Moving toward better health: exercise practice is associated with improved outcomes after spine surgery in people with degenerative lumbar conditions

Carolyn E. Schwartz, ScD
Roland B. Stark, MEd
Phumeena Balasuberamaniam, HBSc
Mopina Shrikumar, HBSc
Abeer Wasim, MSc
Joel A. Finkelstein, MD, MSc

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Correspondence to:
C. Schwartz
DeltaQuest Foundation, Inc.
31 Mitchell Rd
Concord MA 01742
carolyn.schwartz@deltaquest.org

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Background: Recovery and rehabilitation following surgery can take many months. Understanding what patients can do to facilitate recovery would be beneficial for spinal surgeons. This study sought to evaluate the impact of exercise practice, before and after surgery, on long-term outcomes of spine surgery in a robust clinical sample.

Methods: This prospective longitudinal cohort study included adult patients undergoing spinal surgery for degenerative spinal conditions. Patients were administered a survey that included preoperative and postoperative exercise practices and the following patient-reported outcome measures: the physical component score (PCS) and mental component score (MCS) of the Medical Outcomes Study 36-Item Short Form Survey (Rand-36), the Oswestry Disability Index (ODI) score, the Numeric Rating Scale (NRS) score for pain and the Patient-Reported Outcome Measurement Information System (PROMIS) Pain Interference Short Form score. Random effects models investigated the relationship of exercise, follow-up time and their interaction in predicting each patient-reported outcome measure over time, with and without sociodemographic covariates.

Results: There were 168 patients in the study sample with up to 12 months of follow-up data. Analysis revealed modest significant main effects of exercise on PCS, MCS, ODI and PROMIS scores and main effects of time on all outcomes. The exercise-by-time interaction was significant in predicting the trajectories of the ODI and MCS scores. When full models were adjusted for education and employment status, interaction effects were no longer significant, but exercise main effects remained significant for ODI score.

Conclusion: Patients who engage in exercise before and after spine surgery have better mental health and spine-specific recovery trajectories than those who do not. All health care providers should encourage patients to exercise while they are waiting for surgery within preoperative limitations and as soon as they are able after surgery and to continue this over the long term.

Contexte : Le rétablissement et la réadaptation postopératoires s’échelonnent parfois sur plusieurs mois. Comprendre ce que les patients peuvent faire pour faciliter leur rétablissement serait utile aux spécialistes de la chirurgie de la colonne vertébrale. Cette étude a voulu évaluer l’impact de la pratique d’exercices avant et après une chirurgie de la colonne vertébrale sur son issue à long terme dans un solide échantillon clinique.

Méthodes : Cette étude de cohorte longitudinale prospective a regroupé des patients adultes qui devaient subir une chirurgie de la colonne vertébrale pour des maladies dégénératives. Les patients ont été invités à répondre à un questionnaire qui portait entre autre sur la pratique d’exercices pré- et postopératoires et sur les paramètres autorapportés suivants : scores aux composantes physique (PCS) et mentale (MCS) du questionnaire SF-36 (Medical Outcomes Study 36-Item Short Form Survey [Rand-36]), à l’échelle d’incapacité d’Oswestry (ODI), à une échelle d’évaluation numérique (ÉÉN) de la douleur et au questionnaire PROMIS (Patient-Reported Outcome Measurement Information System) sur l’interférence de la douleur. Des modèles à effets aléatoires ont permis d’analyser les liens entre l’exercice, la durée du suivi et leur interaction pour ce qui est de prédire chacun des paramètres autorapportés au fil du temps, avec et sans les covariables sociodémographiques.

Résultats : L’étude a regroupé 168 patients et les données pour un suivi allant jusqu’à 12 mois. L’analyse a fait émerger des effets majeurs significatifs...
Exercise is a health-enhancing behaviour, and there is a broad evidence base suggesting its benefits for physical and mental health. The benefits of exercise have paralleled those of drug therapy in protecting against mortality for cardiovascular conditions and diabetes and in reducing anxiety and depression in older adults.

Exercise is a reserve-building activity that people can do independently at relatively low cost and across the disability spectrum. It can have collateral benefits in terms of social support, cardiovascular health and cognitive function in both healthy and chronically ill populations. The impact of exercise on cognitive function is particularly important in terms of optimizing a range of executive functions. Consequently, exercise enhances cortical plasticity and brain maintenance.

