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Clinical Studies

Time course and correlates of psychological distress post spinal surgery: A longitudinal study

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ABSTRACT

Background: Psychological distress post lumbar spine surgery is associated with poorer outcomes. There is a scarcity of studies devoted to analyzing the risk factors associated with psychological distress in patients who have undergone lumbar fusion surgery. The purpose of this study was to (1) describe the time course and severity of psychological distress using the STarT Back Tool (SBT) and (2) determine the demographic and clinical predictors of SBT score post lumbar spine fusion surgery.

Methods: This retrospective longitudinal study analyzed 227 subjects with 1- and 2-level lumbar fusion surgery who underwent standardized assessment preoperatively and at 4 and 12 weeks postoperatively. Preoperative variables collected were demographic, clinical, and psychological variables. Postoperative psychological distress was measured by self-reported SBT. Risk factors for SBT over time were identified using ordinal and mixed-effects modelling.

Results: Although the trajectory of SBT levels declined postoperatively over time, at week-12, 20% of patients had moderate to high SBT. Postoperative SBT scores at week-4 time point was significantly greater than SBT scores at week-8 (OR = 2.7, 95% credible interval [CrI]; 1.8–3.9). Greater SBT scores at week-4 were strongly associated with greater SBT scores throughout 12 weeks of follow-up (OR = 7.3, [95% CrI; 1.2–31.4]). Greater postoperative SBT levels over time were associated with being male (OR = 2.2, 95% CrI; 1.0–3.9), greater preoperative back or leg pain intensity (OR = 2.2; 95% CrI: 1.0–4.4), greater preoperative leg weakness (OR = 4.2, 95% CrI: 1.7–7.5) and higher preoperative depression levels (OR = 4.8; 95% CrI: 1.6–10.4).

Conclusion: Postoperative SBT levels declined nonlinearly over time. However, a sizable proportion of patients had moderate to high psychological distress at week-12 postsurgery. Greater preoperative back or leg pain intensity, leg weakness and depression levels, and male gender were risk factors of greater psychological distress postsurgery. Although requiring validation, our study has identified potential modifiable risk factors which may give an opportunity to provide early (preoperative) and targeted strategies to optimize postoperative psychosocial outcomes in patients undergoing lumbar fusion surgeries.

Introduction

Lumbar fusion surgery is a costly intervention for patients presenting with degenerative lumbar disease and persistent lower back pain. Importantly, the overall cost of this procedure is growing at an alarming rate; an 80% increase from 1998 to 2014 [1]. While lumbar fusion surgery has demonstrated effective postoperative outcomes in the majority of patients [2], a subgroup continues to develop persistent complex pain and psychological distress following surgery [3]. Given that psychological distress has been associated with higher healthcare costs and increased opioid usage [4], regular monitoring of patients should extend postoperatively to identify those at risk of poor postoperative outcomes

