Prehabilitation and early rehabilitation after spinal surgery: randomized clinical trial

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Objective: To evaluate the outcome after spinal surgery when adding prehabilitation to the early rehabilitation.

Design: A randomized clinical study.

Setting: Orthopaedic surgery department.

Subject: Sixty patients scheduled for surgery followed by inpatient rehabilitation for degenerative lumbar disease.

Interventions: The patients were computer randomized to prehabilitation and early rehabilitation (28 patients) or to standard care exclusively (32 patients). The intervention began two months prior to the operation. The prehabilitation included an intensive exercise programme and optimization of the analgesic treatment. Protein drinks were given the day before surgery. The early postoperative rehabilitation included balanced pain therapy with self-administered epidural analgesia, doubled intensified mobilization and protein supplements.

Main measures: The outcome measurements were postoperative stay, complications, functionality, pain and satisfaction.

Results: At operation the intervention group had improved function, assessed by Roland Morris Questionnaire ($P = 0.001$). After surgery the intervention group reached the recovery milestones faster than the control group (1–6 days versus 3–13, $P = 0.001$), and left hospital earlier (5 (3–9) versus 7 (5–15) days, $P = 0.007$). There was no difference in postoperative complications, adverse events, low back pain and radiating pain, timed up and go, sit-to-stand or in life quality. Patient satisfaction was significantly higher in the intervention group compared with the control group.

Conclusion: The integrated programme of prehabilitation and early rehabilitation improved the outcome and shortened the hospital stay – without more complications, pain or dissatisfaction.

Introduction

An increasing number of patients undergo spinal surgery. Between 1999 and 2001 the frequency increased by more than 200% in the USA, to 61 operations per 100 000 inhabitants.1 In Denmark the
number increased from 26 to 46 per 100,000 between 1997 and 2003. A review of the literature shows that elective spinal surgery for degenerative disease is still related to a significant hospital stay, second surgery rate2,3 and risk of developing postoperative complications.4 The development of better patient clinical pathways with improved outcome in this field is therefore attractive.

In recent years early rehabilitation including fast-track surgery has been introduced to overcome complications, fatigue and delayed convalescence after several surgical interventions.5,6 Early rehabilitation involves coordinated effort, combining modern concepts of patient education with newer anaesthetic and analgesic techniques and minimally invasive surgical techniques; the intention is to reduce the stress response, and to minimize pain and discomfort.7

In addition, prehabilitation is effective in reducing the risk of postoperative complications and hospital stay. Prehabilitation is defined as augmenting functional capacity prior to surgery.8 Evidence-based programmes have already been developed regarding smoking and alcohol cessation intervention, nutrition among others.9–11 However, to our knowledge an integrated perioperative programme including both prehabilitation and early rehabilitation has not been evaluated previously. We hypothesized that an integrated programme for elective spine surgery would result in well-informed patients prepared to play a very active role in the pre- and postoperative period. After the operation patients would experience a shorter time with disability.

The aim of this study was to evaluate the effect of an integrated programme combining prehabilitation and early rehabilitation on outcome after elective spinal surgery for degenerative disease, compared with the clinic’s routine procedures.

Methods

In the 18-month trial period from 2003 to 2005, 88 consecutive patients were referred and scheduled for surgery at the list for elective lumbar spinal surgery for degenerative disease with low back pain and radiating pain. Routinely, these patients had their final indication for surgery established by the surgeon shortly before the operation. Due to the eight weeks prehabilitation programme the patients needed to be included in due time before surgery, and sometimes before the final indication was established. Therefore, it was accepted to include some patients, who in the end did not need an operation. The surgeons made the decision of surgery or no surgery without knowledge of the allocation.

The routine included inpatient rehabilitation. Inclusion criteria were age over 18 years, being able to understand and actively participate in the integrated programme. Fifteen patients did not fulfil these criteria, since they underwent early surgery. Therefore, 73 patients were included and randomized after informed consent 6–8 weeks before scheduled operation. The exclusion criteria were contraindications to surgery in general as well as specific criteria to this study. They include contraindications to the use of epidural catheter, allergy to paracetamol, opiates or analgesics for regional anaesthesia, liver disease, nephropathy or pregnancy. In six of the 73 patients there was no indication of surgery at the time of the planned procedure; one of these six patients cancelled the operation because the pain resolved. Three other patients underwent surgery at another hospital, and 4 withdrew their informed consent (Figure 1).