Exercise is widely prescribed as symptomatic treatment of acute and chronic back pain; however, the level of the evidence for individual studies is low. Exercise is often operationalized in terms of physiotherapy interventions, such as segmental stabilizing exercises; mobilization, motor control or traction exercises; back flexibility and strength exercises; or exercise tolerance on a treadmill. Stress-testing has been used as an indicator of baseline trajectory of recovery after spinal surgery is limited to small samples and low-level evidence. Exercise intervention studies have not, however, demonstrated the long-term impact of exercise on patients who have undergone spinal decompression surgery, but they have suggested that the supervised introduction of aggressive exercise may reduce disability and pain after lumbar discectomy and may speed the attainment of recovery milestones after lumbar fusion surgery. Much of the existing evidence on exercise in orthopedic patients comes from studies with small sample sizes, which limited their ability to detect exercise benefits. In other orthopedic subspecialties, the benefits of the preoperative practice of exercise with respect to the trajectory of outcome have been studied. A systematic review of a small number of clinical trials suggested that exercise may be beneficial after total hip arthroplasty, although there was insufficient evidence to support specific recommendations.

Spinal surgeons promote the concept of maintaining activity when advising patients with back pain, but they may often advise against activity out of fear of doing harm. Given the multifaceted potential benefits of exercise, the present study sought to evaluate the impact of exercise practice, before and after surgery, on the long-term outcomes of spine surgery in a robust clinical sample.

**Methods**

**Sample and design**

This longitudinal study included adults who were recruited from 4 active spine surgery practices from an academic teaching hospital. Eligibility criteria included...
being older than 18 years and having a diagnosis of a degenerative lumbar spinal disorder of disc herniation, neurogenic claudication, degenerative spondylolisthesis or lytic spondylolisthesis. The surgical indication was leg pain with or without back pain. Exclusion criteria were having had a prior lumbar surgery at the same level and not being able to understand English survey-related documents. Surgery was electively planned. The patient needed to be competent to complete self-reported questionnaires.

Eligible patients were recruited consecutively by the clinical research assistants, and study participation was thoroughly explained. All patients provided written informed consent before completing any questionnaires. Data were collected online or by mail at presurgery (up to 2 baselines; i.e., up to 2 presurgical survey assessments) and at 6 weeks, 3 months, 6 months and 12 months after surgery using a secure interface compliant with the Health Insurance Portability and Accountability Act (Alchemer). The study was reviewed and approved by the Sunnybrook Research Ethics Board.

### Measures

The Medical Outcomes Study 36-Item Short-Form Survey (Rand-36)\(^\text{10}\) was used to assess physical and emotional functioning via the physical and mental component scores (PCS and MCS, respectively). Spine-specific disability was measured using the 10-item Oswestry Disability Index (ODI).\(^\text{31}\) Pain impact was measured using 4 Numeric Rating Scale (NRS) items to assess pain at rest, pain with activity, back pain and leg pain\(^\text{32}\) and using the 6-item Patient-Reported Outcome Measurement Information System (PROMIS) Pain Interference Short Form.\(^\text{33}\) To facilitate interpretation of the patient-reported outcome (PRO) measures, all were scored such that high scores reflect better functioning; that is, ODI, NRS and PROMIS Pain Interference scores were recoded to achieve this interpretation.

Demographic characteristics were included for descriptive purposes and to serve as control variables. Exercise practice was determined on the basis of patient responses to questions at baseline and over the course of follow-up about the frequency of muscle-strength exercises, nonstop aerobic activity, and yoga or Pilates. Response options (coded item score) included not allowed (0), rarely or never (1), 1–2 times per week (2), and 3 or more times per week (3). The exercise score was a summation of the patient’s responses to the 3 questions, with a possible total score ranging from 0 to 9.

