Physical Therapy on Postoperative Day Zero Following Spine Surgery is Associated with Decreased Length of Stay

Daniel Hogan M.D.[1*], Blaine Manning M.D.[1], Suryanshi Rawat M.D.[1], Haley Huff[1], Shelby Harris M.D.[1], Stefan Hanish[1], Nathan Cherian M.D.[1], Emily Leary M.D.[1], Theodore Choma M.D.[1], Don Moore M.D.[1]

[1]Department of Orthopaedic Surgery, University of Missouri – Columbia, Missouri

*Corresponding Author: Daniel Hogan, Email: dwhc68@umsystem.edu

Abstract

Study Design: Retrospective cohort study

Objective: Postoperative LOS is a major factor in overall cost for spine surgery, and its duration often depends on discharge clearance from PT. We sought to compare postoperative length of stay (LOS) for patients who initiated physical therapy (PT) on postoperative day (POD) 0 versus POD 1 following cervical or lumbar spine surgery.

Methods: A retrospective review was conducted of 710 patients who underwent elective, inpatient cervical or lumbar spine surgery at 1 institution from 2011-2019. Patients were categorized by postoperative PT timing, with POD 0 defined within 24 hours postoperative. Patients were excluded if admitted under trauma visit, admitted to ICU before discharge for observation or complications, or had qualifying surgery >2 levels (lumbar) or <2 levels (cervical). Results were analyzed using R (R Foundation for Statistical Computing, Vienna, Austria).

Results: In both surgery groups, there was no significant difference between POD 0 and POD 1 cohorts regarding: age, sex, BMI, preoperative ambulation device, discharge destination, or operative approach and fusion levels (for cervical patients). In both groups, median LOS difference was large enough to be of statistical significance. Among lumbar surgery patients, the LOS was 8.9 hours greater for POD 1 PT compared to POD 0 PT (median 65.3 hours for POD 0 PT [interquartile (IQ) range, 43.7-74.6] vs 74.2 hours for POD 1 PT [IQ range 51.6-99.8]; ($P < 0.001$). Among cervical patients, the LOS was 25.7 hours greater for POD 1 PT compared to POD 0 PT (median 46.8 hours for POD 0 PT [IQ range, 25.7-75.4] vs 72.5 hours for POD 1 PT [IQ range 46.8-101.3], ($P < 0.0001$). The difference in distribution of postoperative nights spent in the hospital was also statistically significant for lumbar surgery patients ($P = 0.002$) and cervical patients ($P < 0.001$). None of the POD 1 PT lumbar patients were discharged on POD 1, compared to 18.3% of lumbar patients who initiated PT on POD 0. Among cervical patients, 8.3% of patients who initiated PT on POD 1 were discharged on POD 1, compared to 21.3% of cervical patients who initiated PT on POD 0.

Conclusion: Our study demonstrated a statistically significantly lower postoperative LOS when PT was initiated on POD 0 versus POD 1, suggesting an association between earlier PT and earlier discharge.

Introduction

Cervical and lumbar spine surgery are common procedures in orthopaedic surgery.[1-4] As such, these procedures continue to increase annually.[5, 6] Lowering the cost of these procedures remains an important goal as patients and payors demand lower healthcare costs and improved quality.[7] This has led to a rapid interest in enhanced recovery protocols (ERPs), which focus on expedited recovery and patient discharge through a combination of patient education, multimodal analgesia, limiting unnecessary drains and dressing changes, and early physical therapy (PT). However, the significance of early PT in optimizing early discharge is not well elucidated.