The allocation was based on computer randomization in blocks of 10 patients, to either integrated programme or standard programme. Information on intervention or routine procedure was enclosed in sealed opaque envelopes with consecutive numbers. The randomization was performed by a health professional, which did not otherwise take part in the trial. The randomized study design included several pragmatic aspects that relate to effectiveness, rather than explanatory (efficacy) trials,12,13 such as measuring health outcomes (functionality and quality of life), having a relatively long study duration, testing clinically relevant treatment modalities, assessing adverse events and performing intention to treat analyses.

Assessment

The Brief Pain Inventory Questionnaire was designed to measure the subjective intensity of pain and the impairment caused by pain. It has been
validated in several languages, including Scandinavian languages. The Brief Pain Inventory Questionnaire was simple for most patients to complete and sensitive to the changes in pain. The score is normally separated into three pain qualities: pain related to tissue damage – in this case low back pain; pain related to abdomen; and radiating pain – in this case leg pain. In our study we scored the patients for low back pain and radiating pain. The physiotherapist and a nurse especially trained in pain score, intervention and follow-up performed all assessments. They were not member of the clinical staff and did not participate in the daily patient care. They were not blinded, however, because we could not guarantee that the patients would not disclose their allocation group, and it would be impossible to blind the patients.

The Roland Morris Questionnaire was designed to be completed by patients to assess physical disability due to low back pain. It contained 24

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**Figure 1** Flowchart.
unweighted items, ranging from 0 (no disability) to 24 (maximum disability). The Roland Morris Questionnaire has been translated and validated in several languages, including Danish.\textsuperscript{15} It has a good correlation to other disability instruments.\textsuperscript{16}

The sit-to-stand test is a simple and reliable physical performance test\textsuperscript{17} measuring the time required for the patient to rise from sitting in a chair to standing and return to sitting as quickly as possible five times. The time was measured with a stopwatch.

Timed up and go is a quick and practical test of basic mobility in elderly patients.\textsuperscript{17} The patient rose from a chair, stood, walked forward to a line 3 m away, turned, walked back to the chair, and sat down. Patients were timed as they performed this test.

The 15D test is a generic, comprehensive, 15-dimensional, standardized, self-administered measure of health-related quality of life (HRQoL) that can be used both as a profile and single-index score measure. The 15D scores are shown to be highly reliable, sensitive and responsive to change and generalizable, at least in Western-type societies.\textsuperscript{18}

The milestones the patient can achieve under hospitalization are defined as: assisted positional change in bed, independent positional change in bed, assisted mobilization in bedside, independent mobilization to bedside, assisted mobilization in walking frame, independent mobilization in walking frame, independent personal hygiene, independent daily function on ward, walking without aids, complete training programme, independent stair climb and discharge (Figure 2).

**Follow-up**

Pain was measured with a modified Brief Inventory Questionnaire. Functionality was assessed by Roland Morris Questionnaire, sit-to-stand and timed up and go. Furthermore, the days the clinical milestones in the recovery process were reached was recorded (Figure 2).

Postoperative complications were diagnosed by the surgeons and only registered if they required treatment. The surgeons also decided on discharge. The surgeons were unaware of the allocation, which was not noted in the medical records.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure2.png}
\caption{Milestones on ward. *Significant.}
\end{figure}
Quality of life was measured traditionally with self-reported 15D. \(^\text{19}\) Satisfaction was assessed using a 5-point scale: very satisfied = 5, satisfied, neither satisfied nor dissatisfied, dissatisfied, very dissatisfied = 1.

After registration and inclusion, all patients were assessed for pain and functionality on the day before surgery, on the first, third and fifth postoperative days, at discharge, and again after 1, 3 and 6 months. Quality of life was measured at the same points. Postoperative complications, adverse events, patient satisfaction were assessed at the follow-up one month after operation.

**Preoperative programmes**

In general, treatment at hospitals is free of charge in Denmark, and so were the programmes in this trial.

