

Preoperative Neuroscience Education for Patients Undergoing Surgery for Lumbar Radiculopathy

Researcher

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Abstract

Background: On average one in three patients following lumbar surgery (LS) for radiculopathy experience persistent pain and disability following surgery. No perioperative treatments have shown any ability to decrease this persistent pain and disability. In another challenging low back pain (LBP) population, chronic LBP, pain education focusing on the neurobiology and neurophysiology of pain, has shown an ability to reduce reported pain and disability. The purpose of this research study was to develop and test a preoperative neuroscience education program for LS and determine its effect on pain and disability following LS.

Research Design and Methods: After a series of studies, a newly designed preoperative neuroscience educational tool (PNET) was developed. Eligible patients scheduled for LS for radiculopathy participated in a multi-center study where they were randomized to either receive usual care (preoperative education), or a combination of usual care plus one session covering the content of the PNET, as delivered by a physiotherapist in a one-on-one verbal session. Prior to LS, and one, three and six months after LS, 67 patients completed a series of self-report outcome measures consisting of LBP and leg pain rating (Numeric Rating Scale), function (Oswestry Disability Index), fear avoidance (Fear Avoidance Beliefs Questionnaire), pain catastrophization (Pain Catastrophization Scale), pain knowledge (Pain Neurophysiology Questionnaire), various beliefs and experiences related to LS (Likert Scale), and post-operative utilization of healthcare (Utilization of Healthcare Questionnaire).

Results: At six month follow up there were no statistical difference ($p < 0.05$) between the experimental and control groups in regards to the primary outcome measures of function ($p = 0.296$), LBP ($p = 0.077$) and leg pain ($p = 0.074$). The experimental group scored significantly better on various questions regarding beliefs and experiences having undergone LS, compared to the control group indicating a more positive surgical experience. Analysis of healthcare utilization showed that patients who received the preoperative neuroscience educational program had dramatically less health care utilization (medical tests and treatments) in the six months following LS ($p = 0.001$), resulting in a 38% savings in healthcare cost.

Conclusion: The addition of a preoperative neuroscience educational program to usual care for LS for radiculopathy resulted in a profound behavioral change leading to a more positive surgical experience, decreased healthcare utilization and resultant savings, despite persistent pain and disability.

Opsomming

Agtergrond: Gemiddeld een uit elke drie pasiënte ervaar volgehoue pyn en gestremdheid na lumbale chirurgie (LC) vir radikulopatie. Geen peri-operatiewe behandeling het al getoon dat dit die vermoede om hierdie volgehoue pyn en gestremdheid te verminder nie. In nog 'n uitdagende lae rug pynbevolking, naamlik chroniese lae rugpyn, het pyn-onderlig, wat fokus op die neurobiologie en neurofisiologie van pyn, getoon dat dit kan lei tot verminderde rapportering van pyn en gestremdheid. Die doel van hierdie navorsingstudie was om 'n preoperatiewe neuro-onderlig program vir lumbale chirurgie te ontwikkel en te toets, en die uitwerking daarvan op pyn en gestremdheid na LC te bepaal.

Navorsingsontwerp en Metodiek: Na 'n reeks studies is 'n nuwe preoperatiewe neuro-onderlig hulpmiddel (PNET) ontwikkel. Geskikte pasiënte wat geskeduleer was vir LC weens radikulopatie, het deelgeneem aan 'n veelvuldige- sentrum studie. Deelnemers is lukraak in een van twee groepe ingedeel om of gewone sorg (preoperatiewe onderlig), of 'n kombinasie van gewone sorg met een sessie wat die inhoud van die PNET gedek het. Laasgenoemde sessie is aangebied deur 'n fisioterapeut in 'n een-tot-een verbale sessie. Voor die LC, en een, drie en ses maande na LC, het 67 pasiënte 'n reeks van self-verslaggewende uitkoms metings voltooi, wat insluit: Lae Rug- en beenpyn gradering ('Numeric Pain Rating Scale'), Funksie ('Oswestry Disability Index'), Vrees-vermyding ('Fear Avoidance Beliefs Questionnaire'), Pyn-katastrofering ('Pain Catastrophization Scale'), Pyn-kennis ('Pain Neurophysiology Questionnaire'), verskeie oortuigings en ervarings wat verband hou met LC ('Likert Scale'), en postoperatiewe Gesondheidsorg-benutting ('Utilization of Healthcare Questionnaire').