The postoperative inpatient length of stay (LOS) is a major factor in the overall cost of elective spine procedures, and recent studies have attempted to enact peri-operative protocols in order to reduce costs and improve the value of care.[8, 9] While the duration of post-operative hospitalization may be affected by PT protocols and discharge often depends on clearance from the therapy team, there is a paucity of literature on the impact of physical therapy on LOS. Discharge clearance is determined by the therapist's evaluation of the patient's ability to ambulate safely at a level that meets their post-discharge needs (e.g., stairs to enter the home, transferring from a walker to bed or chair). If a patient is unable to mobilize safely, their postoperative inpatient stay continues until the therapist can determine that the patient is safe for discharge, or they qualify for placement into an inpatient rehabilitation facility. As such, the physical therapist is often the team member who makes the final determination when a patient is medically safe for discharge postoperatively. One potential strategy to reduce inpatient LOS and its associated costs is early initiation of inpatient PT, starting immediately on postoperative day 0 (POD 0).[10-12] While the literature on immediate initiation of postoperative PT for spine patients is scarce, previous authors have demonstrated that PT intervention on POD 0 shortened hospital LOS for both total hip and total knee arthroplasty patients.[12]

The objective of this study is to determine whether inpatient cervical fusion and lumbar laminectomy and fusion patients who started formal PT on POD 0, instead of POD 1, had a shorter postoperative LOS as measured continuously in hours and overall number of nights spent in the hospital.

Methods

Following approval by the institutional review board, a retrospective review of prospectively collected data identified 710 patients who underwent elective, inpatient $\geq$2 level anterior cervical discectomy and instrumented fusion (ACDF), $\geq$2 level posterior cervical instrumented fusion +/- laminectomy, or 1-2 level lumbar laminectomy ± posterior lumbar fusion ± instrumentation at a single center between 2011 to 2019. The study includes 13 spine surgeons at our institution. Exclusion criteria consisted of: (1) incomplete data in the electronic medical record, (2) admission under a trauma visit, (3) admission to the intensive care unit (ICU) between surgery and discharge for observation or complications, (4) lack of formal PT encounter before discharge, and (5) had surgery involving >2 levels (lumbar patients) or <2 levels (cervical patients).

Demographics, intraoperative, and postoperative variables were collected. Demographic information included age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) classification, Charlson Comorbidity Index (CCI), insurance type (i.e., Medicare, private insurance), comorbidities (e.g., diabetes), use of a preoperative ambulation aid (i.e., cane, walker, or wheelchair), and postoperative discharge destination (i.e., home, inpatient rehabilitation). All patients underwent surgery under general anesthesia in the prone (lumbar or posterior cervical surgery) or supine (ACDF) position on a Jackson table. Intraoperative variables included the number of levels fused and anterior, posterior, or combined approach. Foley catheters placed intraoperatively were removed prior to transfer to the postoperative recovery unit. Patients received our institution's postoperative pain regimen, which included anti-inflammatories, acetaminophen, muscle relaxers, and opioid analgesics, including as needed IV medications available for breakthrough pain. Postoperative Patient Controlled Analgesia (PCA) was not routinely used. Patients were categorized by timing of postoperative PT, with POD 0 defined as within 24 hours after surgery as documented in the medical record under surgery stop times and initial PT encounter times. Postoperative care did not differ between groups except regarding their timing of PT initiation.

Statistical Methods

Data were checked for quality and completeness. Summary statistics for continuous variables were mean and standard deviation or median and interquartile range. Categorical variables were summarized using frequencies and percentages. Bivariate analysis used Chi-square tests of independence or Fisher's Exact tests, if Chi-square assumptions were not met. For continuous variables, normality was tested using a Shapiro-Wilk test and a two-sample t-test or Mann-Whitney test was used to determine differences across POD groups. Data were analyzed using R version 4.0.2 with two-sided alpha < 0.05 considered significant.