**Routine programme for the control group**

The control group followed departmental routines. Once the surgeon took the decision on surgery, the surgeon informed the patient about the operation and advised regarding cessation of smoking and harmful drinking before surgery. At admission the anaesthesiologist informed the patient about anaesthesia and postoperative pain treatment and the nurse in the surgical department informed the patient about the plan for postoperative rehabilitation in hospital, including pain treatment, diet and physiotherapy following the operation day, aiming for discharge on the eighth postoperative day. The physiotherapist mobilized the patients if possible on the day of the operation and trained daily 30 minutes with the patients in the following days. There was no reporting on further self-rehabilitation for control patients.

**Prehabilitation programme for the intervention group**

All intervention patients received a 6- to 8-week, individualized, preoperative training programme for exercise at home. It consisted of a daily 30-minute programme and the patients monitored their training using a logbook. The programme focused on improvement of muscle strength for the back and abdomen and included cardiovascular conditioning. A physiotherapist supervised the learning process at the day of inclusion and again two weeks before the operation. The compliance of the intervention group was measured for every type of exercise by daily self-reporting in a logbook.

The patients were informed and advised regarding cessation of smoking and harmful drinking before surgery.

Fourteen days before the operation the intervention group, eventually with relatives, met with the physiotherapist, and once again received information about the operation, postoperative mobilization and rehabilitation.

The evening before surgery, the intervention group supplemented their usual food intake with 200 mL protein-rich drinks (Fortimel; Nutricia Ltd, Trowbridge, Wilts, UK).

Intraoperative procedures were similar for both groups.

The anaesthesiological and surgical procedures were similar for the two groups. All patients had prophylactic antibiotics (cefuroxime 1.5 g intravenously) and thromboembolic prophylaxis (Innohep tinzaparin natrium 20 000 anti-Xa IE/mL, 3500 IE subcutaneous) before the operation began.

The patients received propofol, remifentanil and cisatracurium anaesthesia; they underwent intubation and surgery in the prone position. An epidural catheter was placed and 20 microgram sufentanil was administered epidurally before extubation. A bolus of 16 mg ropivacaine and 8 microgram sufentanil was installed using a pump (Baxter), when the patient was awake and could control his or her lower extremities again.

The surgical procedures did not include more than two levels; 80% of the patients underwent primary non-instrumented spondylodesis due to degenerative disc disease with or without leg pain and 50% of these procedures were performed in combination with decompression using autologous bone graft for posterolateral fusion. A small number of patients underwent instrumented fusion using the same technique. The decision to use pedicle screws was taken by the surgeon during the operation. A small number of patients underwent secondary surgery because
of pseudarthrosis. One case of disc prosthesis at the L5–S1 level was included in each group.

No patients undergoing other procedures, such as discectomy, anterior lumbar interbody fusion or posterior lumbar interbody fusion, were included.

The patients were included when they were booked for surgery 6–8 weeks before the operation. Because at that time the procedure was not always decided, different kinds of lumbar spinal surgery were included. The patients were randomly assigned after the first assessment. Senior surgeons performed all the procedures. There was no difference between the groups regarding surgery, anaesthetics, fluid therapy or blood transfusion.

Postoperative pain treatment and rehabilitation

All the patients had 1000 mg paracetamol four times a day. After three days the epidural catheter was removed and the treatment was changed to oxycodone CR tablets 20 mg, twice a day until discharge. There was no difference between the two groups in the use of analgesics.

The nurses actively mobilized all the patients in both groups for dressing, meals and toileting, etc.

The control group

The patients in the control group received routine pain treatment consisting of epidural infusion of 12 mg ropivacaine and 6 micrograms sufentanil per hour and supplementary 10 mg ropivacaine at break-through pain.

The control group was mobilized once daily and followed the routine rehabilitation for inpatients, aiming to discharge after eight days.

The intervention group

The intervention group had balanced and patient-controlled epidural analgesia, which consisted of a basic dose (8 mg ropivacaine and 4 microgram sufentanil per hour) and a bolus infusion to supplement (6 mg ropivacaine and 3 microgram sufentanil up to three times every hour for break-through pain).

