



Prediction of Objectively Measured Physical Activity and Self-Reported Disability Following Lumbar Fusion Surgery

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■ **OBJECTIVE:** To investigate the predictive value of preoperative fear-avoidance factors (self-efficacy for exercise, pain catastrophizing, kinesiophobia, and depression), walking capacity, and traditional predictor variables for predicting postoperative changes in physical activity level and disability 6 months after lumbar fusion surgery in patients with chronic low back pain (LBP).

■ **METHODS:** We prospectively enrolled 118 patients scheduled for lumbar fusion surgery for motion-elicited chronic LBP with degenerative changes in 1–3 segments of the lumbar spine. Associations between the predictors and the dependent variables were investigated with multiple linear regression analysis. Dependent variables were physical activity level as objectively measured with a triaxial accelerometer and disability as measured with the Oswestry Disability Index.

■ **RESULTS:** Preoperative physical activity level ($\beta = -0.349$; $P < 0.001$) and self-efficacy for exercise ($\beta = 0.176$; $P = 0.021$) were significant predictors of the postoperative change in physical activity. Preoperative disability ($\beta = -0.790$; $P < 0.001$), self-efficacy for exercise ($\beta = 0.152$; $P = 0.024$), and pain catastrophizing ($\beta = 0.383$; $P = 0.033$) were significant predictors for the change in the Oswestry Disability Index.

■ **CONCLUSIONS:** Patients with low levels of preoperative physical activity were more likely to increase their level of physical activity after lumbar fusion surgery, especially when their self-efficacy for exercise was high. However,

most of these patients still had low levels of physical activity after surgery, and they may therefore need extra support in increasing their postoperative physical activity levels.

INTRODUCTION

The most frequent reason for elective lumbar spine surgery is lumbar degenerative disease, including disc herniation, spinal stenosis, and chronic low back pain (LBP) caused by degenerative disc disease.^{1,2} The incidence and prevalence of lumbar fusion operations have increased by up to 300% worldwide over the past 2 decades,^{1,3,4} and lumbar fusion surgery caused the highest aggregate hospital costs of any surgical procedure in the United States in 2011.¹

A recent call for action highlighted the importance of incorporating a clearer health focus in the management of LBP.⁵ Increased physical activity contributes to better health^{6,7} and should be promoted to everyone, regardless of condition.⁸ Previously, we reported that 83% of patients with chronic LBP scheduled for lumbar fusion surgery did not adhere to the World Health Organization (WHO) recommendations on physical activity before surgery,⁹ suggesting that these patients may be at risk for poor health due to insufficient physical activity.⁸ Moreover, there was no statistically significant increase in the patients' physical activity 6 months after lumbar fusion surgery, despite reduced disability and pain (H. Lotzke et al., unpublished data, 2018).¹⁰ Similar results have been seen in patients with lumbar spinal stenosis 6

Key words

- Disability
- Lumbar fusion surgery
- Pain catastrophizing
- Physical activity
- Predictors
- Prognosis
- Self-efficacy

Abbreviations and Acronyms

- LBP:** Low back pain
ODI: Oswestry Disability Index
RCT: Randomized controlled trial
WHO: World Health Organization

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months after decompression surgery.¹¹ Considering the beneficial effects of physical activity,^{6,7} it is important to identify preoperative factors that can predict the postoperative change in physical activity after lumbar spine surgery. However, research into the prediction of lumbar fusion surgery outcomes primarily focuses on disability.¹²⁻¹⁴

Traditional variables in prediction models for disability include gender, smoking, and pain duration.¹⁵ Modern prediction models usually take a biopsychosocial approach and include both traditional and psychological variables, such as the factors found in the cognitive behavioral fear-avoidance model.^{13,16} This model describes 2 potential trajectories depending on how a patient interprets a pain episode. In the first trajectory (shown to the left in **Figure 1**), the model suggests that patients who respond to pain with catastrophizing thoughts may develop fear of movement (kinesiophobia in its extreme form). The model then proposes that the fear of movement gradually results in avoidance behavior, disability, and depression.¹⁶ In the second trajectory, patients who view the pain as nonthreatening and transitory go back to their usual activities and experience gradually reduced levels of disability and depression. Other investigators have added functional self-efficacy to the model, such that patients with low functional self-efficacy are more likely to develop disability compared with those with high functional self-efficacy (**Figure 1**).^{17,18} Previous studies have shown that high levels of preoperative fear of movement^{19,20} and pain catastrophizing¹³ are significant predictors for a poorer disability outcome after lumbar spine surgery.

The variables in the fear-avoidance model have mainly been used to predict postoperative changes in disability rather than physical activity.^{13,19,20} However, the fear-avoidance model describes how

psychological factors can result in avoidance behavior,¹⁶ and it can be assumed that avoidance behavior could in turn lead to decreased physical activity (**Figure 1**).¹⁷ The fear-avoidance model therefore has the potential to predict postoperative changes in physical activity. We further hypothesize that self-efficacy to exercise is more likely than functional self-efficacy to predict physical activity, as exercise represents a subset of physical activity. We also suggest that walking capacity is a potential predictor of postoperative changes in physical activity and disability based on findings in previous prediction studies^{21,22} and because walking capacity is highly correlated with health status.²³⁻²⁶