Results

A total of 710 patients (374 cervical and 336 lumbar) met inclusion criteria. Among lumbar patients, formal PT was initiated on POD 0 for 202 patients, and POD 1 for 134 patients (Table 1). For those who received lumbar surgery, there were no significant differences between POD 0 and POD 1 groups regarding age (57.9 ± 14.4 years vs. 58.4 ± 14.3 years, P = 0.66), sex (45.5% male vs. 52.2%, P = 0.28), BMI (33.2 ± 7.8 kg/m^2 vs. 31.7 ± 5.8, P = 0.23), Charlson Comorbidity Index (CCI) classification (CCI 1.03$\pm$1.12 vs. 1.27 $\pm$ 1.55, P=0.56), ASA classification (ASA 1 or 2 for 43.1% vs. 39.6%, P = 0.58), preoperative use of ambulation aid (18.3% vs. 12.7%, P = 0.22), or discharge destination (discharge

Table 1. Patient Baseline Characteristics, by Postoperative Day PT Group

Characteristic	Lumbar Patients* (n=336)			Cervical Patients** (n=374)		
	POD 0 PT (n=202)	POD 1 PT (n=134)	*P* Value	POD 0 PT (n=240)	POD 1 PT (n=134)	*P* Value
Age (mean +/- SD)	57.9 +/- 14.4	58.4 +/- 14.3	0.66	57.7 +/- 11.0	57.8 +/- 14.3	0.98
Body mass index (kg/m²; mean +/- SD)	33.2 +/- 7.8	31.7 +/- 5.8	0.23	31.2 +/- 7.3	30.4 +/- 7.2	0.31
Male Gender (n [%])	92 (45.5)	70 (52.2)	0.28	134 (55.8)	64 (47.8)	0.16
Insurance: Medicare (n [%])	85 (42.1)	59 (44.0)	0.58	97 (40.4)	64 (47.8)	**0.04**
Insurance: Medicaid (n [%])	36 (17.8)	27 (20.1)	0.58	39 (16.3)	26 (19.4)	**0.04**
Insurance: Private (n [%])	53 (26.2)	29 (21.6)	0.58	73 (30.4)	21 (15.7)	**0.04**
ASA Classification: 1 or 2 (n [%])	87 (43.1)	53 (39.6)	0.58	84 (35.0)	46 (34.3)	0.99
Charlson Comorbidity Index (CCI)	1.03 +/- 1.12	1.27 +/-1.55	0.56	1.34 +/- 1.57	1.43 +/- 1.76	0.78
Diabetes (n [%])	49 (24.3)	31 (23.1)	0.92	55 (22.9)	33 (24.6)	0.81
Preoperative Ambulation Aid (n [%])	37 (18.3)	17 (12.7)	0.22	70 (29.2)	49 (36.8)	0.17
Preoperative Myelopathy (Cervical patients only)	n/a	n/a	n/a	142 (59.4)	85 (63.4)	0.51
Discharge Destination: Home (n [%])	179 (88.6)	114 (85.1)	0.61	195 (81.3)	96 (71.6)	0.08

POD, postoperative day; PT, physical therapy; ASA, American Society of Anesthesiologists

**Lumbar Patients: elective, inpatient 1-2 level lumbar laminectomy ± posterior lumbar fusion ± instrumentation*

***Cervical Patients: inpatient, elective ≥2 level anterior cervical discectomy and instrumented fusion (ACDF) and ≥2 level posterior cervical instrumented fusion +/- laminectomy*

Table 2. Cervical Patient Operative Characteristics, By Postoperative Day PT Group

	Cervical Spine Surgery Patients (n=374)*		
	POD 0 PT (n=240)	POD 1 PT (n=134)	*P* Value
Approach			0.088
Anterior (n [%])	141 (58.8)	72 (53.7)	
Posterior (n [%])	82 (34.2)	58 (43.3)	
Combined (Anterior/Posterior) (n [%])	17 (7)	4 (2.9)	
Number of Levels Fused			0.3772
2 (n [%])	101 (42.1)	57 (42.5)	
3 (n [%])	63 (26.3)	36 (26.9)	
4 (n [%])	48 (20)	19 (14.2)	
5 or more (n [%])	28 (11.7)	22 (16.4)	

POD, postoperative day; PT, physical therapy; ASA, American Society of Anesthesiologists