Resultate: Tydens die ses-maande-opvolg was daar geen statistiese verskil ($p < 0,05$) tussen die eksperimentele- en kontrolegroepe met betrekking tot die primêre uitkoms metings van Funksie ($p = 0,296$), Lae rug Pyn ($p = 0,077$) en beenpyn ($p = 0,074$), nie. Die eksperimentele-groep het betekenisvol beter gevaar met verskeie vrae oor oortuiging en ervarings na afloop van LC. Ontleding van gesondheidsorg benutting, het getoon dat pasiënte wie die preoperatiewe neuro-onderlig program ontvang het, dramaties minder Gesondheidsorg (mediese toetse en behandelings) in die ses maande na LC benodig het, ($p = 0,001$), wat gelei het tot 'n 38% besparing in gesondheidsorgkoste.

Gevolgtrekking: Die byvoeging van 'n preoperatiewe neuro-onderlig program, tot die gewone-sorg vir LC weens radikulopatie, het 'n noemenswaardige gedragsverandering veroorsaak wat tot 'n meer positiewe chirurgiese ervaring, verminderde gesondheidsorg benutting en finansiële besparing gelei het, ten spyte van volgehoue pyn en gestremdheid.

Dedication and Acknowledgements

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Ethics Approval

Approval for this project was obtained from the Committee for Human Research of Stellenbosch University (Appendix 1). The project was conducted according to internationally accepted ethical standards and guidelines of the international Declaration of Helsinki, the South African Guidelines for Good Clinical Practice and the Medical Research Council (MRC) Ethical Guidelines for Research.

Chapter 1

1.1 Introduction

Low back pain (LBP) is the most widely reported musculoskeletal disorder in the world, and it is reported that 70 – 80% of all people will experience LBP during their lifetime.¹⁻³ Epidemiological data shows that LBP is at epidemic proportions, and the prevalence of LBP is still increasing, resulting in an increasingly debilitating and costly problem.^{2,4} In the United States (US) LBP accounts for a productivity loss estimated at \$28 billion per year.⁵ LBP can manifest itself with or without lumbar radiculopathy.^{3,6,7} With failed conservative care and worsening symptoms, patients with LBP and/or lumbar radiculopathy often consider lumbar surgery (LS) to alleviate their pain and dysfunction.^{8,9}

LS is very common in the US. The likelihood of having LS in the US is at least 40% higher than in any other country and more than five times higher than in the United Kingdom.¹⁰⁻¹² The primary surgical intervention for lumbar radiculopathy is lumbar laminectomy or lumbar laminotomy with or without discectomy.^{9,13} Studies of lumbar disc surgery primarily for radiculopathy have shown that this surgical intervention has a success rate of between 60% and 90%.⁹⁻¹¹ These figures show that, following lumbar disc surgery, 10 – 40% of patients will have a poor outcome, with resulting pain, loss of movement and loss of function.¹⁴ With persistent disability following LS, rehabilitation (consisting mainly of exercise) is often prescribed and is postulated to decrease disability, increase movement and facilitate return to regular activities.^{9,12,15-17} A Cochrane review, however, highlighted the limited research and poor methodology in regards to postoperative rehabilitation programs as well as the heterogeneous nature of postoperative rehabilitation following lumbar disc surgery, including variations in the content and frequency of the programs.¹² Most important, the review showed limited efficacy of postoperative rehabilitation in producing intermediate and long-term benefits for patients undergoing lumbar disc surgery.¹² The results from this Cochrane review¹² and subsequent randomized controlled trials,^{18,19} along with data indicating that surgeons do not readily send patients to rehabilitation following LS,¹⁷ may indicate that many patients often suffer long-term disability following LS for radiculopathy.