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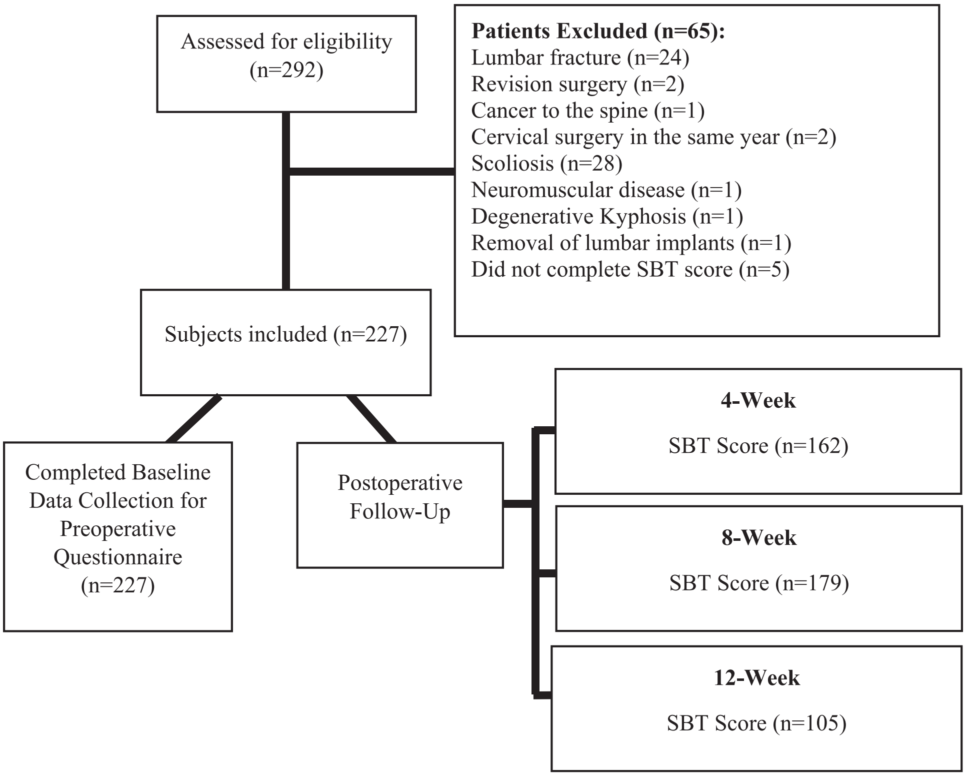

Fig. 1. Flowchart according to STROBE guidelines.

[5]. Identification of these patients is important to ensure accessibility to appropriate postoperative intervention (eg, psychologically-informed physiotherapy care).

In both primary and secondary care settings, the STarT Back Tool (SBT) was used as a clinical measure of psychological distress [6,7] as well as a prognostic tool for clinical outcomes in pain intensity [7,8] and disability [9] in low back pain sufferers. In summary, there is compelling evidence to show that high SBT levels are associated with poor health outcomes in all physical and psychological domains. However, compared with several studies that have examined the time course of SBT levels in patients with conservatively managed LBP [6,10], no studies have provided detailed longitudinal data of SBT measures in patients who have undergone lumbar fusion surgery. Much emphasis has been placed on identifying the at-risk group of patients developing chronic, persistent nonsurgical low back pain in rehabilitation settings using the SBT but not much attention has been directed to postoperative spinal surgery patients. Furthermore, hardly any studies have examined the associations of preoperative predictors of postoperative psychological outcome. Only 1 recent study found that there was no association between preoperative physical function and postoperative depression in 119 patients who underwent lumbar fusion surgery [11]. However, that study used the Patient Health Questionnaire (PHQ-9) to measure depression, which is a generic outcome measure of depression [12], unlike the SBT which has a psychosocial component that has been specifically validated for the low back pain population [13].

Therefore, to help address these gaps, this retrospective longitudinal study aimed to (1) describe the time course and severity of SBT-derived psychological distress post lumbar fusion surgery and (2) to identify its demographic and clinical predictors.

Material and methods

Study sample

Between January 2017 to December 2018, we identified from our medical records, 292 patients who underwent lumbar spine fusion surgery ≤2 levels and attended outpatient physiotherapy at the Singapore General Hospital—the largest tertiary teaching hospital in Singapore. Of these patients, we included 227 patients in the present analyses (Fig. 1). Patients diagnosed with degenerative lumbar stenosis and spondylolisthesis were included. To minimize the potential confounding influence of multisegmented (>2 levels) lumbar fusion on clinical outcomes [13,14], these patients were excluded. We also excluded patients who had metastatic cancer to the spine, previous spinal surgery within a year and other neurological diseases (Fig. 1).

Post lumbar fusion surgery, all patients underwent inpatient rehabilitation and were referred for outpatient physiotherapy within 2 to 6 weeks following discharge. Patients who attended rehabilitation were given exercises, patient education and any modalities at the physiotherapist's discretion. One hundred sixty-two patients were evaluated within a month preoperatively, and were scheduled for 4-, 8- and 12-week postoperative assessments as part of routine clinical care. All data were collected by technicians (n = 4) and physiotherapists (n = 14). The institutional review board approved the study with a waiver of informed consent (Singhealth CIRB 2016/2445, Singapore).