* inpatient, elective ≥2 level anterior cervical discectomy and instrumented fusion (ACDF) and ≥2 level posterior cervical instrumented fusion +/- laminectomy

home 88.6% vs. 85.1%, *P* = 0.61) (Table 1). Among cervical patients, formal PT was initiated on POD 0 for 240 patients, and POD 1 for 134 patients (Table 1). Similarly, among cervical patients, there were no significant differences between POD 0 and POD 1 groups regarding age (57.7 ± 11.0 years vs. 57.8 ± 14.3 years, *P* = 0.98), sex (55.8% male vs. 47.8%, *P* = 0.16), BMI (31.2 ± 7.3 kg/m² vs. 30.4 ± 7.2, *P* = 0.31), Charlson Comorbidity Index (CCI) (CCI 1.34 ± 1.57 vs. 1.43 ± 1.76, *P*=0.78), ASA classification (ASA 1 or 2 for 35.0% vs. 34.3%, *P* = 0.99), preoperative use of ambulation aid (29.2% vs. 36.8%, *P* = 0.17), preoperative myelopathy (59.4% vs 63.4%, *P* = 0.51), or discharge destination (discharge home 81.3% vs. 71.6%, p=0.08) (Table 1). However, there was a significant difference between the POD 0 PT and POD 1 PT among cervical patients with private insurance

Table 3. Postoperative Length of Stay, By Postoperative Day PT Group

Outcome	Lumbar Patients* (n=336)			Cervical Patients** (n=374)		
	POD 0 PT (n=202)	POD 1 PT (n=134)	*P* Value	POD 0 PT (n=240)	POD 1 PT (n=134)	*P* Value
Hospital stay in hours (median [IQ range])	65.3 (43.7-74.6)	74.2 (51.6-99.8)	**<0.0001**	46.8 (25.7-75.4)	72.5 (46.8-101.3)	**<0.001**
Hospital stay in number of nights			**0.002**			**<0.001**
1 Night (n [%])	43 (21.3)	11 (8.3)		44 (18.3)	0 (0.0)	
2 Nights (n [%])	52 (25.7)	33 (24.8)		81 (33.7)	35 (26.1)	
3 Nights (n [%])	62 (30.7)	40 (30.1)		49 (20.4)	31 (23.1)	
≥ 4 Nights (n [%])	45 (22.3)	49 (36.8)		66 (27.5)	68 (50.7)	

POD, postoperative day; PT, physical therapy; ASA, American Society of Anesthesiologists
**Lumbar Patients: elective, inpatient 1-2 level lumbar laminectomy ± posterior lumbar fusion ± instrumentation*
***Cervical Patients: inpatient, elective ≥2 level anterior cervical discectomy and instrumented fusion (ACDF) and ≥2 level posterior cervical instrumented fusion +/- laminectomy*

(30.4% vs 15.7%, *P* = 0.0017) (Table 1). Among cervical patients, there were no significant differences between POD 0 and POD 1 PT groups regarding approach (anterior, posterior, combined anterior/posterior, p=0.088) or number of levels fused (p=0.3772) (Table 2).

The difference in LOS was statistically significant in both groups, with POD 0 PT patients having shorter LOS. Among lumbar surgery patients, the LOS was 8.9 hours greater for POD 1 PT compared to POD 0 PT (median 65.3 hours for POD 0 PT [interquartile (IQ) range, 43.7-74.6] vs 74.2 hours for POD 1 PT [IQ range 51.6-99.8]; (*P* < 0.001) (Table 3). Among cervical patients, the LOS was 25.7 hours greater for POD 1 PT compared to POD 0 PT (median 46.8 hours for POD 0 PT [interquartile (IQ) range, 25.7-75.4] vs 72.5 hours for POD 1 PT [IQ range 46.8-101.3], (*P* < 0.0001) (Table 3). The difference in distribution of postoperative nights spent in the hospital was also statistically significant for lumbar surgery patients (*P* = 0.002) and cervical patients (*P* < 0.001) (Table 3). None of the POD 1 PT lumbar patients were discharged on POD 1, while 18.3% of lumbar patients who initiated PT on POD 0 were discharged on POD 1. Among cervical patients, 8.3% of patients who initiated PT on POD 1 were discharged on POD 1, compared to 21.3% of cervical patients who initiated PT on POD 0.