Preoperative education has been proposed as a strategy to decrease postoperative complications and disability,^{20,21} and has been utilized in patient groups undergoing hip replacement,²²⁻²⁶ knee replacement,^{23,24,26-28} cardiac surgery,²⁹⁻³³ abdominal surgery^{20,34-37} and dental surgery.³⁸⁻⁴⁰ Results from these studies demonstrated increased knowledge of the surgical procedure,^{23,41-43} reduced anxiety,^{30,36,44-46} reduced postoperative pain,^{36,47-50} decreased

length of hospital (LOH) stay^{21,23,25,50} and faster return to preoperative functional levels.^{25,29,47,48,51} However, to date, only a limited number of studies have been conducted on the outcome of preoperative education for LS patients.^{23,49,51-57} Douglas et al⁴⁷ conducted a nurse-led preoperative educational study focusing on anatomy, risks of the surgery, complications, general hospital procedures, goals and length of hospital stay, compared with a control group which did not have access to the same preoperative education. The study results demonstrated that the group that received the education perceived a greater increase in vitality and mental health and decreased LOH stay, but the study did not differentiate among the types of preoperative diagnoses, types of surgery or different past histories of LS. A study by LaMontagne et al,⁴⁹ showed that preoperatively teaching adolescents a coping strategy of dealing with postoperative pain, is beneficial. Three studies surveyed patients who had undergone LS, to determine their preferences regarding preoperative education for LS.^{51,56-58} The studies concluded that there is no consensus on the preferred content of preoperative education, but in the study by Louw et al⁵⁸ patients indicated that they require more information on their pain and how surgery will impact on this. The study by Ronnberg et al⁵¹ showed that patients undergoing disc surgery, are in general satisfied with the care given to them preoperatively but not with the content of the information regarding the impending spinal surgery. No published research results could be found on the contents and delivery of preoperative education for lumbar radiculopathy.

Education has long been used to help alleviate the disability associated with LBP.⁵⁹⁻⁶² In the orthopedic domain, there are a number of studies on the effect of education on pain and disability, with outcomes ranging from “excellent”⁶³ to “poor.”^{64,65} A study by Udermann et al⁶³ showed that introduction of an individualized educational booklet on back biomechanics resulted in decreased pain and frequency of LBP episodes in chronic LBP patients. In contrast to these findings, two systematic reviews on the effect of individualized and/or group education for LBP or mechanical neck pain showed little efficacy of such education.^{64,65} Most educational programs used in orthopedics utilize biomedical models of anatomy and biomechanics to address pain,^{59,66-68} which not only has shown limited efficacy,^{59,66,69,70} but may even have increased patient fears and thus negatively impacted on their outcomes.^{66,71-73} Cognitive behavioral therapy (CBT) which focuses on the sensory, cognitive, affective and behavioral aspects of pain, and aims to reassure patients and address fears related to movement, pathology and function, has also been used to educate LBP patients. The outcomes of CBT also demonstrated limited efficacy in the management of LBP.^{59,74}

Recent research evaluated the use of neuroscience education (NE) in decreasing pain and disability among patients with LBP. Although NE is also aimed at reducing the fear associated

with LBP, it aims to teach patients more about pain, specifically the neurophysiology and neurobiology of their pain experience, thus deemphasizing traditional anatomical tissue-based models.^{75,76} NE does not include the behavioral components of CBT, but underscores the importance of changing cognitions, which in essence supports CBT. Studies which utilized NE demonstrated decrease in fear and change in a patient's perception of his/her pain,^{77,78} an immediate improvement in patients' attitudes about and their relation to pain,⁶⁷ pain cognition and physical performance,⁷⁹ pain thresholds during physical tasks,⁸⁰ and outcomes of therapeutic exercises,⁸¹ as well as significant reduction in widespread brain activity characteristic of a pain experience.⁸² Furthermore, these results have shown to extend beyond the short term and to be maintained at one-year follow-up.^{77,78,81}

Considering the proposed positive effects of NE and the persistent pain and disability many patients experience following LS, this study set out to develop a preoperative NE program for patients undergoing LS for radiculopathy and to determine if such a program would result in superior outcomes compared to usual care. This thesis aims to report on a series of studies towards this aim (Figure 1.1):

1. Establishment of the current "usual care" for LS patients for radiculopathy pertaining to preoperative patient education (Chapter 2).
2. Development of a preoperative neuroscience education tool for LS patients for radiculopathy (Chapters 3, 4, 5, 6 and 7).
3. Measurement of the efficacy of the newly developed preoperative neuroscience education tool for LS patients for lumbar radiculopathy (Chapters 8, 9 and 10).