Preoperative risk factors

We extracted from medical records variables that were considered to be plausible risk factors of SBT. The extracted information included patient demographics such as gender, age, body mass index (BMI) and preoperative depression, self-reported preoperative leg numbness and weakness.

Preoperative depression: To assess self-reported depression, a single question (Q28) from the SF-36 ('How much of the time during the past 4 weeks have you felt downhearted and depressed?') was used. Based on a prespecified classification, we recoded the 6 possible response choices into 3 categories: (1) "Good Bit or Most or All the time" (response choices 1, 2, and 3); (2) "Little or Some of the time" (response choices 4 and 5); and (3) "None of the time" (response choice 6).

Preoperative leg weakness and numbness: To assess preoperative leg weakness and numbness, self-reported frequency of numbness and weakness experienced in the lower limb (thigh, calf, ankle, or foot) in the past week were identified using items 12 and 13 of the modified

NASS Low Back Pain Outcome Instrument respectively. Both items were evaluated using a 6-item Likert scale and were further categorised into 3 categories: (1) "none" (response choice 1); (2) little or some (response choices 2 and 3); and (3) good bit or most or all (response choices 4, 5, and 6)'.

Follow-up measures

At around 4 and 12 weeks postoperatively, SBT scores were measured.

SBT scores: The SBT psychological subscale consisted of 5-items, which was extracted from the full SBT scale of maximum 9-items [13]. The SBT psychological subscale score (ranging from 0 to 5) was determined by summing the 5-items related to fear, anxiety, catastrophizing, depression, and bothersomeness. For descriptive purposes, we defined "none" as a subscale score of 0, "mild" as 1 to 2 points, and "moderate-to-high" as 3 to 5 points.

Back/leg pain intensity

At preoperative and all postoperative visits, patients were asked to rate their worst level of back and leg pain intensity over the past 1 week, using an 11-point numeric pain-rating scale, with 0 indicating "no pain" and 10 indicating "worst pain ever experienced." For descriptive purposes, we summarized pain intensity levels as "none" (level 0), "mild" (levels 1–4), "moderate" (levels 5–7), and "severe" (levels 8–10). Notably, pain intensity was analyzed as an ordinal variable rather than as a dichotomous (present or absent) variable to preserve statistical power [14,15].

Statistical analyses

To examine the time course of postoperative SBT levels and its correlates, we fitted separate Bayesian proportional-odds ordinal mixed-effects models [16,17] which included postoperative SBT levels as the response variable. To account for multiple observations from each patient, we used mixed-effects models with patient-level random intercepts. All models included selected predictor variables (assessed preoperatively and week-4 postoperatively) and time (weeks since lumbar surgery) as fixed effects. To avoid assuming linearity, time was modelled flexibly as a restricted cubic spline in all models [15]. For week-4 SBT score and preoperative ordinal variables, these predictors were modelled as monotonic ordered predictors [18].

In our modelling strategy, we first considered possible covariates in the association between preoperative depression and postoperative SBT scores using a directed acyclic graph (DAG) approach [19]. Because week-4 postoperative SBT scores could be an intermediate variable between preoperative depression and longer-term postoperative SBT (Appendix Fig. 1), we fitted separate models for the preoperative predictors alone. Furthermore, because preoperative depression could be an intermediate variable in the pathways between preoperative back/leg symptoms and postoperative SBT, we fitted another model that excluded preoperative depression levels.

To reduce the likelihood of estimating unrealistic values without excluding reasonable values [20], we set weakly-informative prior distributions for all model parameters. All Bayesian models were fitted using the *brms* [21] *R* package, and each model used 8 chains, 2,000 iterations per chain, to generate the posterior samples for all exponentiated regression coefficients (that is, the odds ratios [ORs]). From these samples, we calculated the proportion of distribution that exceeded 1.0 (null value), thereby estimating the (posterior) probability that a given predictor was associated with the outcome.