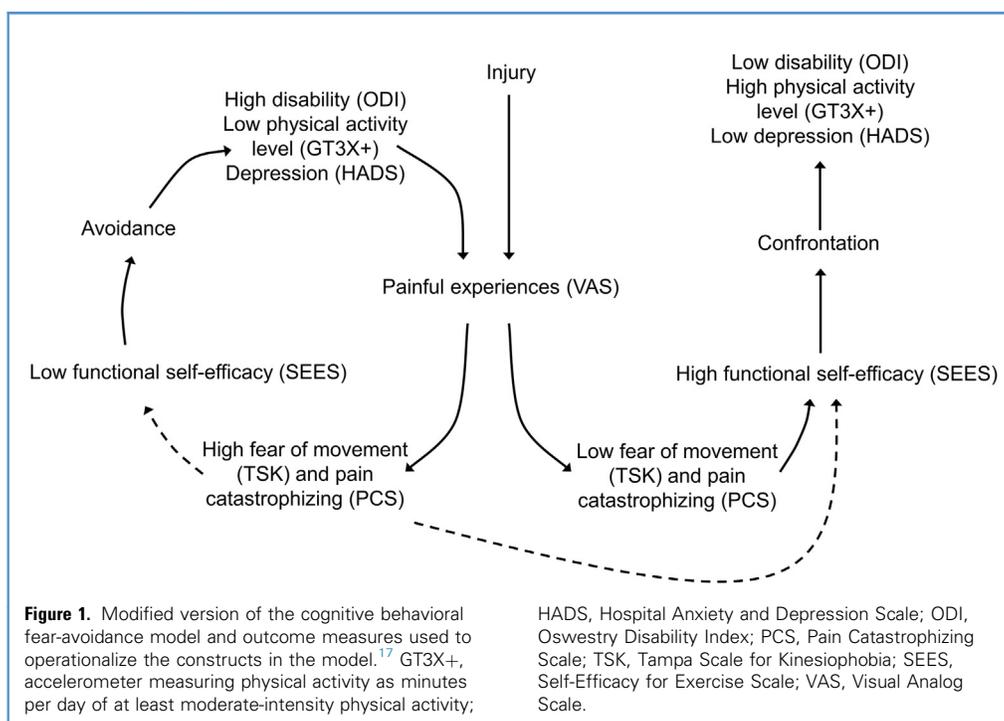
In summary, it is important to identify predictors of postoperative change in physical activity after lumbar spine surgery because of the importance of physical activity to overall health.^{6,7} Fear-avoidance factors and walking capacity seem to be promising variables for predicting the postoperative change of both physical activity level and disability for patients undergoing lumbar spine surgery but have not yet been investigated.

Aim

The aim of this study was to investigate the predictive value of preoperative fear-avoidance factors, walking capacity, and traditional predictor variables for predicting postoperative changes in physical activity level and disability 6 months after lumbar fusion surgery in patients with chronic LBP.

METHODS

This prospective cohort study included data from a randomized controlled trial (RCT).¹⁷ The procedure and intervention of the



RCT have been described in detail elsewhere¹⁷ and are summarized below.

Study Population

Patients 18–70 years of age scheduled for lumbar fusion surgery were recruited from 1 university hospital and 2 private spine clinics in Sweden. Patients with motion-elicited chronic LBP with degenerative changes in 1–3 segments of the lumbar spine were included. The patients' main surgical procedure was lumbar fusion surgery with the aim of alleviating back pain, but patients could have additional minor radiating symptoms with or without a simultaneous surgical procedure for disc herniation, isthmic spondylolisthesis, or foraminal stenosis. We excluded patients who had previously undergone decompression surgery for spinal stenosis or who had a confirmed neurologic or rheumatic disorder, spinal malignancy, dominating radiculopathy, deformities in the thoracolumbar spine such as idiopathic scoliosis, or a poor understanding of Swedish.

Procedure

Patients met with an independent observer 8–12 weeks before surgery at 1 of the spine clinics to fill out patient-reported outcome measures, perform 2 walking capacity tasks, and receive an accelerometer that measures physical activity. Patients were then randomly allocated to groups either participating in a prehabilitation program or receiving conventional care before surgery.¹⁷ The results of the RCT showed that there were no statistically significant differences between the groups in changes in disability and physical activity from baseline to the 6-month follow-up.¹⁰

Data from baseline and the 6-month postoperative assessment of the RCT¹⁷ were used for the purposes of the present study. This study adhered to the Code of Ethics of the World Medical Association (Declaration of Helsinki) and was approved by the regional ethical review board of Gothenburg (Dnr.586-11).

Outcome Measures

The selection of the dependent and predictor variables was primarily based on a modified version of the fear-avoidance model as described by Lotzke et al. (Figure 1).¹⁷ Other variables were included based on the empirical evidence presented in other studies investigating predictors for the outcome of lumbar spine surgery.^{13-15,21,22,27-30} The reliability and validity of the outcome measures used to measure the dependent and predictor variables have been described in detail elsewhere.¹⁷

Dependent Variables

- Physical activity level was measured with a GT3X+ accelerometer (Actigraph, Pensacola, Florida, USA) and expressed as minutes per day spent in at least moderate-intensity physical activity.³¹ Moderate-intensity physical activity is comparable to the intensity of a brisk walk.³² The accelerometer was worn for 7 consecutive days during waking hours, and data were included in the prediction analyses if the accelerometer had been worn for at least 10 hours per day for a minimum of 4 days.^{33,34}
- Disability was measured with the Oswestry Disability Index (ODI) version 2.0.^{35,36} The patient rated their perceived

disability on 10 items relating to pain intensity, personal care, lifting, walking, sitting, standing, sleeping, sex life, social life, and traveling.

