measurement format. Although the correlations for psychological flexibility were small, they may still be clinically important, particularly considering that the effect of psychological processes may, at times, be delayed. A medium positive correlation was also shown with activity engagement and a large correlation was shown with positive mood. Regarding the correlation with activity engagement, this is noteworthy given the theoretical, and empirically grounded, model of transition from acute to chronic pain, with behavioral responses of engaging in activities as central for recovery^{12,13} and the previously reported predictive effect of psychological flexibility on pediatric postsurgical recovery.¹⁰ These 2 variables and the correlation between them are thus of great interest for studies investigating psychological processes in postsurgical pain. For psychological flexibility, a significant small positive correlation was also shown with questionnaire data. With regard to the small magnitude of this correlation, the items of the diary measure and the Avoidance and Fusion Questionnaire for Youth differ and may measure different, potentially complementary, aspects of psychological flexibility. Diary-measured activity

engagement also correlated significantly with questionnaire data. Overall, the results support the validity of the diary items of psychological flexibility and activity engagement in the study. For the activity avoidance, large correlations were shown with other diary variables, and medium correlations were shown with questionnaire data, which also is in line with previous research and supports the validity of activity avoidance in a diary format.³³ However, for parent-reported instructions to engage and avoid, correlations with questionnaire data on parent-reported pain acceptance were partly insignificant and small, indicating vague associations of parental pain acceptance and parent instructions to their child. All correlations for adolescent-reported mood were significant and in the expected directions. Mood has previously been shown to be associated with postoperative recovery in adults,³⁴ but not in adolescents.² The results therefore indicate that mood may be a relevant factor to investigate further, including in pediatric CPSP. However, all correlations for parent-reported positive mood were all small, including nonsignificant in 1 case, which leads to ambiguity regarding the relevance of mood in pediatric postsurgical recovery. Furthermore, the correlations for both pain interference and general functioning were also in line with previous research in the field,² supporting the validity of these as diary variables. Regarding parent instructions and protective behavior, correlations were mainly

significant, indicating associations between parental behavior and relevant risk and resilience variables and outcomes for adolescent postsurgical pain and recovery, supporting the validity of these diary variables.

Dynamics of the Diary Measure

Regarding variability, the results were mixed. For adolescent variables, variability was considered adequate for positive mood, activity engagement, and psychological flexibility. For pain catastrophizing, pain-related fear, negative mood, activity avoidance, and adolescent reported parental instructions and protective behavior, although variables displayed full ranges of scores, IQRs and standard deviations showed limited variability. For parents, ranges covered the whole score span for all variables except for parental pain catastrophizing, for which scores were positively skewed. However, IQRs and standard deviations generally indicated low variability except for positive mood, which showed adequate variability. Diary assessments of affect have a long history, thus, the present findings of dynamic positive mood are in line with previous research.³⁵ Regarding the limited variability in some variables, possibly, some measures eventually reach stability, which may indicate recovery. Still, variability should be closely monitored and investigated further for the diary variables in future studies. Studies using multilevel or network modelling are advanced to unravel the dynamics of daily measures further.

Strengths and Limitations

To the authors' knowledge, this is the first study to explore the reliability, validity, and variability of a diary measure to examine risk and resilience factors in the everyday life of adolescents and their parents in the context of pediatric CPSP and recovery. A validated diary measure would yield insights into the daily dynamic psychological processes, including the interplay between adolescents and parents, impacting the recovery trajectory for adolescents undergoing spinal fusion surgery. Clinically, by screening for these risk and resilience variables in everyday life, daily diary measures enable timely interventions to prevent CPSP and promote recovery. The sample of almost 100 pairs with more than 5000 diary assessments and complementary questionnaire data over a 12-month period provides a useful database for the psychometric evaluations. However, several limitations should be considered when interpreting the findings. There was a substantial proportion of missing data in the study, with 12 participants excluded from analyses and further missing data for the participants that were included, with completion rates about 80%. Whereas this compliance rate is common in diary studies³⁶ (and data were sufficient for the analyses conducted), missing data may affect the generalizability of the results. This means that there may be a possibility that patients declining participation

and participants omitting to complete the diaries differed in some way and that the results thus are not representative for the whole population. Also, analyses did not include evaluations of responsiveness of the diary variables, which should be addressed in future studies. To assess a measure's ability to detect change, multiple change coefficients have often been used under the assumption that consistent findings support the results. A more theoretically grounded approach has been advocated taking a sample's change characteristic into account.³⁷ Several strategies underscoring the complexity of assessing responsiveness have further been suggested.³⁸ Based on these recommendations, the complexity of evaluating sensitivity to change should be considered beforehand in future studies, including the specific target of change of the sample investigated.

CONCLUSIONS

The results of the present study support the psychometric properties regarding reliability, validity, and variability of a diary measure to monitor both adolescent and parental variables of postsurgical recovery in everyday life in adolescents undergoing spinal fusion surgery. To promote individual-level analyses, psychometrically robust measures to evaluate the dynamic interrelationships between psychological factors in everyday life, such as daily diaries, have been requested. Although the present study supports this diary measure, results are preliminary, and replications are needed to validate the findings. The new studies should ideally include analyses of variability and sensitivity to change using advanced statistical models.

CRedit AUTHORSHIP CONTRIBUTION STATEMENT

Jenny Thorsell Cederberg: Writing – review & editing, Writing – original draft, Methodology, Funding acquisition, Formal analysis, Conceptualization. **Vendela Zetterqvist:** Writing – review & editing, Methodology, Conceptualization. **Rikard K. Wicksell:** Writing – review & editing, Supervision, Conceptualization. **Liesbet Goubert:** Writing – review & editing, Resources, Project administration, Funding acquisition, Data curation. **Sara Lauren Bartels:** Writing – review & editing, Writing – original draft, Methodology, Conceptualization.

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