To assess statistical significance, we interpreted a predictor effect as statistically "significant" if its posterior probability exceeded 95%. To assess potential clinical significance, we (1) computed the adjusted ORs associated with a 5-point (for 11-point scales) or 3-point (for 6-point scales) change and (2) estimated the probability that the ORs exceeded 1.5 ("moderate" effect size) or 2.0 ("moderate-to-large" effect size). Finally, to complement the ORs, we transformed the predictor effects back to the original (count) scale and computed the difference in mean postoperative SBT levels at the week-12 timepoint. (Appendix details the model implementation.) We used *R* software (http://www.r-project.org) for all analyses and graphing.

Table 1
Demographic and clinical characteristics.

Variables	Sample size (n = 227)
Demographics	
Age (years)	60.3, **66.1**, 70.2 (64.2 ± 9.2)
BMI (kg/m^2)	23.7, **26.0**, 28.9 (26.4 ± 4.2)
Women	58% (131)
Preoperative back/leg symptoms	
Leg numbness frequency	
None	18% (40)
Little or some	25% (56)
Good bit or most or all	58% (259)
Leg weakness frequency	
None	51% (115)
Little or some	18% (40)
Good bit or most or all	32% (72)
Preoperative depressive levels	
Depression	
None	52% (118)
Little or some	33% (74)
Good bit or most or all	15% (35)
Postoperative SBT score*	
Week 4 (n = 162)	
None	20% (33)
Mild	46% (75)
Moderate-to-high	33% (54)
Week 8 (n = 179)	
None	37% (67)
Mild	42% (75)
Moderate-to-high	21% (37)
Week 12 (n =105)	
None	43% (45)
Mild	37% (39)
Moderate-to-high	20% (21)

SBT, STarT Back Screening Tool; BMI, Body Mass Index.
Continuous variables are summarized as 25th, **50th**, 75th percentiles (mean ± SD).
Categorical variables are summarized as percentages and frequencies (N).
The values in bold in the table are the 50th percentile figures for the Continuous variables.
* For postoperative SBT scores, we defined none as 0, mild as 1-2, and moderate-to-high scores as 3-5.

Results

Patient characteristics

Table 1 shows the demographics, preoperative and postoperative clinical characteristics of the study patients, comprising 58% women and a mean age of 64.1 years (SD = 8.8), with mean body mass index (BMI) of 26.3kg/m^2 (SD = 4.2). Based on recommended BMI cut-offs for the Asian population, 43% of our sample was overweight (BMI: 23–27.5kg/m^2) and 36% was obese (BMI≥27.5 kg/m^2).

Postoperative SBT scores

Fig. 2 shows the smoothed model-predicted postoperative SBT over time. Overall, postoperative SBT scores improved (reduced) nonlinearly over time: a steep improvement rate was observed in the first 6 to 8 weeks, beyond which the improvement was more gradual. Based on the proportional odds model (Model 1), comparing the 2 timepoints at weeks 4 and 8, the estimated OR was 2.7 (95% credible interval [CrI],