Potential Predictors

- Age, gender, body mass index, sick leave at baseline (yes/no), previous back surgery (yes/no), smoking (yes/no), and back pain duration (≤ 2 years/ > 2 years) were self-reported in the questionnaire used in the Swedish Spine Registry (Swespine).²
- Back pain intensity level and referred leg pain intensity over the previous week were measured using 100-mm visual analog scales.³⁷
- Pain catastrophizing was measured using the Pain Catastrophizing Scale, which includes 13 items assessing catastrophizing thoughts about pain.³⁸
- Fear of movement was rated using the Tampa Scale for Kinesiophobia, which consists of 17 items assessing thoughts of fear of movement.³⁹
- Self-efficacy for exercise was measured using the Self-Efficacy for Exercise Scale. The patients rate their confidence that they could exercise 3 times per week (20 minutes each session) under 9 different conditions such as “if you experienced pain while you exercised” or “if you felt tired.”⁴⁰
- Depression was assessed using the Hospital Anxiety and Depression Scale, which includes 7 items assessing depressive symptoms.⁴¹
- Walking capacity was measured with 5-minute walking, defined as the distance the patient can walk in 5 minutes, and 15-meter walk, defined as the time it takes for a patient to walk 15 meters as fast as possible.⁴²

Statistical Analyses

Descriptive Statistics. Frequencies, means, medians, and their respective measures of statistical dispersion (percentages, standard deviations, and interquartile ranges) were calculated to broadly characterize the participants at baseline. Means at the 6-month follow-up as well as the change from baseline to the 6-month follow-up were calculated in addition to the baseline means for the dependent variables physical activity level and ODI. These calculations were performed for the whole sample as well as for quartiles based on preoperative physical activity level and disability. Fisher's exact test, independent samples t test, and Mann-Whitney U test were used to test for statistically significant baseline differences between patients who were included and excluded from the prediction analyses. The choice of methods for the descriptive statistics depended on the data level and distribution of each variable.

Handling of Missing Data. Patients who did not have sufficient accelerometer wear time at either baseline or the 6-month follow-up were excluded from the prediction analysis for physical activity, and patients who did not have any ODI data at either baseline or the 6-month follow-up were excluded from the prediction analysis for ODI. ODI questionnaires with internal missing items were scored by removing the missing

items and adjusting the scoring algorithm according to the manual.⁴³

Prediction Analyses. The associations between baseline variables with change scores (the difference between baseline and 6-month assessments) for physical activity level and ODI were investigated in 2 separate multiple linear regression models. A purposeful selection method with 3 steps was used to select predictors for the prediction models.⁴⁴

First, predictors associated with the dependent variable at a P value ≤ 0.25 in univariate regression analyses were carried forward to the second step of the analysis.

Second, the remaining predictors were included in a backward multiple regression analysis along with the baseline equivalent of the dependent variable. Including the baseline equivalent is a standard procedure in prediction analysis, because this variable is usually the most important predictor in the regression model.⁴⁵ Predictors with a P value > 0.15 were removed in the backward multiple regression analysis, if the β coefficients of the remaining predictors did not change more than 15%.

Third, the predictors that were excluded in the initial univariate regression analyses (step 1) were added back to the multiple regression model one by one and were kept only if they had a P value ≤ 0.15 . This final step was performed to identify predictors