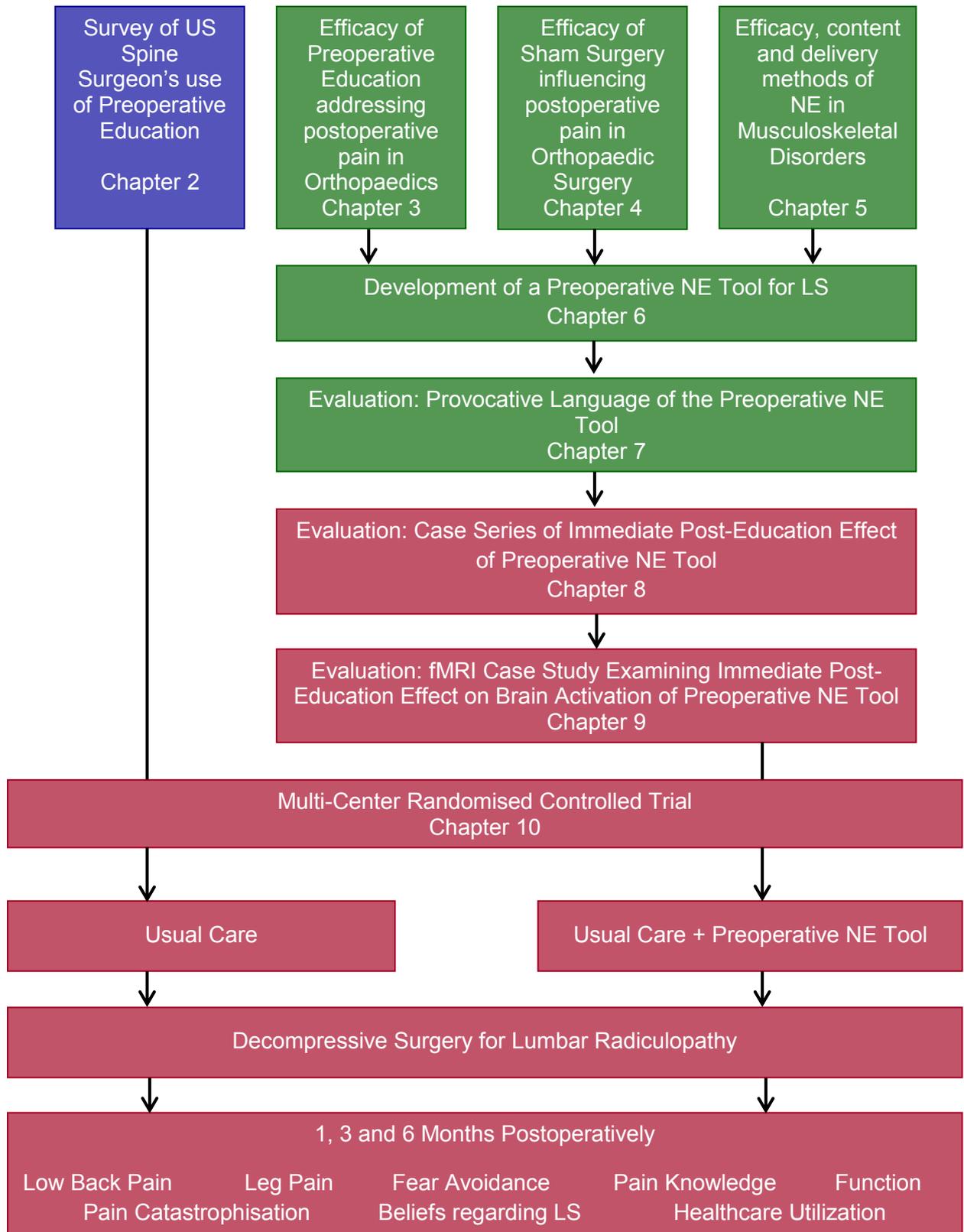