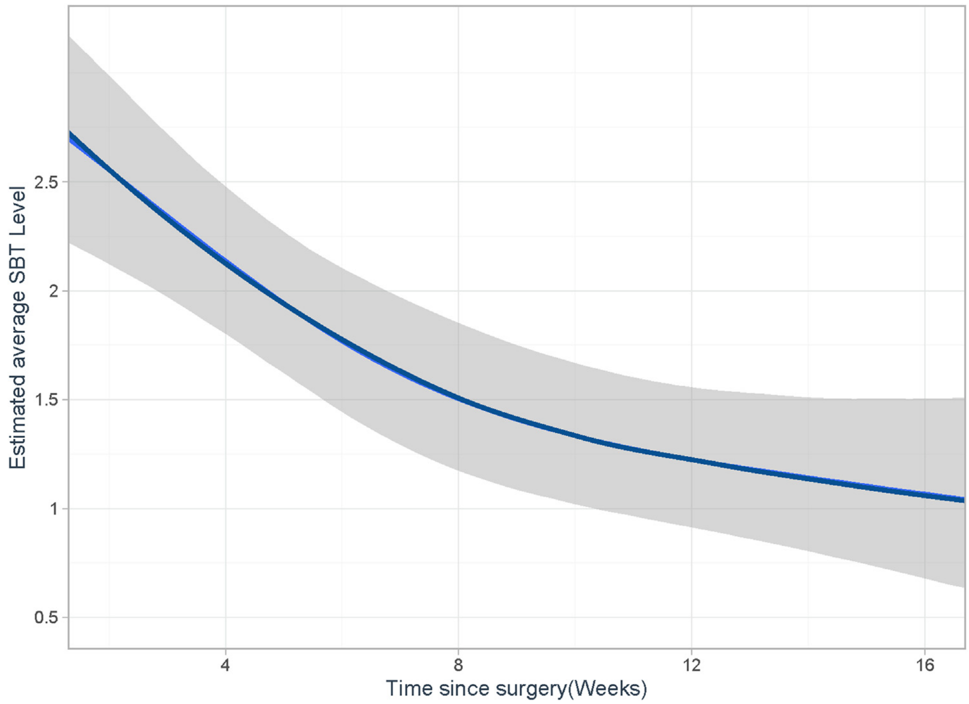

Fig. 2. Natural spline-smoothed predicted mean SBT levels with 95% credible intervals (shaded) over time post lumbar fusion surgery. Model 3 was used to generate model-predicted data.

Table 2
Predictors of SBT scores post lumbar fusion surgery.

Predictor	Comparison	OR (95% CrI)	Probability of effect size (%)*			Adjusted difference†
			OR>1.0	OR>1.5	OR>2.0	mean (95% CrI)
Model 1						
Age (years)	60 vs. 70	1.13 (0.74–1.54)	75.1	5.4	0.1	0.06 (-0.10 to 0.22)
BMI (kg/m^2)	28 vs. 23	1.10 (0.72–1.55)	68.8	5.0	0.2	0.04 (-0.14 to 0.21)
Gender	Men vs. Women	2.24 (1.01–3.92)	99.4	89.1	63.6	0.43 (0.12–0.77)
Model 2						
Preoperative pain intensity	8 vs. 3	2.24 (1.02–4.43)	99.5	88.7	62.3	0.24 (0.06–0.43)
Preoperative leg numbness	Good bit or most or all vs. none	1.16 (0.44–2.23)	65.4	24.2	7.8	0.04 (-0.17 to 0.32)
Preoperative leg weakness	Good bit or most or all vs. none	4.16 (1.70–7.53)	>99.9	99.9	98.6	0.61 (0.30–0.93)
Model 3						
Preoperative depressive symptoms	Good bit or most or all vs. none	4.78 (1.64–10.35)	>99.9	99.8	98.7	0.57 (0.17–0.96)
Model 4						
Early postoperative STarT Back Score	3 vs. 0	7.31 (1.15–31.36)	>99.9	99.5	97.6	0.62 (0.15–1.48)

SBT, STarT Back Screening Tool; BMI, Body Mass Index; OR, Odds Ratio; 95% CrI, 95% Credible Interval.
All models were Bayesian proportional-odds mixed-effects models with patient-level random intercepts and adjusted by time since surgery.
Model 1 included age, gender, and BMI.
Model 2 included demographic variables and preoperative back/leg symptoms.
Model 3 included demographic variables, preoperative back/leg symptoms, and preoperative depressive levels.
Model 4 included demographic variables, preoperative back/leg symptoms, preoperative depressive levels, and week-4 postoperative SBT scores.
For each predictor, adjusted ORs (95% CI) compare the odds of greater postoperative SBT scores between 2 comparison values. For example, other variables being equal, a patient with a back/leg pain intensity of 8 points had, on average, 2.3 times (95% CrI: 1.02–4.43 times) the odds of having greater popstoperative SBT scores relative to the patient with a pain intensity of 3 points. The posterior probability that back/leg pain intensity was associated with postoperative SBT at an OR exceeding 2.0 was 62%.