The intervention group had an additional rehabilitation programme, which aimed to discharge on the fifth postoperative day. The physiotherapist intensively mobilized the patient on the day of the operation and 30 minutes twice daily in the following days. The postoperative exercise was similar to the preoperative exercises.

The intervention group began enteral nutrition in the evening on the day of surgery, (150 mL Fortimel), and continued to drink $4 \times 150$ mL a day in addition to the ordinary hospital diet, while the control group received the ordinary diet only.

Analyses and statistics

We planned to evaluate a minimal relevant difference of two to three days of hospital stay. The postoperative stay for routine procedures in the department was eight days (including inpatient rehabilitation), based on patient records over the past three years, whereas the hospital stay for patients in the intervention group was expected to be five days. Calculating a 5% risk of a type I error and a 20% risk of a type II error, we concluded that about 30 patients should be included in each group.

The groups were compared using non-paired two-sided tests: Mann–Whitney test and Fisher’s exact test. The statistician was blinded. The results were analysed according to intention to treat, except for the postoperative complications and stay, because of the high risk for underestimated results due to the inclusion of patients who were not operated on in those analyses, thereby presenting a lower frequency of complications and a lower stay in hospital. Area under curve was used for analyses of measurements over time in order to reduce the number of tests. The level of significance was 0.05. The subgroup analysis was performed as planned by using multivariate analyses (SPSS for Windows; SPSS Inc., Chicago, IL, USA).

Ethical considerations

The study was performed in accordance with the Helsinki II Declaration, and all patients participated after informed consent. The Regional Scientific Ethical Committee 01-041/03 approved the protocol, and the study has been registered in the international protocol registration system www.ClinicalTrials.gov, ID NCT 00459966.
Results

A total of 38 patients entered the intervention group and 35 entered the control group; 28 and 32 patients fulfilled the study in the two groups, respectively, thereby giving a drop-out rate of 19%. All 13 patients but one stopped within the first week. Two months before surgery there were no differences between the groups regarding the characteristics (Table 1). At the time of operation, however, the intervention group had increased function assessed by Roland Morris ($P = 0.001$), although there were no differences in timed up and go or sit-to-stand between groups (Table 2). Exercise compliance in the intervention group was high; the patients exercised 85% of possible days.

After surgery, the intervention group reached the milestones in the recovery process significantly faster than the control group (1–6 days versus 3–13 days, $P = 0.001$), and they left the hospital significantly earlier (median 5 (3–9) days versus 7 (5–15) days, $P = 0.007$, Figure 2). Complications and adverse events tended to be followed by a lengthier hospital stay in the control group (30 days versus 18 days, $P = 0.06$, Table 3). The 15 patients (10 women and 5 men, median age 45 years, range 24–66) from the non-included group underwent surgery and stayed a median of 6 days (range 4–13). The further 4 patients (2 women and 2 men, age 67 years, range 38–78) who withdrew their informed consent stayed for 8 days (range 5–13). These numbers were too small for statistical analysis.

More patients in the intervention group experienced significantly less pain, measured as area under curve ($P = 0.03$), and less low back pain intensity (area under curve, $P = 0.02$). There were no differences in average and worst low back pain or all kinds of radiating pains between groups. Patients who had major complications or stayed longer at hospital did not experienced more pain compared with patients without major complications or who stayed for a shorter time.

Significantly more patients in the intervention group were very satisfied with the overall treatment and outcome compared with the control group (15 of 28 patients versus 7 of 32, $P = 0.02$). The quality of life was similar for both groups.

Table 1  Characteristics of all patients at inclusion time; number (per cent) or median (range)