### Statistical analysis

Random effects models\(^\text{34}\) were used to investigate the relationship between exercise and follow-up time on PRO scores over time, before and after adjusting for education level and employment status. Analyses were conducted on the subsample of patients with at least 2 follow-up records. Dependent variables (PROs) were standardized for use in multivariable analysis (mean 50, standard deviation [SD] 10) to facilitate comparison of parameter estimates. Study identification was treated as a random effect, while exercise, time, their interaction, and covariates were treated as fixed effects. We began by testing simple main effects of exercise and time in predicting PRO scores over time and then added the exercise-by-time interactions. We then adjusted the main effects and interaction models for covariates (education, employment status). Final models were selected on the basis of a type I error rate of 0.05. Stata release 15 (StataCorp LLC) and SPSS version 26 (IBM) were used for the analyses.

### RESULTS

The surgical indication was leg pain with or without back pain. Table 1 shows the distribution of diagnoses and primary procedures, as well as the demographic characteristics of the sample. A total of 168 patients had at least 2 follow-up records and were included in the analysis. The study patients had a mean age of 60.59 (SD 16.12) years and there were an equal number of men and women. They had an average of 1.90 comorbidities (range 0–6), with the most common being hypertension and osteoarthritis. The majority of the patients had more than a college degree, and about one-third were employed. Less than 5% reported being on workers’ compensation currently or in the recent past.

Table 2 shows descriptive statistics for the exercise items and total score and for the PRO scores. It is notable that most of the patients either were not allowed to or chose not to engage in the exercise types assessed at baseline. Indeed, only 37% (n = 62) engaged at least once a week in muscle-strength training, 29% (n = 49) in aerobic exercise and 9% (n = 15) in yoga or Pilates. In response to the question asking “Do you usually walk or bicycle to work?” 8% of patients (n = 13) responded that they usually walk to work; none indicated that they usually bicycle to work. PRO scores indicated very low physical and very low mental functioning at baseline, as well as high pain levels and spine-specific disability.

### Association between exercise, time and patient-reported outcomes

Random effects models revealed modest but statistically significant main effects of exercise and time on PCS, MCS, PROMIS Pain Interference and ODI scores (Table 3). There were significant exercise-by-time interactions in predicting the MCS and the ODI
trajectories in these unadjusted models (Appendix 1, available at canjsurg.ca/010620-a1). When full models were adjusted for education and employment status, interaction effects were no longer significant (Appendix 1), but the main effect of exercise remained significant for the ODI (Table 3 and Appendix 1). The main effect of time remained significant for all of the PROs (Table 3).

Figure 1 illustrates associations with exercise, with and without covariate adjustment. According to common criteria, the effect size was “small” in the...
unadjusted and adjusted models predicting the ODI score, in the unadjusted model predicting the PCS score and (arguably) in the adjusted model predicting the MCS score. It did not meet the common threshold for “small” in predicting the other spine outcomes. The following illustrates the strength of the largest effect: the adjusted exercise coefficient on an ODI score of 0.78 suggests that the 2-step difference between aerobic exercise categories “rarely or never” and “3 or more times per week” implies an ODI score difference of 1.6 points, where the standardized mean ODI score is 50 and the SD is 10.

These analyses suggest that the links between exercise and outcomes could also be explained by education and employment status. We thus examined how the available demographic characteristics predicted exercise practice by computing separate random effects models testing demographic predictors separately after adjusting for time and predicting the exercise score. The results revealed that people who were male, currently working and younger were more likely to exercise (Table 4).

**DISCUSSION**

Results of the present study suggest that exercise and time since surgery are associated with improved outcomes in models not adjusted for sociodemographic covariates. When the models were adjusted for sociodemographic covariates, only spine-specific disability and mental health trajectories showed a beneficial link with exercise. A similar pattern occurred with models evaluating the differential effect of exercise on time to improved mental health and spine-specific disability outcomes (i.e., exercise-by-time interactions). Rather than seeing these findings as undermining the role of exercise, we wonder whether a propensity to exercise may be bundled with other salutogenic characteristics. For example, people who exercise may be more likely to be disciplined, may have better executive functioning, may be more likely to listen to their doctor or may be more likely to engage in better health behaviours such as following a healthy diet and not smoking. We did find that some patient subgroups may be more likely to exercise (men, patients who are currently working and younger patients). Surgeons cannot influence a patient’s sex, employment status or age, but they can encourage patients to engage in exercise as a lifestyle choice. This would be a worthwhile focus of the provider–patient encounter.