Discussion

As the annual utilization of spine surgery continues to increase, lowering the associated costs remains an important goal as patients and payors demand decreased healthcare expenditures and improved quality. Postoperative LOS is a major factor in the overall costs of cervical and lumbar spine surgery.[13] For medically stable patients, discharge is often dependent on clearance from PT. In our retrospective cohort study of 374 cervical and 336 lumbar patients, we found a significant median difference (25.7 hours for cervical and 8.9 hours for lumbar surgery) in overall LOS and distribution of nights spent in the hospital after surgery (Table 3) in patients who initiated physical therapy on POD 0 vs POD 1. The data suggested no difference between POD PT groups regarding demographics, preoperative ambulation aid use, discharge destination, preoperative myelopathy (for cervical patients), surgical approach or number of levels fused (for cervical patients), which limits concern for confounding variables. Our results demonstrate initiation of PT on POD 0 following >2 level cervical fusion or 1-2 level lumbar laminectomy with or without fusion is associated with decreased postoperative length of stay.

Previous investigations have shown that early postoperative mobilization after orthopaedic surgery may reduce costs, improve outcomes, and shorten postoperative LOS.[12, 14-16] However, much of this literature has focused on total hip arthroplasty and total knee arthroplasty (TKA) patients and the findings have varied. In one prospective cohort study conducted on 136 primary total joint arthroplasties, isolated PT intervention on POD 0 shortened hospital LOS, regardless of the intervention performed (e.g., ambulation vs moving from bed to chair).[12] A similar study found starting PT on POD 0 was associated with a 1-day decreased LOS with lower pain scores at discharge.[17] However, in another randomized, controlled trial of 394 TKA patients, the authors did not observe a significant difference in hospital LOS or patient satisfaction when PT was initiated on the day of surgery vs the morning after surgery.[18] Although not conclusive, the general trend in orthopaedic literature is that early initiation of PT is associated with decreased length of stay, which is similar to our findings. Despite these findings in similar studies on non-spine orthopaedic patients, there is a lack of information to assess the impact of PT timing on postoperative LOS in spine patients.

Significant variation may exist among different institutions in the delivery, timing, and content of postoperative spine rehabilitation. There are no clear guidelines for patients or providers that describe the best evidence for timing, duration, or content of an optimal postoperative PT regimen. In one study of patient information leaflets from 32 different hospitals that perform lumbar spine surgery in the English National Health Service (NHS), Low et al found significant variations in prescribed frequency and duration of postoperative exercises, descriptions of functional activities, and advice regarding return to normal activity.[19] In another randomized, controlled trial comparing a standard rehabilitation regimen to a fast track rehabilitation regimen for TKA patients, the fast track program patients had a shorter LOS with specific program contents: POD 0 PT, 2 hour daily sessions of PT, group therapy, an organizing case manager, and allowing patients to compare their progress with peers (i.e., "competitive care").[16] In a study of 159 patients undergoing lumbar decompression surgery, Mannion et al found no difference in patient-reported pain or disability between patients who underwent a non-standardized therapy regimen compared to patients whose regimen consisted of specified session frequency, duration, and content of specific isometric exercises according to a published rehabilitation program.[20, 21] The optimal timing, dosage, and content of postoperative PT deserves further investigation, given the impact of rehabilitation quality on recurrent injury, subsequent disability scores, and health care use.[19, 22]

Although the overall length of stay between POD 0 and POD 1 groups differed significantly, over 50% of patients in each group were discharged after 2 or more nights in the hospital, regardless of POD PT timing (Table 3). One explanation of shorter overall LOS for POD 0 patients was that those patients would exhibit greater confidence in subsequent PT sessions, regardless of achievement during the initial session (e.g., getting out of bed to chair vs ambulating in hallway). Initiation of PT on POD 0 may potentially increase patients' self-efficacy in their activity level and their comfort level with PT, thus increasing their progress towards PT discharge clearance in subsequent sessions. While there is limited research on patient's confidence at discharge following spine surgery and physical therapy, previous authors have suggested that patients often complain of a lack of information regarding practical and behavioral recommendations for while at home, which can often be addressed by the physical and occupational therapy teams.[23] It is reasonable to postulate that the earlier that these conversations occur, the earlier a patient may be reassured and more confident in discharging home.