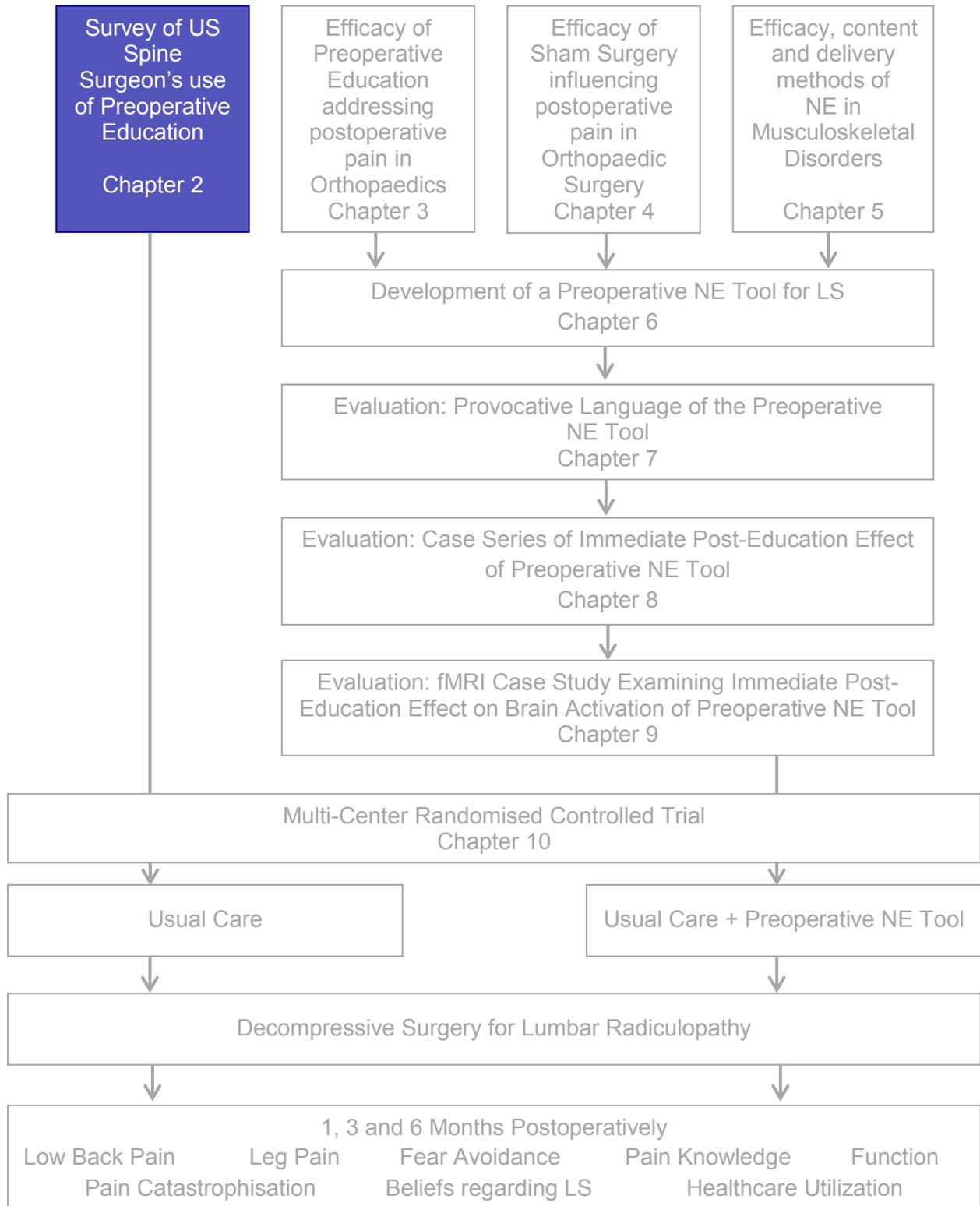