Although there is a strong theoretical basis to support the implementation of an exercise protocol, the variability in its benefits described by PROs after lumbar spine surgery suggests that the effects of physical activity as an intervention for chronic low back pain are complex and may depend on several factors such as timing, duration and type of exercise. As there is insufficient evidence to suggest the use of one form of
Table 3. Results of longitudinal random effects models evaluating main effects, without and with covariate adjustment

| Predictor or covariate | Without covariate adjustment | | | With covariate adjustment | | |
|------------------------|-----------------------------|---|---|-----------------------------|---|---|
|                        | b  | SE  | p value | b  | SE  | p value |
| **Rand-36 physical component score** | | | | | | |
| Time | 0.022 | 0.002 | < 0.001 | 0.019 | 0.003 | < 0.001 |
| Exercise score | 0.600 | 0.186 | 0.001 | 0.31 | 0.35 | 0.37 |
| Education | | | | | | |
| Some college | -0.48 | 2.08 | 0.82 | | | |
| College | 3.62 | 1.89 | 0.06 | | | |
| Postgraduate | 2.14 | 1.95 | 0.27 | | | |
| Employment | | | | | | |
| Currently working | 6.73 | 1.73 | < 0.001 | | | |
| Retired | -1.15 | 1.76 | 0.51 | | | |
| **Rand-36 mental component score** | | | | | | |
| Time | 0.009 | 0.002 | < 0.001 | 0.004 | 0.003 | 0.16 |
| Exercise score | 0.367 | 0.172 | 0.033 | 0.46 | 0.37 | 0.21 |
| Education | | | | | | |
| Some college | 6.96 | 2.29 | < 0.001 | | | |
| College | 3.67 | 2.09 | 0.08 | | | |
| Postgraduate | 5.62 | 2.15 | 0.01 | | | |
| Employment | | | | | | |
| Currently working | 0.62 | 1.85 | 0.74 | | | |
| Retired | 7.06 | 1.89 | < 0.001 | | | |
| **PROMIS Pain Interference score** | | | | | | |
| Time | 0.030 | 0.002 | < 0.001 | 0.026 | 0.003 | < 0.001 |
| Exercise score | 0.376 | 0.182 | 0.039 | 0.35 | 0.31 | 0.26 |
| Education | | | | | | |
| Some college | 1.13 | 1.76 | 0.52 | | | |
| College | 2.81 | 1.60 | 0.08 | | | |
| Postgraduate | 1.37 | 1.65 | 0.40 | | | |
| Employment | | | | | | |
| Currently working | 1.34 | 1.50 | 0.37 | | | |
| Retired | 1.27 | 1.51 | 0.40 | | | |
| **Oswestry Disability Index score** | | | | | | |
| Time | 0.027 | 0.002 | < 0.001 | 0.023 | 0.003 | < 0.001 |
| Exercise score | 0.584 | 0.163 | < 0.001 | 0.78 | 0.29 | 0.01 |
| Education | | | | | | |
| Some college | 2.65 | 1.76 | 0.13 | | | |
| College | 3.93 | 1.61 | 0.01 | | | |
| Postgraduate | 2.56 | 1.65 | 0.12 | | | |
| Employment | | | | | | |
| Currently working | 4.65 | 1.47 | < 0.001 | | | |
| Retired | 4.23 | 1.48 | < 0.001 | | | |
| **Numeric Rating Scale** | | | | | | |
| Time | 0.030 | 0.002 | < 0.001 | 0.024 | 0.003 | < 0.001 |
| Exercise score | -0.016 | 0.182 | 0.93 | 0.21 | 0.32 | 0.51 |
| Education | | | | | | |
| Some college | 1.73 | 1.88 | 0.36 | | | |
| College | 2.81 | 1.72 | 0.10 | | | |
| Postgraduate | 3.23 | 1.76 | 0.07 | | | |
| Employment | | | | | | |
| Currently working | 0.07 | 1.58 | 0.96 | | | |
| Retired | 0.12 | 1.59 | 0.94 | | | |

PROMIS = Patient-Reported Outcome Measurement Information System; Rand-36 = Medical Outcomes Study 36-Item Short-Form Survey; SE = standard error.