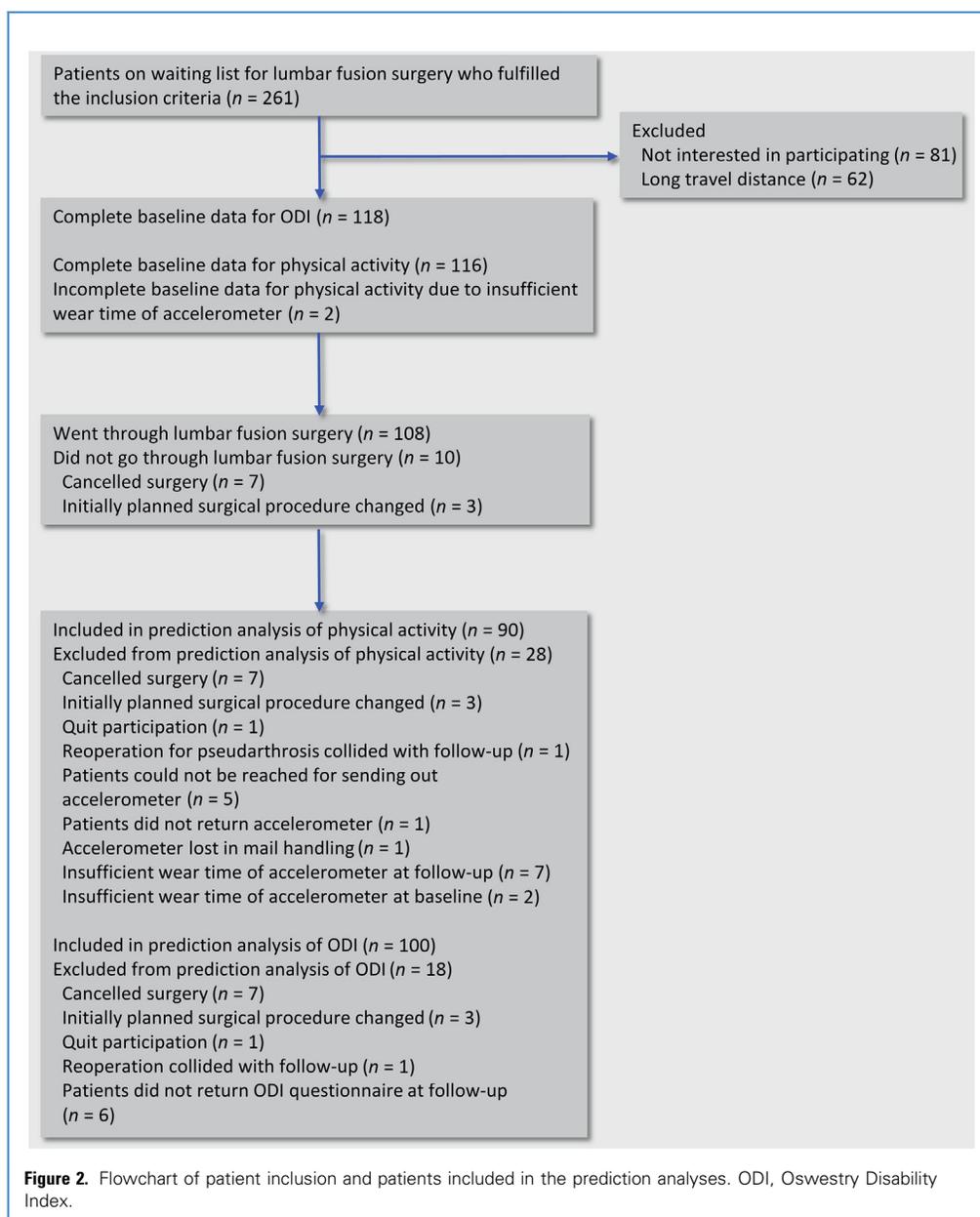


Table 1. Patient Characteristics at Baseline

Variable	Included in Prediction of Physical Activity (n = 90/118)	Excluded from Prediction of Physical Activity (n = 28/118)	<i>P</i> *	Included in Prediction of ODI (n = 100/118)	Excluded from Prediction of ODI (n = 18/118)	<i>P</i> †	Score Interpretation
Age, mean (SD)	46.4 (8.2)	43.5 (8.5)	0.12	46.6 (7.9)	41.0 (9.4)	0.01	Swespine: 46.0 years ²
Gender, n (%)			0.23			0.80	
Women	49 (54.4)	14 (50.0)	—	54 (54.0)	9 (50.0)		Swespine: 53% ²
Men	41 (45.6)	14 (50.0)	—	46 (46.0)	9 (50.0)		Swespine: 47% ²
Education level, n (%)			0.35			0.83	
Elementary school	5 (5.6)	2 (7.1)	—	7 (7.0)	0 (0.0)	—	—
High school	35 (38.9)	16 (57.1)	—	42 (42.0)	9 (50)	—	—
University or college	36 (40.0)	6 (21.4)	—	36 (36.0)	6 (33.3)	—	—
Vocational education	13 (14.4)	4 (14.3)	—	14 (14.0)	3 (16.7)	—	—
Missing information	1 (1.1)	0 (0.0)	—	1 (1.0)	0 (0.0)	—	—
Work status, frequency (%)			0.24			0.19	
Working	50 (55.6)	23 (82.1)	—	58 (58.0)	15 (83.3)	—	—
Partial sick leave/absence	14 (15.6)	3 (10.7)	—	16 (16.0)	0 (0.0)	—	—
Full-time absence	19 (21.1)	4 (14.3)	—	18 (18.0)	3 (16.7)	—	—
Unemployed	4 (4.4)	1 (3.6)	—	5 (5.0)	0 (0.0)	—	—
Missing information	3 (3.3)	0 (0.0)	—	1 (1.0)	0 (0.0)	—	—
Back pain duration, n (%)			0.15			0.72	
3–12 months	8 (8.9)	1 (3.6)	—	8 (8.0)	1 (5.5)	—	Swespine: 7% ²
>1 year to ≤2 years	17 (18.9)	3 (10.7)	—	17 (17.0)	3 (16.7)	—	Swespine: 18% ²
>2 years	63 (70.0)	24 (85.7)	—	73 (73.0)	14 (77.8)	—	Swespine: 74% ²
Missing information	2 (2.2)	0 (0.0)	—	2 (2.0)	0 (0.0)	—	—
Previous back surgery, n (%)			1.00			0.21	
0 occasions	80 (88.9)	27 (96.4)	—	89 (89.0)	18 (100.0)	—	Swespine: 69% ²
1 occasion	6 (6.7)	1 (3.6)	—	7 (7.0)	0 (0.0)	—	—
2 occasions	3 (3.3)	0 (0.0)	—	3 (3.0)	0 (0.0)	—	—
Missing information	1 (1.1)	0 (0.0)	—	1 (1.0)	0 (0.0)	—	—

ODI, Oswestry Disability Index; SD, standard deviation; GT3X+, accelerometer measuring physical activity level as minutes per day of at least moderate-intensity physical activity; VAS, visual analog scale; Swespine, Swedish Spine Registry (preoperative values for patients with low back pain caused by degenerative disc disease who underwent lumbar fusion in 2016 are presented).

**P* value for statistical significance testing between patients included and excluded from prediction analysis of physical activity. *P* values <0.05 are marked in bold.

†*P* value for statistical significance testing between patients included and excluded from prediction analysis of ODI. *P* values <0.05 are marked in bold.

‡Patients who did not go through surgery were not included in the statistical significance testing for the variables current surgical procedure and number of fusion levels.