* Probability of posterior distributions of ORs exceeding 1.0 (null value), 1.5 (moderate effect size), and 2.0 (moderate-to-large effect size).

† Adjusted differences indicated the difference in week-12 SBT scores between the 2 comparison values of each predictor.

1.8–3.9). Specifically, the odds for greater postoperative SBT levels for an average patient at the week-4 timepoint was 2.7 times that for the average patient at the week-8 timepoint.

Risk factors

Table 2 shows the results of an ordinal mixed-effects regression model that used only the demographics variables of age, gender, and BMI (Model 1), a model that included demographics variables plus preoperative back/leg symptoms (Model 2), a model that included demographics variables plus preoperative back/leg symptoms plus preoperative depressive levels (Model 3), and a model that included Model 3 variables plus week-4 postoperative SBT scores (Model 4).

In Model 4, week-4 postoperative SBT was most strongly associated with greater postoperative SBT during the 12 weeks of follow-up (OR comparing week-4 SBT scores of 3 and 0 was 7.3 [95% CrI, 1.2–31.4]). Fig. 3 shows that the difference in expected week-12 SBT scores between week-4 SBT scores of 3 and 0 was 0.62 points (95% CrI, 0.15–1.48).

Demographics and preoperative characteristics that were independently associated with greater SBT levels over time included gender (OR comparing men and women was 2.2 [95% CrI, 1.0–3.9]; Model 1), preoperative back or leg pain intensity (OR comparing pain intensity of

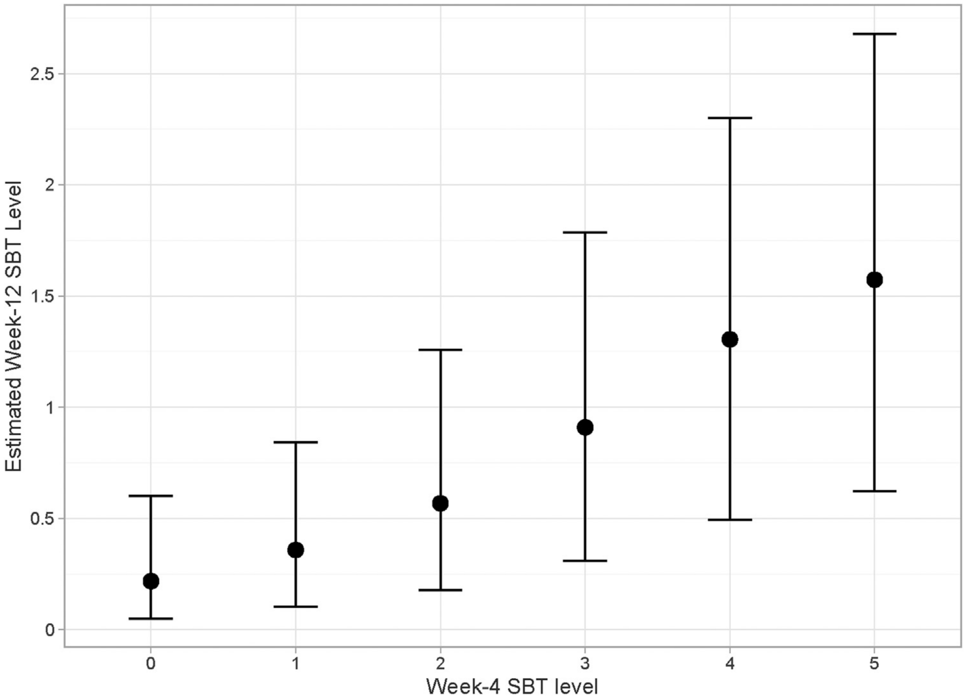

Fig. 3. Conditional associations of week-4 SBT scores with week-12 SBT scores. Error bars represent 95% credible interval for the regression estimates. To generate the partial plot from the Bayesian mixed-effects model (Model 1), model covariates were set at their median (continuous variables) or mode (categorical variables) values.