Figure 1.1: Schematic layout of the thesis

**Phase 1:
Establishing the current “usual care” for LS patients for radiculopathy pertaining to preoperative patient education**

(Published Article – Appendix 2)



Chapter 2:

Preoperative education for lumbar radiculopathy: A survey of US spine surgeons

This chapter is adapted from: Louw A, Butler DS, Diener I, Puentedura EJ. *Preoperative education for lumbar radiculopathy: A Survey of US Spine Surgeons. International Journal of Spine Surgery. 2012;6:130-139.* The referencing format and headings/subheadings from the original publication have been modified and the headings within the chapter have been numbered for consistency throughout the thesis.

2.1 Introduction

The literature on lumbar surgery (LS) is dominated by studies that employ experimental designs to measure the effects of various perioperative treatments on patient outcomes, including education.^{42,83-85} These studies predominantly compare structured perioperative interventions with the usual care that patients receive. What 'usual care' comprises, however, is largely elusive and unexplored.⁸³ To date, several studies have been conducted in reference to education for LS,^{23,49,51-57} but the heterogeneous nature of these studies does not provide a clear view of what constitutes 'usual care' for preoperative education for spinal surgery. These were explored in different spinal surgical interventions, such as surgery for scoliosis,^{49,54} disc surgery,^{56,57} decompressive surgery,^{56,57} and "not specified".^{52,55} The delivery methods also vary between verbal education by a nurse,^{52,54} a surgeon,^{51,55} a physiotherapist,⁵¹ or video-only instruction.^{49,53} Content of preoperative education varies between cognitive behavioral therapy (CBT),^{49,53} information regarding the surgical procedure,^{49,52,53,55} information on activities of daily living (ADLs),⁵¹ anatomy,⁵² risks associated with the surgery,^{51-53,55} general hospital procedures^{52,53} and length of hospital (LOH) stay.^{52,53} Educational interventions utilize various types of educational aids including leaflets and booklets,^{52,54,55} spine models,⁵⁵ posters,^{54,55} or verbal communication with no educational aids.⁵⁴ Preoperative education is administered to adults^{52,55} as well as adolescents and children.^{49,53,54} In regards to timing and duration of the education, only one study specifies preoperative education to be administered 1 to 2 weeks preoperatively for 40 minutes.⁵²

It is clear from the vast variety of methods in the literature reviewed, that very little is known in regards to what constitutes 'usual care' as it relates to the utilization, content and preferred

education delivery methods used in studies, and thus also by spine surgeons in the US. The purpose of this study was to determine the current utilization, content and delivery methods of preoperative education by spine surgeons in the United States (US) for patients undergoing LS for radiculopathy. Additionally, the study aimed to determine the importance that spine surgeons in the US place on preoperative education for lumbar radiculopathy. This information would inform the planned multi-center randomized controlled trial (RCT) (final and main study reported on in this thesis), which employed an experimental design to measure the effects of a newly designed neuroscience education (NE) program versus 'usual care', on patient outcomes after spinal surgery in the US. Additionally, future studies employing similar experimental designs can benefit from a greater understanding of usual care, as utilized by US spine surgeons.

2.2 Materials and Methods

2.2.1 Questionnaire Development and Administration

Since no similar studies could be found in the literature, a Spinal Surgery Education Questionnaire (SSEQ) was developed to determine the utilization, content, delivery methods and importance of education as rated by spine surgeons in the US (Appendix 2). The questionnaire was designed based on previous surveys of physicians and surgeons related to various other surgical interventions,⁸⁶⁻⁹³ a previous study surveying patients having undergone LS for radiculopathy⁵⁶ and objectives of the current study. Section 1 of the questionnaire gathered demographic and practice information from the responding spine surgeon, while section 2 gathered information on the content, delivery methods and utilization of patient education before spinal surgery, as well as the importance of this, as rated by the surgeons.

A draft questionnaire was sent to a panel of national and international experts in the fields of patient education, questionnaire design and LS, to follow a semi Delphi-method to establish face and content validity⁹⁴. Upon completion of the expert panel review, a pilot study testing the questionnaire in a convenience sample of 5 spine surgeons was conducted, to review the content, the ease of completion and the time it took to complete the questionnaire. The finalized SSEQ was uploaded on a secure website for use in the study. To obtain a random sample of US spine surgeons, a company tracking outcomes for US spine surgeons (Visiontree™) as well as a marketing agency (Medical Marketing Services, Inc.) was asked to provide a random sample of spine surgeons, representing all states of the US to participate in the survey study. Electronic mail invitations were sent to 200 surgeons describing the study and asking them to participate in the online survey. Surgeons included in the study were male or female, practicing in the US, and actively involved in performing LS. Exclusion criteria included those not fluent in

reading or writing the English language, and those not actively involved in spinal surgery. Data was collected over a 3 month period with 4 separate e-mail messages sent to the surgeons as reminders, and one sent in appreciation for their time and participation.

2.2.2 Statistical Analysis

The survey data was captured by the website software and compiled in Microsoft Excel spreadsheet files and statistical calculation was performed using SPSS software (SPSS 16.00, SPSS Inc., Chicago, IL). Descriptive statistics such as counts and percentages, frequency distributions, means, standard deviations and confidence intervals were used to describe variables. Some pre-specified comparisons were made between certain variables. Where both variables were categorical, contingency analysis was used to detect association. Both the Chi-squared and Fisher's exact test were used. Statistical significance was set at $p < 0.05$. When relationships between a categorical variable and a continuous outcome were analyzed a t-test or analysis of variance (ANOVA) were used to detect significant differences. Where the assumptions of normality were violated, the non-parametric equivalents were used to analyze the data.