Continues

Table 1. Continued

Variable	Included in Prediction of Physical Activity (n = 90/118)	Excluded from Prediction of Physical Activity (n = 28/118)	P*	Included in Prediction of ODI (n = 100/118)	Excluded from Prediction of ODI (n = 18/118)	P†	Score Interpretation
Current surgical procedure, n (%)			1.00			1.00	
Instrumented posterior fusion	85 (94.5)	17 (60.7)	—	94 (94.0)	8 (44.4)	—	Swespine: 36% ²
Instrumented combined posterior and interbody fusion	4 (4.4)	1 (3.6)	—	5 (5.0)	0	—	—
Instrumented anterior interbody fusion	1 (1.1)	0 (0.0)	—	1 (1.0)	0	—	Swespine: 17% ²
Did not go through fusion surgery‡	0 (0.0)	10 (35.7)	—	0 (0.0)	10 (55.6)	—	—
Number of fusion levels, n (%)			0.54			0.64	—
1 level	55 (61.1)	9 (32.1)	—	60 (60.0)	4 (22.2)	—	—
2 levels	31 (34.5)	8 (28.6)	—	35 (35.0)	4 (22.2)	—	—
3 levels	4 (4.4)	1 (3.6)	—	5 (5.0)	0 (0.0)	—	—
Did not go through fusion surgery‡	0 (0.0)	10 (35.7)	—	0 (0.0)	10 (55.6)	—	—
Body mass index, mean (SD)	26.1 (3.7)	27.2 (3.5)	0.16	26.3 (3.6)	26.4 (4.2)	0.88	—
Disability, ODI, mean (SD)	36.0 (11.8)	39.5 (13.8)	0.20	36.6 (11.8)	37.9 (15.2)	0.69	Swespine: 43.0 ²
Physical activity level, GT3X+, mean (SD)	29.9 (21.9)	22.4 (11.0)	0.02	29.0 (21.2)	23.9 (12.5)	0.32	Swedish norm values, 40–59 years: 33.3 minutes ⁴⁶
Back pain intensity, VAS, mean (SD)	59.0 (19.9)	67.9 (16.6)	0.04	60.6 (19.9)	63.8 (19.8)	0.53	Swespine: 67.0 ²
Leg pain intensity, VAS, median (interquartile range)	29.2 (3.4–59.4)	52.0 (22.5–66.3)	0.095	30.4 (3.4–59.9)	58.4 (9.9–68.0)	0.29	Swespine: 4.1 ²
Self-efficacy for exercise, Self-Efficacy for Exercise Scale, mean (SD)	62.2 (19.6)	57.8 (23.2)	0.32	61.6 (20.0)	58.5 (22.9)	0.55	—
Pain catastrophizing, Pain Catastrophizing Scale, mean (SD)	22.2 (8.0)	24.5 (8.4)	0.20	22.4 (8.1)	25.0 (7.7)	0.22	≥20: Threshold for pain catastrophizing ⁴⁷
Depressed mood, Hospital Anxiety and Depression Scale, mean (SD)	5.1 (3.6)	6.3 (3.5)	0.14	5.2 (3.7)	6.4 (3.2)	0.18	0–7: Normal level of depression ⁴⁸

Continues

Table 1. Continued

Variable	Included in Prediction of Physical Activity (n = 90/118)	Excluded from Prediction of Physical Activity (n = 28/118)	<i>P</i> *	Included in Prediction of ODI (n = 100/118)	Excluded from Prediction of ODI (n = 18/118)	<i>P</i> †	Score Interpretation
Fear of movement, Tampa Scale for Kinesiophobia, mean (SD)	37.4 (8.5)	40.7 (7.9)	0.08	37.8 (8.6)	41.0 (6.1)	0.19	≥37: Threshold for kinesiophobia ³⁹
Walking capacity, 5-minute walk, mean (SD)	425.7 (83.9)	396.0 (74.8)	0.09	420.5 (81.8)	408.1 (82.6)	0.55	Pain-free population, United States: 518 m ⁴²
Walking capacity, 15-meter walk, mean (SD)	9.2 (2.9)	9.3 (2.2)	0.82	9.3 (2.8)	9.0 (2.4)	0.71	Pain-free population, United States: 8.4 seconds ⁴²

ODI, Oswestry Disability Index; SD, standard deviation; GT3X+, accelerometer measuring physical activity level as minutes per day of at least moderate-intensity physical activity; VAS, visual analog scale; Swespine, Swedish Spine Registry (preoperative values for patients with low back pain caused by degenerative disc disease who underwent lumbar fusion in 2016 are presented).

**P* value for statistical significance testing between patients included and excluded from prediction analysis of physical activity. *P* values <0.05 are marked in bold.

†*P* value for statistical significance testing between patients included and excluded from prediction analysis of ODI. *P* values <0.05 are marked in bold.

‡Patients who did not go through surgery were not included in the statistical significance testing for the variables current surgical procedure and number of fusion levels.

that were significant in the presence of other predictors but not to the dependent variable alone.⁴⁴

The independent variables in the final model were controlled for multicollinearity and the standardized residuals from the final regression models were checked for normality and heteroscedasticity.

All statistical analyses were performed with SPSS version 24 (IBM Corp., Armonk, New York, USA).