<table>
<thead>
<tr>
<th></th>
<th>Intervention n = 35</th>
<th>Control n = 38</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Women</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>48 (31–80)</td>
<td>52 (23–88)</td>
<td>0.92</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>79 (48–118)</td>
<td>74 (51–107)</td>
<td>0.59</td>
</tr>
<tr>
<td>BMI (kg/m$^2$)</td>
<td>25 (21–33)</td>
<td>26 (17–33)</td>
<td>0.49</td>
</tr>
<tr>
<td>Daily smokers*</td>
<td>3 (11%)</td>
<td>5 (16%)</td>
<td>0.72</td>
</tr>
<tr>
<td>Harmful drinkers*</td>
<td>0</td>
<td>0</td>
<td>–</td>
</tr>
<tr>
<td>ASA Classification (I–V)$^b$</td>
<td>1 (I–II)</td>
<td>1 (I–II)</td>
<td>0.18</td>
</tr>
<tr>
<td>Comorbidity (clinical diseases requiring treatment)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Pulmonary disease</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Diabetes (type 1/type 2)</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Functionality: RMQ (0–23)$^c$</td>
<td>16 (8–21)</td>
<td>17 (6–22)</td>
<td>0.17</td>
</tr>
<tr>
<td>Sit to stand to sit × 5 (seconds)</td>
<td>17 (10–27)</td>
<td>18 (9–46)</td>
<td>0.57</td>
</tr>
<tr>
<td>Timed up and go (seconds to leave an armchair, walk 3m, return, sit down again)</td>
<td>10 (7–20)</td>
<td>11 (6–27)</td>
<td>0.83</td>
</tr>
<tr>
<td>Radiating pain (visual analogue scale: 0–100)$^d$</td>
<td>38 (0–95)</td>
<td>37 (0–94)</td>
<td>0.39</td>
</tr>
<tr>
<td>Low back pain (visual analogue scale: 0–100)$^d$</td>
<td>49 (0–87)</td>
<td>54 (0–91)</td>
<td>0.81</td>
</tr>
</tbody>
</table>

*Harmful drinkers were defined by an intake over the limits recommended by the Danish National Board of Health (less than 21 drinks per week for men and 14 for women; one drink contained 12 g of ethanol).

$^b$American Society of Anaesthesiology, classification of risk at surgery; I (no increased risk) to V (moribund patient).

$^c$Ronald Morris Questionnaire for evaluation function level for patients with low back pain and radiating pain; the score ranges from 0 (no functional limitation) to 23 (the worst).

$^d$Brief Pain Inventory Questionnaire for the pain score level and causal factors.

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Results

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The intervention group experienced significantly less pain, measured as area under curve ($P = 0.03$), and less low back pain intensity (area under curve, $P = 0.02$). There were no differences in average and worst low back pain or all kinds of radiating pains between groups. Patients who had major complications or stayed longer at hospital did not experienced more pain compared with patients without major complications or who stayed for a shorter time.

Significantly more patients in the intervention group were very satisfied with the overall treatment and outcome compared with the control group (15 of 28 patients versus 7 of 32, $P = 0.02$). The quality of life was similar for both groups.
The only predictor for major postoperative complication was preoperative low back pain intensity (odds ratio 10.45; 95% confidence interval 2.29–47.70; multivariate analyses) and the only predictor for prolonged stay was belonging to the control group (7.40; 1.92–28.50).

Discussion

We found that the integrated programme, which included prehabilitation and early postoperative rehabilitation, was followed by better postoperative functionality, faster recovery and shorter hospital stay among patients undergoing lumbar spine surgery. The control group left the hospital after seven days, which was not significantly different from the expected eight days. The integrated programme actively involved the patients without simultaneously increasing the pain level or complication rate; instead the patients expressed higher level of satisfaction.

The programme comprised several elements, which have been shown per se to improve the outcome after elective procedures other than spine surgery. Hospital stay duration is influenced by several factors, such as the development of complications and second surgery, traditions and expectations from the staff and the patient. The expectation could influence the length of stay, exclusively. A study concerning day case discectomy noted that the patients admitted as inpatients failed to be discharged as day cases, whereas those admitted to the day case unit did. Furthermore, differences between therapists’ and patients’ expectations and goals may influence the length of hospital stay.

In order to avoid the latter we used a fixed milestones assessment to obtain identical functionalities before discharge. Despite this, we found that nearly all the patients stayed in the hospital for one day or more after they had met the milestones and were ready for discharge. This delay in discharge was more pronounced for the intervention group. The prolongation was due to delayed order of nursing in home, culture and routines in discharge procedures.

The intervention group reduced the postoperative stay by 29%. Part of the explanation could be the intensive exercise programme. Though
intensive physical training is an integrated part of the rehabilitation programmes for non-surgical patients with low back pain, we have not found any randomized studies looking at perioperative training in relation to spinal surgery in the literature. This could be explained by the routines and clinical principles used by which patients lie down for a longer period after surgery in order to reduce the risk of spinal instability. Furthermore, the classical discrepancy between medical and surgical interventions may previously have been a barrier to the evaluation of a training programme for patients scheduled for spine surgery.