2.3 Results

A total of 89 out of the 200 (45%) surgeons responded to the online survey. Eight questionnaires had to be excluded due to incomplete data, resulting in a total of 81 completed questionnaires that were available for analysis.

2.3.1 Physician demographics

The spine surgeons responding to this survey could best be described as male orthopedic surgeons from the US, trained as a medical doctor, with approximately 20 years of experience, working in a private practice, overseeing the training of medical students/residents, having no additional training in pain management and averaging approximately 10 decompressive surgeries for lumbar radiculopathy per month. Additionally, this surgeon would not have personally undergone LS and most likely no immediate family member has undergone LS.

2.3.1.1 Type of surgeon

Of the 81 surgeons contained in the results of the study, more than 90% (90.12%) were orthopedic surgeons. The remaining 9.88% of surgeons were neurosurgeons

2.3.1.2 Qualification of the surgeon

Spine surgeons in the US could either constitute a medical degree (M.D) or be trained as a doctor of osteopathy (D.O). Of all the surgeons who completed the survey, 91.36% were MD's, while 8.64 were qualified as DO's

2.3.1.3 Gender

The vast majority of the surgeon's in the study were male (97.53%).

2.3.1.4 Experience

The surgeons in this study were experienced surgeons. Surgeons were given four options to indicate their experience as a spine surgeon: > 20 years, 10-20 years, 5-10 years and < 5 years. Nearly half the surgeons (46.91%) indicated they have been practicing more than 20 years, followed by 30.86% indicating being a surgeon between 10 and 20 years, followed by 16.05% practicing between 5 and 10 years. Only a small percentage (6.17%) of the surgeons has been practicing less than 5 years. The results indicate that 93.83% of the surgeons have been practicing at more than 5 years.

2.3.1.5 Practice setting

Surgeons were asked to indicate the setting of their practice by choosing between private practice, academic setting or a combination of both. The majority of surgeons (56.79%) are working in a private practice exclusively, while 27.16% indicated they worked in an academic setting. A small group of surgeons (13.58%) indicated they worked in both private practice and academic settings.

2.3.1.6 Teaching students, residents

On the question whether they are involved with providing teaching for medical students or resident surgeons, almost two-thirds (65.43%) of the respondents indicated they provide education for students or residents.

2.3.1.7 Practicing state

Surgeons were asked to indicate in which state they primarily practice. Eighty surgeons responded to this question. Twenty seven states (out of 50) were represented by the surgeons in this study. The three highest represented states were California (13.58%), New York (9.88%) and Missouri (8.64%).

2.3.1.8 Additional pain management training

On the question whether they have undergone any additional training in pain management (residency, fellowship), only a few surgeons (n = 7; 8.64%) indicated additional training in pain management.

2.3.1.9 Surgeries per month

Surgeons were asked to estimate the number of decompressive surgeries they perform per month specifically for lumbar radiculopathy. Forty three percent (43.21%) indicated less than 10 such surgeries per month, followed by 38.27% performing between 10 – 20 surgeries and 18.52% indicating > 20 decompressive surgeries per month.

2.3.1.10 Personally undergone lumbar surgery?

On the question whether they have personally undergone LS, the majority of surgeons (86.42%) indicated they have not undergone LS themselves.

2.3.1.11 Family members having undergone lumbar surgery

On the question whether any immediate family members have undergone LS, nearly two-thirds of the surgeons (65.43%) indicated that they do not have an immediate family member who has undergone LS.

2.3.2 Education provided preoperatively

Section 2 of the SSEQ focused on the surgeon's practice pattern and beliefs regarding providing preoperative education for patient undergoing LS for radiculopathy. In summary, preoperative education for LS for radiculopathy in the US is provided as informal sessions, by

the actual surgeons during the last consultation prior to surgery, usually lasts more than 15 minutes and occurs approximately two-and-a-half weeks before LS.

2.3.2.1 Education session description

Surgeons were asked to indicate if their educational sessions would be considered informal (during the course of clinical consultation) or a more formal education session (specially designed and planned session). Nearly two thirds of the surgeons (64.20%) of the surgeons indicated that their preoperative education was provided informally during the course of clinical consultation (Figure 2.1).