RESULTS

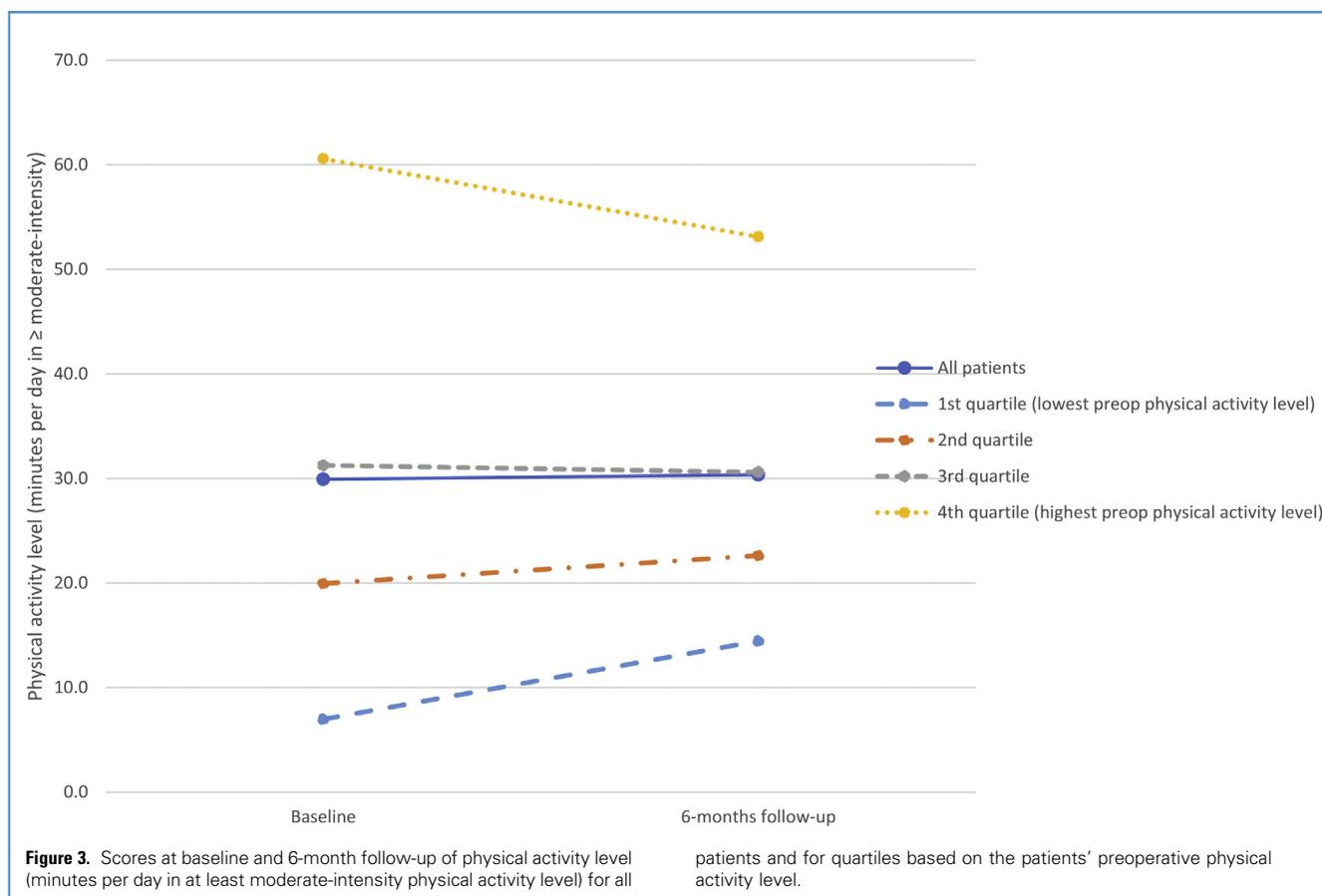
Missing Data

One-hundred and eighteen patients were included, 10 of whom did not receive lumbar fusion surgery (Figure 2). Two of the remaining 108 patients had incomplete accelerometer data for baseline physical activity level (1.9%) and 16 had incomplete data at the 6-month follow-up (16.7%), such that 90 patients

Table 2. Baseline Scores, 6-Month Follow-Up Scores, and Change Scores of Physical Activity Level and Oswestry Disability Index

Variable	Patients	Baseline (T1)	6-Month Follow-Up (T2)	Change Score (T2-T1)
Physical activity level (GT3X+),* mean (standard deviation)	All patients	29.9 (21.9)	30.4 (20.4)	0.5 (15.6)
	First quartile (lowest preoperative physical activity level)	7.0 (3.6)	14.5 (11.3)	7.5 (9.6)
	Second quartile	19.9 (3.1)	22.6 (11.2)	2.7 (11.0)
	Third quartile	31.3 (4.0)	30.6 (13.9)	-0.7 (15.0)
	Fourth quartile (highest preoperative physical activity level)	60.6 (17.0)	53.1 (19.7)	-7.5 (20.9)
Disability (Oswestry Disability Index), mean (standard deviation)	All patients	36.6	18.5	-18.1 (16.0)
	First quartile (lowest preoperative disability level)	23.3 (4.3)	17.2 (13.3)	-6.1 (13.6)
	Second quartile	31.9 (1.7)	15.0 (13.0)	-16.9 (12.6)
	Third quartile	39.4 (3.1)	21.3 (14.9)	-18.1 (15.2)
	Fourth quartile (highest preoperative disability level)	52.0 (9.2)	20.5 (14.8)	-31.5 (12.2)

*Accelerometer measuring physical activity level as minutes per day of at least moderate-intensity physical activity.



were included in the prediction analyses for physical activity. Eight of the 108 patients (7.4%) who received lumbar fusion surgery did not have any ODI data at the 6-month follow-up, leaving 100 patients for the ODI prediction analysis. Patients who were excluded from prediction analyses for physical activity had a significantly lower preoperative physical activity level and a higher back pain intensity compared with the included patients (Table 1). Patients who were excluded from prediction analyses for ODI were significantly younger compared with the patients included in the analyses. There were no other statistically significant differences between the groups.

ODI questionnaires had <1% of internal items missing. The number of internal missing items of the predictor variables was <2%, but there were no internal items missing for the predictors that were included in the final prediction models.