Limitations

Our study subjects were patients from one academic medical center from a single geographic region. Thus, our findings may not be representative of all spine patients in other practice settings and geographic regions. Additionally, we included data from 13 surgeons, who may differ in surgical indications and post-operative algorithms, and we did not control for these differences. Discharge times used for analysis were also based on patients' time of exit from the hospital as logged by the nurse. This time could potentially differ from the actual time they were cleared for discharge by PT if the discharge paperwork process was delayed or the patient was waiting for transportation. However, there were no differences between POD PT groups regarding discharge to a rehabilitation facility (thus requiring waiting for pre-arranged transportation), which could cause such discharge delays.

Our study did not examine postoperative outcomes such as step counts or patient-reported outcomes (e.g., functional score or pain level), and we did not account for patient initiation of activity progression independently or with nursing prior to the first formal PT session (e.g., getting out of bed to chair or hanging the feet over the bedside). Our attributed direct cost per day at inpatient floor status

($724) may not reflect all patients due to variations in care. However, this is the standard calculated value used by our institution's financial analytics department. Other factors besides the timing of PT initiation, including complications (e.g., durotomy preventing early mobilization), absence of a home caregiver, or prolonged determination of post-discharge placement by case management. Finally, we did not assess patient reported outcomes and the potential role early PT has on improving objective outcome scores. Further studies should focus on obtaining more generalizable results from multiple practice settings and geographic locations, while accounting for the above-noted limitations through standardization and prospective randomization.

Conclusion

There are few studies regarding the association between timing of postoperative PT initiation and postoperative LOS in cervical fusion and lumbar laminectomy patients. Nevertheless, early initiation of PT has been proposed to facilitate earlier discharge following orthopaedic surgery. Our study demonstrated a statistically significant difference in postoperative LOS after cervical or lumbar spine surgery when PT was initiated on POD 0 vs POD 1, suggesting an association between earlier PT and earlier discharge.

Blinded COI Statement

No funds were received in support of this work. No benefits in any form have been or will be received from any commercial party related directly or indirectly to the subject of this manuscript