Research from other surgical procedures, however, has presented conflicting results for physical training. In some studies of hip replacement therapy the outcome improved, some only showed moderate effect, while other authors did not see any effect of preoperative exercise. Preoperative training did not influence the outcome after knee replacement. Hitherto, no authors have published aggravated functions, more complications or prolonged stay as a result of training programmes in the surgical period. The shorter hospital stay and better functionality in this study was not related to reduced development of complications in the intervention group. The explanation could be the overall low complication rate in this study, and that the study was not designed to evaluate minor differences in complications after lumbar surgery. This would require a much larger study population. The risk of type 2 failure should be considered; however, our findings did not indicate that a significant difference in postoperative complications between the two groups could be achieved unless more than 4500 patients were included. Instead, the early and intensive rehabilitation might have increased the demands for bodily resources, so we should be satisfied with a status quo regarding development of complications in the intervention group.

### Table 3: Surgical intervention and outcome; given as number (per cent) or median (range)

<table>
<thead>
<tr>
<th>Intervention ($n=28$)</th>
<th>Control ($n=32$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary spondylodesis instrumental</strong></td>
<td>2 / 28 (7%)</td>
</tr>
<tr>
<td><strong>Non-instrumental</strong></td>
<td>23 / 28 (82%)</td>
</tr>
<tr>
<td><strong>Secondary spondylodesis (non-instrumental)</strong></td>
<td>2 / 28 (7%)</td>
</tr>
<tr>
<td><strong>Implementation of discus prosthesis</strong></td>
<td>1 / 28 (4%)</td>
</tr>
<tr>
<td><strong>Duration of operation (minutes)</strong></td>
<td>110 (85–260)</td>
</tr>
<tr>
<td><strong>Fluid infusion at operation (mL)</strong></td>
<td>2450 (1300–4500)</td>
</tr>
<tr>
<td><strong>Patients with major complications</strong></td>
<td>8</td>
</tr>
<tr>
<td><strong>Cardiopulmonary insufficiency</strong></td>
<td>0</td>
</tr>
<tr>
<td><strong>Thromboembolic complications</strong></td>
<td>0</td>
</tr>
<tr>
<td><strong>Haematomas</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>Severe pain (&gt;70 on VAS)</strong></td>
<td>6</td>
</tr>
<tr>
<td><strong>Allergic reaction</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>Patients with minor complications</strong></td>
<td>4</td>
</tr>
<tr>
<td><strong>Pneumonia (antibiotics)</strong></td>
<td>0</td>
</tr>
<tr>
<td><strong>Wound infection (antibiotics)</strong></td>
<td>0</td>
</tr>
<tr>
<td><strong>Urinary tract infection (&gt;10⁶ bacteria/mL)</strong></td>
<td>2</td>
</tr>
<tr>
<td><strong>Urinary retention (tubulation)</strong></td>
<td>0</td>
</tr>
<tr>
<td><strong>Constipation ( laxities)</strong></td>
<td>2</td>
</tr>
<tr>
<td><strong>Patients with adverse events</strong></td>
<td>3</td>
</tr>
<tr>
<td><strong>Delayed order of nursing at home</strong></td>
<td>2</td>
</tr>
<tr>
<td><strong>Surgery on Friday</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>Hospital stay after surgery (days)</strong></td>
<td>5 (4–9)*</td>
</tr>
<tr>
<td><strong>Stay until reaching all milestones</strong></td>
<td>4 (1–6)*</td>
</tr>
<tr>
<td><strong>Extra stay due to complications</strong></td>
<td>18*</td>
</tr>
</tbody>
</table>

Values are number (%) or median (range).

*P* < 0.01.