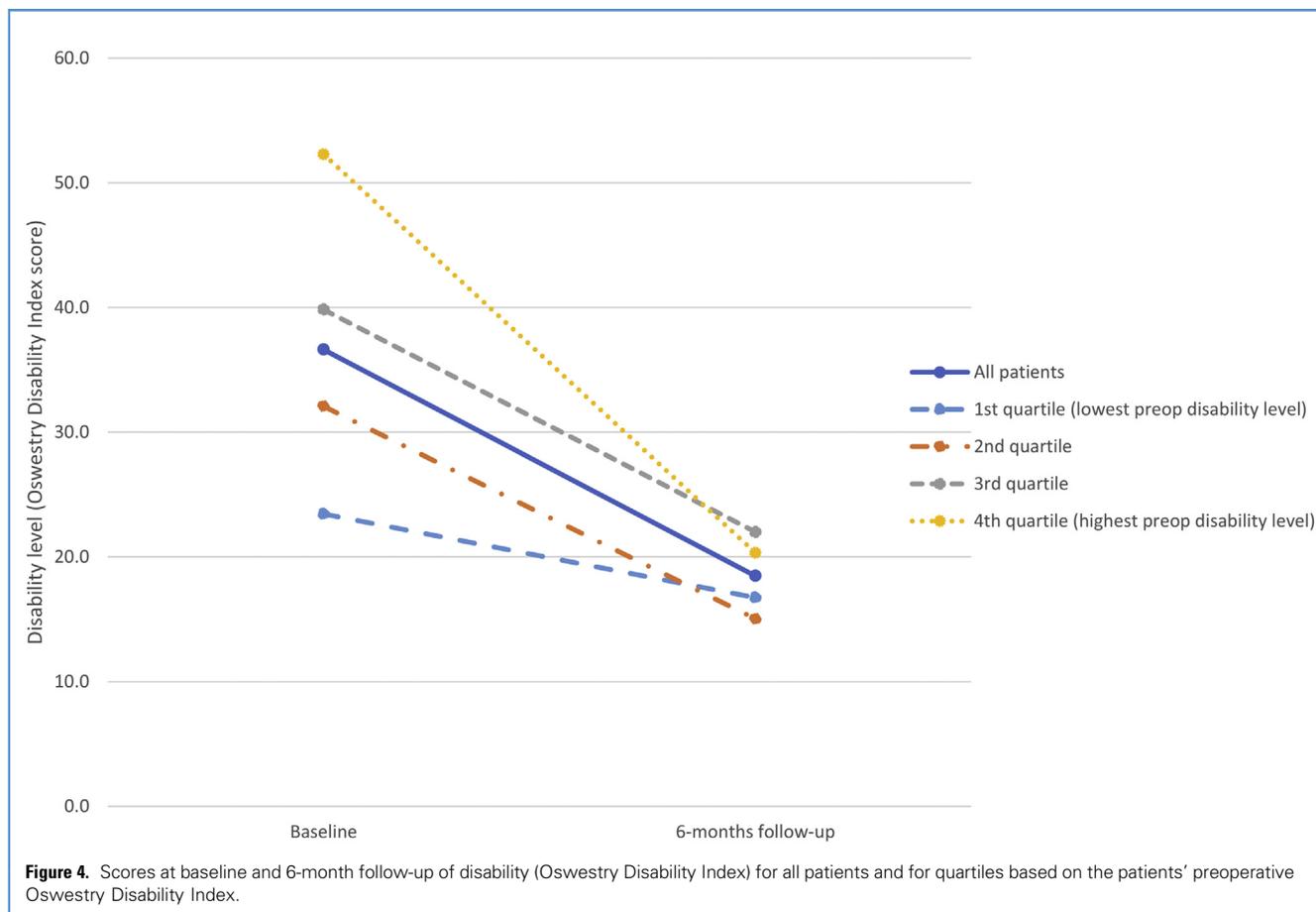
Descriptive Statistics

The baseline characteristics of the patients are presented in Table 1. Instrumented posterior fusion was the most common surgical procedure (94.5%). One patient had misplacement of pedicle screws and therefore underwent a reoperation 2 weeks after the first surgery. There were no other reported surgical complications among the patients who were included in the prediction analyses. On average, patients increased their level of physical activity defined as minutes per day in at least moderate-

intensity physical activity by 0.5 minutes (standard deviation = 15.6) and reported a decrease in ODI score of 18.1 points (standard deviation = 16.0) at the 6-month follow-up (Table 2). The changes from baseline to the 6-month follow-up for physical activity level and ODI for the entire sample as well as for quartiles based on the preoperative physical activity level intensity and ODI are summarized in Figures 3 and 4.

Prediction Analyses

Physical Activity Prediction Model. Preoperative physical activity level ($\beta = -0.349$; $P < 0.001$) and self-efficacy for exercise ($\beta = 0.176$; $P = 0.021$) were significant predictors of the change in level of physical activity from baseline to the 6-month follow-up ($R^2 = 0.251$) (Table 3). These results show that patients with a low preoperative level of physical activity were more likely to increase their postoperative physical activity level, relative to those with a higher preoperative level of activity ($R^2 = 0.204$). Figure 3 illustrates this relationship and shows that patients in the lowest quartile of preoperative physical activity level had the largest increase at the 6-month follow-up. The prediction model also shows that patients with a high preoperative self-efficacy for exercise were more likely to increase their postoperative physical activity level, although the explained variance for this association was low ($R^2 = 0.047$).



Prediction Model of Disability. Preoperative disability ($\beta = -0.790$; $P < 0.001$), self-efficacy for exercise ($\beta = 0.152$; $P = 0.024$), and pain catastrophizing ($\beta = 0.383$; $P = 0.033$) were significant predictors of the change in disability from baseline to the 6-month follow-up

($R^2 = 0.342$) (Table 3). These results indicate that patients with high preoperative ODI scores were more likely to have a larger reduction in postoperative disability compared with those with low preoperative disability ($R^2 = 0.278$). Figure 4 shows that

Table 3. Overview of the Prediction Models for Oswestry Disability Index and Physical Activity							
Model	Predictors	Unstandardized β	Standardized β	P	95% Confidence Interval for β		Explained Variance, R^2
					Lower	Upper	
Model 1: physical activity level	Constant	-0.081	—	0.987	-9.931	9.770	—
	Preoperative physical activity level	-0.349	-0.491	<0.001	-0.482	-0.216	Partial $R^2 = 0.204$
	Preoperative self-efficacy for exercise	0.176	0.221	0.021	0.027	0.325	Partial $R^2 = 0.047$
							Total $R^2 = 0.251$
Model 2: Oswestry Disability Index	Constant	-7.150	—	0.287	-20.416	6.116	—
	Preoperative Oswestry Disability Index	-0.790	-0.583	0.000	-1.026	-0.553	Partial $R^2 = 0.278$
	Preoperative self-efficacy for exercise	0.152	0.190	0.024	0.020	0.284	Partial $R^2 = 0.031$
	Preoperative pain catastrophizing	0.383	0.195	0.030	0.038	0.728	Partial $R^2 = 0.033$
						Total $R^2 = 0.342$	

patients in the highest quartile of preoperative ODI (high level of disability) had the largest reduction in disability at the 6-month follow-up. The prediction model shows that patients with high preoperative levels of self-efficacy for exercise ($R^2 = 0.031$) and pain catastrophizing ($R^2 = 0.033$) tended to have less favorable changes in ODI compared with those with low preoperative levels.