References

1. Palit M, Schofferman J, Goldthwaite N, et al. Anterior discectomy and fusion for the management of neck pain. *Spine (Phila Pa 1976).* 1999;24:2224-2228.
2. Buttermann GR. Anterior Cervical Discectomy and Fusion Outcomes over 10 Years: A Prospective Study. *Spine (Phila Pa 1976).* 2018;43:207-214.
3. Atlas SJ, Keller RB, Robson D, Deyo RA, Singer DE. Surgical and nonsurgical management of lumbar spinal stenosis: four-year outcomes from the maine lumbar spine study. *Spine (Phila Pa 1976).* 2000;25:556-562.
4. Carreon LY, Glassman SD, Howard J. Fusion and nonsurgical treatment for symptomatic lumbar degenerative disease: a systematic review of Oswestry Disability Index and MOS Short Form-36 outcomes. *Spine J.* 2008;8:747-755.
5. Liu CY, Zygourakis CC, Yoon S, et al. Trends in Utilization and Cost of Cervical Spine Surgery Using the National Inpatient Sample Database, 2001 to 2013. *Spine (Phila Pa 1976).* 2017;42:E906-E913.
6. Saifi C, Fein AW, Cazzulino A, et al. Trends in resource utilization and rate of cervical disc arthroplasty and anterior cervical discectomy and fusion throughout the United States from 2006 to 2013. *Spine J.* 2018;18:1022-1029.
7. Rihn JA, Currier BL, Phillips FM, Glassman SD, Albert TJ. Defining the value of spine care. *J Am Acad Orthop Surg.* 2013;21:419-426.
8. Sivaganesan A, Wick JB, Chotai S, Cherkesky C, Stephens BF, Devin CJ. Perioperative Protocol for Elective Spine Surgery Is Associated With Reduced Length of Stay and Complications. *JAAOS - Journal of the American Academy of Orthopaedic Surgeons.* March 1, 2019;27.
9. Naik BI, Dunn LK, Wanchek TN. Incremental Cost-effectiveness Analysis on Length of Stay of an Enhanced Recovery After Spine Surgery Program: A Single-center, Retrospective Cohort Study. *Journal of Neurosurgical Anesthesiology.* April 2023;35.
10. Danielsen JM, Johnsen R, Kibsgaard SK, Hellevik E. Early aggressive exercise for postoperative rehabilitation after discectomy. *Spine (Phila Pa 1976).* 2000;25:1015-1020.
11. Nielsen PR, Andreasen J, Asmussen M, Tonnesen H. Costs and quality of life for prehabilitation and early rehabilitation after surgery of the lumbar spine. *BMC Health Serv Res.* 2008;8:209.
12. Chen AF, Stewart MK, Heyl AE, Klatt BA. Effect of immediate postoperative physical therapy on length of stay for total joint arthroplasty patients. *J Arthroplasty.* 2012;27:851-856.
13. Gamblin A, Garry JG, Wilde HW, et al. Cost Analysis of Inpatient Rehabilitation after Spinal Injury: A Retrospective Cohort Analysis. *Cureus.* 2019;11:e5747.
14. Larsen K, Sorensen OG, Hansen TB, Thomsen PB, Soballe K. Accelerated perioperative care and rehabilitation intervention for hip and knee replacement is effective: a randomized clinical trial involving 87 patients with 3 months of follow-up. *Acta Orthop.* 2008;79:149-159.
15. Larsen K, Hansen TB, Thomsen PB,

Christiansen T, Soballe K. Cost-effectiveness of accelerated perioperative care and rehabilitation after total hip and knee arthroplasty. *J Bone Joint Surg Am.* 2009;91:761-772.
16. den Hertog A, Gliesche K, Timm J, Muhlbauer B, Zebrowski S. Pathway-controlled fast-track rehabilitation after total knee arthroplasty: a randomized prospective clinical study evaluating the recovery pattern, drug consumption, and length of stay. *Arch Orthop Trauma Surg.* 2012;132:1153-1163.
17. Smith TO, McCabe C, Lister S, Christie SP, Cross J. Rehabilitation implications during the development of the Norwich Enhanced Recovery Programme (NERP) for patients following total knee and total hip arthroplasty. *Orthop Traumatol Surg Res.* 2012;98:499-505.
18. Bohl DD, Li J, Calkins TE, et al. Physical Therapy on Postoperative Day Zero Following Total Knee Arthroplasty: A Randomized, Controlled Trial of 394 Patients. *J Arthroplasty.* 2019;34:S173-S177 e171.
19. Low M, Burgess LC, Wainwright TW. A Critical Analysis of the Exercise Prescription and Return to Activity Advice That Is Provided in Patient Information Leaflets Following Lumbar Spine Surgery. *Medicina (Kaunas).* 2019;55.
20. Mannion AF, Denzler R, Dvorak J, Muntener M, Grob D. A randomised controlled trial of post-operative rehabilitation after surgical decompression of the lumbar spine. *Eur Spine J.* 2007;16:1101-1117.
21. Richardson CA, Jull GA. Muscle control-pain control. What exercises would you prescribe? *Man Ther.* 1995;1:2-10.
22. Madera M, Brady J, Deily S, et al. The role of physical therapy and rehabilitation after lumbar fusion surgery for degenerative disease: a systematic review. *J Neurosurg Spine.* 2017;26:694-704.
23. Ferrari S, Cedraschi C, Mapelli N, et al. Thoughts and concerns of patients at hospital discharge after lumbar spine surgery. A qualitative study. *Disability and Rehabilitation.* 2023-11-20;45.