8 and 3 was 2.2 [95% CrI, 1.0–4.4]; Model 2), preoperative leg weakness (OR comparing highest and lowest weakness categories was 4.2 [95% CrI, 1.7–7.5]; Model 2), and preoperative depression levels (OR comparing highest and lowest depression categories was 4.8 [95% CrI, 1.6–10.4]; Model 3). Using an OR threshold of 2.0, the posterior probabilities of potentially clinically relevant associations of gender and preoperative back/leg pain intensity with postoperative SBT were ~63% whilst the posterior probabilities for preoperative leg weakness and depression both exceeded 95% (~98%). In contrast, age, BMI, and preoperative leg numbness had low (65%–75%) probability of any associations with postoperative SBT levels.

Discussion

The purpose of this longitudinal study was to track the trajectory and severity of the postoperative SBT and to identify the predictors of postoperative SBT in patients who underwent lumbar fusion. Our results show that postoperative SBT scores reduced over time (Fig. 2). Specifically, postoperative SBT scores at week-4 time point was significantly greater than SBT scores at week-8 (OR = 2.7; 95% CrI, 1.8–3.9). Additionally, greater SBT scores at week-4 were strongly associated with greater SBT scores throughout 12 weeks of follow-up (OR = 7.3; 95% CrI, 1.2–31.4). Factors associated with greater postoperative SBT levels over time were male gender (OR = 2.2; 95% CrI, 1.0–3.9), greater preoperative back or leg pain intensity (OR = 2.2; 95% CrI, 1.0–4.4), greater preoperative leg weakness (OR = 4.2, 95% CrI, 1.7–7.5) and higher preoperative depression levels (OR = 4.8; 95% CrI, 1.6–10.4). To our knowledge, this is the first study to report these findings in patients with lumbar fusion surgery (≤2 levels).

Postoperative SBT scores

As expected, SBT levels declined postoperatively, with the greatest decline occurring within the first 6 to 8 weeks postoperatively (Fig. 2). However, it is noteworthy that even at week 12, around 20% of the patients had moderate to high SBT. This is a sizable proportion, and our study results are similar to those of Power and colleagues (2019) [5] who found 17% of postoperative lumbar spine patients had depression symptoms at 3-months using the Hospital Anxiety and Depression Scale. Moreover, our findings also showed that more severe SBT scores at 4 weeks after surgery were strongly associated with worse SBT scores over 12 weeks of follow-up (OR = 7.3; 95% CrI, 1.2–31.4). As such, our findings highlight the need for close monitoring postoperatively, given that persistently high levels of postoperative psychological distress may eventuate in poor surgical outcomes [5].

Gender and SBT

We found that men had higher SBT scores than women postoperatively, which contrasts with recent reports that gender was not a risk factor for psychological distress (depression) symptoms experienced in patients after lumbar spine fusion surgery [22]. The explanation for our findings is uncertain but it is possible for gender differences to reduce over time, leading to more comparable scores between genders over the long term [23]. Hence future studies with longer follow-up data are needed to confirm our findings.

Pain and preoperative depression symptoms as a predictor of SBT

Our study demonstrated that greater preoperative self-reported back/leg pain and preoperative depression symptoms were strong predictors of greater postoperative SBT scores. Although we do not have similar studies to compare with, our results are plausible. It is possible that pain causes psychological distress [24] and also possible that both pain and depression coexist via neuroimmune and neuroinflammatory mechanisms [25]. The research literature is not clear whether pain causes psychological distress or does psychological distress cause pain. These 2 factors are bidirectional and mutually interactive, but are so closely intertwined that their origins are obscure. Even though the relationship between pain and psychological distress is complex and difficult to unravel, there may be important clinical implications of our findings.