DISCUSSION

To our knowledge, this is the first study to investigate the predictive value of preoperative fear-avoidance factors and walking capacity for predicting postoperative changes in physical activity levels and disability 6 months after lumbar fusion surgery in patients with chronic LBP. Preoperative physical activity level and self-efficacy for exercise were significant predictors of the postoperative change in physical activity. Preoperative disability and the fear-avoidance factors self-efficacy for exercise and pain catastrophizing were significant predictors for the change in disability (ODI). Walking capacity was not a significant predictor of postoperative changes in either physical activity or disability.

The prediction results for postoperative changes in physical activity suggest that patients with a low level of preoperative physical activity are more likely to show a postoperative increase in their physical activity. Patients with a more sedentary lifestyle are therefore likely to experience the health-enhancing effects of physical activity after surgery, especially because physical activity can most benefit those who are more sedentary to begin with.^{6,7} However, the patients in our sample with low preoperative physical activity levels still had low physical activity levels after surgery, despite the changes. On average, patients in the lowest quartile of preoperative levels of physical activity (defined as minutes per day in at least moderate-intensity physical activity) increased their level of physical activity to 14.5 minutes per day at the 6-month follow-up. That value equals a physical activity level of 101.5 minutes per week, still lower than the WHO recommendations of 150 minutes per week.⁸ Patients with low levels of preoperative physical activity may therefore need additional support to reach the WHO recommendations for physical activity if that is one of the goals of the surgery.

The results of the prediction model for ODI suggest that patients with a high preoperative ODI are more likely to show a larger reduction in disability 6 months postoperatively. Similar findings have been reported previously.^{13,49} A likely explanation is that patients with high preoperative ODI scores simply have more room for improvement compared with patients with low preoperative scores. As shown in **Figure 4**, patients reached similar levels of disability at the 6-month follow-up almost regardless of their starting point, and most patients reached “minimal disability” ($ODI < 21$ ⁴³). These results raise concerns about whether the success of the surgery in relation to disability should be defined in terms of absolute change, relative change, or the final ODI score at the time of interest.

Fear-avoidance factors were significant predictors in the models, whereas traditional predictors such as gender, smoking, and back pain duration¹⁵ were not. The results of the fear-avoidance factors should, however, be interpreted with caution because of the small added explained variances above that of

the preoperative values of physical activity level and ODI. The result that low preoperative pain catastrophizing is predictive of larger reductions in disability is in line with a previous study of patients undergoing lumbar fusion surgery¹³ as well as other surgical procedures.⁵⁰⁻⁵⁵ The finding that high preoperative self-efficacy for exercise is predictive of a positive postoperative change in physical activity is in line with previous research into the predictive value of self-efficacy for patients undergoing various types of surgery.⁵⁶⁻⁵⁸ However, self-efficacy for exercise predicted changes in ODI in the opposite direction suggested by the fear-avoidance model.¹⁷ The fear-avoidance model that we used for this study includes functional self-efficacy,¹⁷ but we chose to instead measure self-efficacy for exercise to better predict physical activity. The contradictory result for ODI prediction is likely explained by the fact that self-efficacy for exercise may be a too distant construct to disability.

The main strength of the study is the use of accelerometers, which provide a more objective measurement of physical activity level compared with questionnaires assessing physical activity.⁵⁹ In contrast to such questionnaires, accelerometers are not reliant on accurate recall of the intensity, frequency, and duration of physical activity and are less subject to misinterpretation and social desirability bias.⁶⁰ However, a limitation of accelerometers worn on the hip is that they primarily measure ambulatory activities and cannot capture activities that predominantly involve upper body movement, such as weightlifting. Activities that cause little movement of the center of gravity of the body such as cycling are also not measured as accurately as walking or running. Levels of physical activity may therefore be underestimated for some individuals.⁶¹ However, research suggests that the results provided by accelerometers provide an accurate group-level representation of physical activity.³³

The patients included were part of an RCT, and potential selection bias may limit the generalizability of the results. First, we believe that the study sample had a higher level of preoperative physical activity and a lower preoperative disability level compared with the average patient undergoing lumbar fusion surgery for chronic LBP. Second, most of the patients underwent instrumented posterior fusion of 1 or 2 segments instead of more invasive types of lumbar fusion procedures. However, the patients were similar to patients in the Swedish Spine Registry (Swespine) registry who undergo lumbar fusion surgery for chronic LBP in terms of age, the proportion of men and women, and pain duration. It is therefore reasonable to assume that our findings are generalizable to most patients undergoing instrumented posterior fusion for chronic LBP. The results are probably less generalizable to patients with chronic LBP who are either very sedentary or have a high disability level before surgery.

In conclusion, patients with a low preoperative level of physical activity were more likely to increase their physical activity after lumbar fusion surgery, especially when their self-efficacy for exercise was high. However, patients with a low preoperative level of physical activity before surgery still had low levels of physical activity after surgery and may therefore need extra support to reach a sufficient level of physical activity.

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