*Score recoded such that high scores reflect better functioning. Each outcome is standardized to have mean 50, standard deviation 10.
Exercise over another, a more patient-tailored approach is recommended. Exercise is not appropriate for patients with certain spinal conditions, such as acute disc herniations with severe sciatica. Nerve root irritations are associated with different levels of impairment with acute to chronic sciatica symptoms. The patient with an acute disc injury may not be able to exercise but the patient with a more chronic disc herniation may have tolerance limitations and be able to exercise to some extent. The patients in our study sample would be more in the latter category, as patients with spinal stenosis may also feel pain with walking beyond a particular distance. Our results indicate that exercise within the patient’s tolerance limitations is beneficial for surgical outcome, and surgeons should encourage this rather than prescribing complete rest.

Furthermore, it is worth noting that the psychosocial effects of chronic low back pain, such as fear-avoidance behaviours, kinesiophobia and anxiety, should be taken into consideration as a potential barrier to physical activity when trying to encourage patients to implement exercises before and after surgery. There is some evidence to suggest that a combination of exercise and cognitive-behavioural therapy when implemented within the first month after surgery is more effective at reducing disability and improving health-related quality of life measures than exercise alone. In addition, although preoperative fear of movement has not been found to be predictive of poorer surgical outcomes, postoperative fear of movement was independently associated with increased postoperative pain intensity and disability.

| Table 4. Results of separate random effects models predicting exercise score |
|---------------------------------------------------------------|
| Predictor or covariate | Coefficient | SE  | z    | P > |z| |
| Sex (male = 1; female = 2) | -0.01 | 0.00 | -1.74 | 0.08 |
| Comorbidities | 0.09 | 0.12 | 0.72 | 0.47 |
| Married | 0.16 | 0.24 | 0.67 | 0.50 |
| Education | |
| Some college | -0.44 | 0.28 | -1.57 | 0.12 |
| College graduate | 0.08 | 0.25 | 0.30 | 0.76 |
| Postgraduate | 0.23 | 0.25 | 0.89 | 0.37 |
| Employment status | |
| Currently working | 0.76 | 0.28 | 2.73 | 0.01 |
| Retired | 0.17 | 0.28 | 0.58 | 0.56 |
| Smoking | |
| Used to smoke | -0.24 | 0.20 | -1.18 | 0.24 |
| Currently smoke | -0.22 | 0.37 | -0.60 | 0.56 |
| Age | -0.34 | 0.15 | -2.23 | 0.03 |

SE = standard error.
Limitations

Although our sample is of robust size and we followed participants sufficiently after lumbar spinal surgery to enable a meaningful assessment of the connection between exercise and spine outcomes, the limitations of the study should be acknowledged. First, our study was best able to address muscle-strength training and aerobic exercise. It is unfortunate that there were too few yoga practitioners to permit subgroup analysis. Imaging research has demonstrated a preventive benefit of yoga against degenerative disc disease, and emerging evidence from clinical trials and observational research has suggested short-term benefits in terms of pain, depression and anxiety in people with chronic low back pain. There is some imaging evidence of longer term disc and vertebral changes in patients with lower back pain who participated in a yoga intervention. Future research might address the impact of encouraging a 3-pronged exercise routine (encouraging muscle-strength training, aerobic exercise and yoga) in this patient population as soon after spine surgery as is deemed safe by their physician. A second limitation is that we could not control for unmeasured factors that are associated with patient preferences to engage in exercise. It is possible that the benefit of exercise after spine surgery is confounded with the aforementioned “bundle” of unmeasured factors.

Conclusion

Our study of patients undergoing spine surgery indicates a benefit of exercise practice (strength training, aerobic exercise, yoga or Pilates) that is maintained preoperatively and as tolerated throughout follow-up (within procedure-specific limitations). People who maintain their exercise may experience more rapid improvements in their mental health and spine-specific disability, although such benefits may be dependent on other bundled characteristics. These findings support encouraging patients to engage in exercise to the extent they can and helping them reduce barriers to this salutogenic practice. This study is the first level-2 evidence demonstrating the beneficial effect of a patient’s personal exercise practice maintained preoperatively and continuing as tolerated postoperatively. Surgeons and other health care providers should be educated to avoid discouraging patients from exercising while they are awaiting spine surgery. Disseminating this information widely will facilitate optimal spine surgery outcomes in many domains. This is particularly relevant given the long surgical waiting lists and unexpected delays that have occurred during the COVID-19 pandemic.

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