**a**Requiring intensive treatment or secondary surgery.

**b**Not followed by physiotherapy in the weekend.
Although the intervention group experienced less pain when measured over time, the number of patients who developed episodes of severe breakthrough pain was similar in the two groups. Other research groups also found no significant effect on pain relief and other complications by self-administered analgesics taken epidurally, but the consumption of local anaesthetics and opioids was smaller and the patients has less motor block.\textsuperscript{31,32} It could be expected that our intervention group had a higher pain score and higher need for analgesics due to the intensive training programme, but this was not the case. A bias could be that we may have overlooked a difference in the duration of episodes with severe pain because we only asked the patients about the pain level. Other limitations of our study are the relatively small number of patients and risk of bias due to the non-blinded design. Both could add to an overestimation of positive results. Finally, the risk of type I failure (giving a significant result by chance) should be considered, which repeating the study could overcome.\textsuperscript{33} The drop-out rate in the present study of 19\% was acceptable and may add to the strength of the study, especially because some of them did not completely drop out.

Of the possible predictors only a high score of preoperative low back pain was significantly associated with the development of postoperative complications. This is in agreement with the literature showing that preoperative pain is a predictor for the incidence and intensity of postoperative pain,\textsuperscript{34,35} and severe postoperative pain may further lead to immobilization and increased risk of postoperative complications. The multivariate analyses supported the conclusion that belonging to the control regime was associated with a significantly prolonged postoperative stay.

This study has demonstrated the benefits of adding a prehabilitation programme to the early rehabilitation standard which is now under implementation in our institution. In direct costs, the reduced postoperative hospital stay seems to offset the extra cost of the preoperative outpatient programme.\textsuperscript{36} However, this may not be reflected in the balances because of a lack of sensitivity in our reimbursement systems, which are based on average costs.

Even though the differences between the two groups seem minor, the clinical relevance of the results (i.e. shorter period of disability) seems major for the individual patient, which is also reflected by the higher level of satisfaction.

We could not show any effect after three or six months. It would be interesting to combine the prehabilitation programme with a late rehabilitation programme beginning three months postoperatively as described by Christensen et al.\textsuperscript{37,38} A ‘back-cafe group’ had significant better daily function, lesser pain and lower cost after eight weeks of video-training at home combined with café meetings compared with physiotherapy programme or video-training, exclusively.\textsuperscript{37,38} Another relevant issue would be to measure whether a postoperative long-term exercise regimen would be beneficial by inhibiting the relative frequent relapses of pain within the first years after the surgical intervention.

We could not identify the most effective elements or exclude ineffective elements from this combined programme due to the pragmatic design. Furthermore, it is not possible to exclude a positive impact from the expected discharge day. This may be a minor effect caused by the earlier discharge in the control group than expected.

As this is the first study to evaluate an integrated perioperative programme adding prehabilitation to early rehabilitation, confirmation from other studies is needed. Future studies should focus on optimization of the treatment, for example introduction of further optimized surgical procedures and organizational improvements that might reduce the complication rate. It would also be relevant to investigate the effect of the prehabilitation concept separately as well as the integrated programme on different surgical procedures. The new research should also consider economic consequences and cost-effectiveness analysis. A possible effect of the integrated programme in other surgical interventions also remains to be investigated.

In conclusion, besides surgery a package of attentional efforts consisting of an integrated programme of prehabilitation and early rehabilitation improved the early outcome and shortened the hospital stay for patients undergoing elective surgery for degenerative spine disease – without producing more pain or dissatisfaction. As a consequence of several pragmatic aspects it is not possible from this study to identify the effective
elements in the programme. In an optimal clinical setting our new integrated programme would allow us to operate on elective spine patients on Mondays, aiming the discharge at Fridays, thus reducing the workload over the weekends. However, there is still room for further improvement of the outcome.

Clinical messages

- A prehabilitation programme beginning two months prior to operation significantly improved patients’ functionality at admission for operation.
- After surgery the intervention group reached the recovery milestones significantly faster than the control group and left hospital earlier.
- Patient satisfaction was significantly higher in the intervention group than in the control group.

Contributors

PN designed and managed the study, recruited the patients and obtained, recorded, and interpreted the data. LJ recruited the patients and obtained the data. BD recruited the patients and interpreted the data. TP analysed and interpreted the data. HT designed the study and analysed and interpreted the data. PN and HT wrote the paper. LJ, BD and TP edited the paper.

Conflict of interest

No conflicts of interest.

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