Given that in patients who have undergone lumbar fusion, higher postoperative levels of anxiety and/or depression are associated with significantly higher healthcare costs and opioid use [4], it may be helpful to identify patients with high pain scores and significant depression symptoms preoperatively and closely monitor their mental health well-being and psychological distress postoperatively so that appropriate and timely intervention can be administered to prevent further complications and facilitate recovery.

Preoperative leg weakness associated with postoperative SBT

Our study is the first to our knowledge to show that preoperative self-reported leg weakness frequency was strongly associated with higher postoperative SBT scores (OR = 4.2; 95% CrI, 1.7–7.5). Although we lack studies to compare with, our study results are biologically plausible. In particular, previous studies have suggested that muscle weakness associated with lumbar stenosis may lead to gait disturbances [26] and reduced walking ability [27,28], and this may in turn lead to psychological distress. Because our analyses were adjusted for pain intensity, it is unlikely that this association was mediated by pain. Indeed, our findings are supported by Wahlman et al. [23], who found that a reduction in pain post lumbar surgery did not correlate proportionally with decrease in depression scores [23].

Given that 1 previous intervention study has demonstrated moderate associations between improvements in preoperative leg muscle strength and greater postoperative (1-year) physical activity levels [29], future studies are warranted to examine if improving leg weakness prior to surgery improves postoperative SBT scores, mediated by improvements in physical function.

Clinical implications

Our study has clinical implications. First, having an understanding of the trajectory of SBT during the postsurgery recovery period in patients after lumbar fusion surgery may instil confidence and give reassurance to patients as well as young clinicians that mild levels of psychological distress are expected in the initial postoperative phase. Second, our data could provide valuable information to assist in educating patients about what to expect after surgery. Third, our study highlights that high distress levels at week 4 were strongly predictive of worst SBT score over time, and this finding warrants the importance of early screening using the SBT to identify at-risk patient group of developing complex persistent low back pain post lumbar spine surgery.

Additionally, because psychological health screening is not a routine practice in a busy orthopedic practice, it is understandable that previous study demonstrated that spine surgeons from a single academic spine center failed to diagnose psychological disorders in up to 21% of cases despite their attempts to screen preoperatively [30]. This calls for attention for closer monitoring of psychological distress for patients undergoing spine surgery. Accordingly, the ease of scoring and brevity of the SBT makes it a valuable and efficient tool in a busy clinical setting to screen for psychological distress as it can be administered within 5 minutes.

Limitations

Our study has limitations. First, data collection was limited to a single institution and follow-up period was limited to 12-week for the self-reported SBT measures. Therefore, future larger multicenter cohort studies with longer-term follow-up are needed to confirm our findings. Second, our sample size was modest which limited our ability to assess potential interactions of risk factors with time. Third, although the present study has examined several preoperative clinical and demographic factors, we acknowledge that more detailed factors such as physical activity or step count should be considered. Fourth, while every effort was made to ensure timely data collection, our missing data rate ranged between 29% and 54% across the follow-up time points. Although we used a full-likelihood approach to reduce the potential biases caused by missing data, some residual bias is likely to remain.

Conclusion

In conclusion, our study findings showed that the trajectory of SBT score reduced over time postoperatively. However, a sizable proportion of patients reported moderate to high SBT scores 12-weeks postsurgery. Factors associated with greater postoperative SBT levels over time were being male, higher preoperative back or leg pain intensity, preoperative leg weakness and preoperative depression symptoms. Understanding the trajectory of SBT score over time may help clinicians to identify the at-risk patients of developing disabling back pain and lead to improved care. Additionally, identifying potentially modifiable preoperative factors of leg weakness and depression could open up opportunities to provide effective preventive care and education for at-risk patients post lumbar fusion surgery. Preoperative intervention may potentially optimize postoperative psychosocial health in patients undergoing lumbar fusion surgeries, however future studies are warranted to verify this.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

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