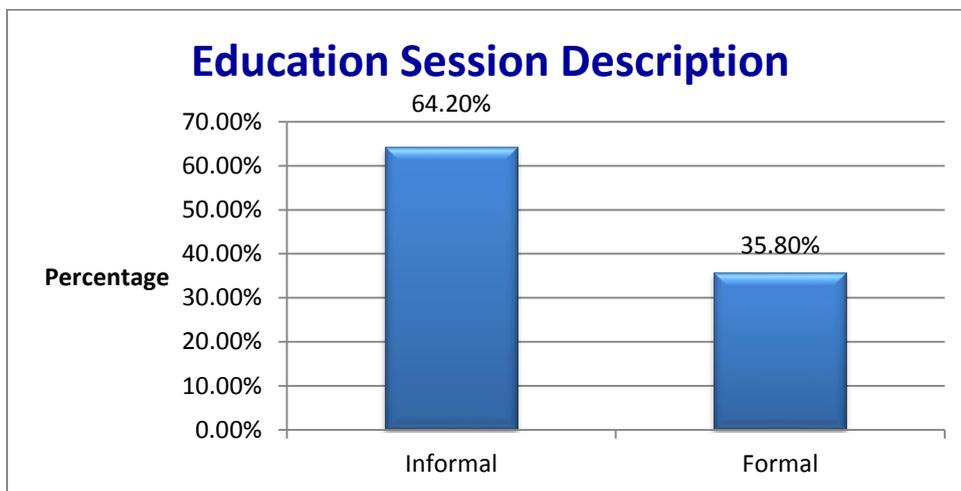


Figure 2.1: Education session descriptions by surgeons who completed the SSEQ

2.3.2.2 Provider of the education

Surgeons were asked to indicate who primarily provides the preoperative educational session. Three-quarters of the surgeons (75.31%) indicated that they themselves provide the educational session (Figure 2.2).

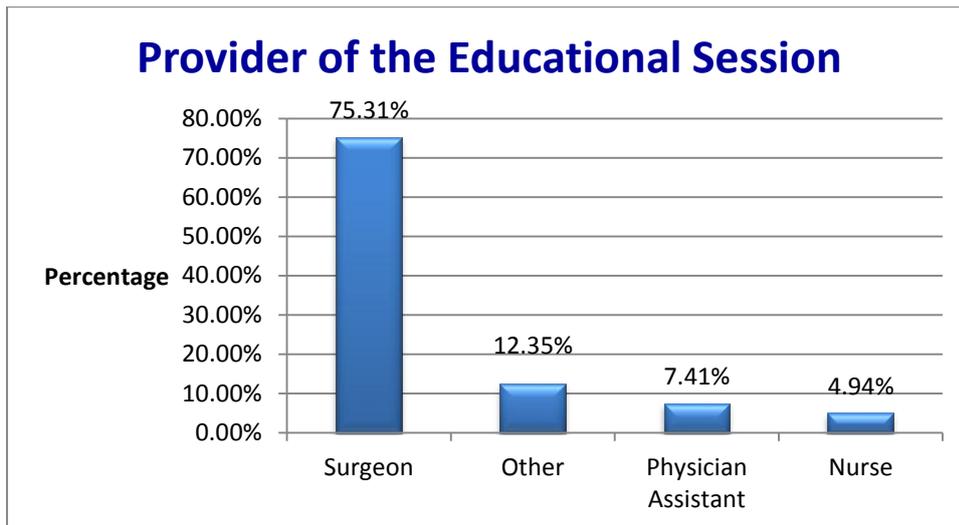


Figure 2.2: Indication of the primary provider of the preoperative educational session

The data exploring the description of the professionals listed in the “other” category, showed “all of us” (surgeon, assistant and nurse), and “other professions”(nurse practitioner and physiotherapist).

2.3.2.3 Timing of the preoperative education

The vast majority of surgeons (83.95%) indicated that they provided their preoperative education during the final consultation session at their office.

2.3.2.4 Length of the educational session

Surgeons were asked to indicate how long they estimate they spend on the educational session. Nearly two thirds of the surgeons (64.2%) estimated the educational session lasting more than 15 minutes, followed by 34.6% reporting spending between 5 to 15 minutes.

2.3.2.5 Time between consultation and surgery

Surgeons were asked to estimate the average time (in days), between a patient deciding to undergo LS (surgical consultation) to the actual surgical procedure. Surgeons varied considerably between reported times to surgery from 2 days to 183 days from the time the decision is made to undergo surgery. The mean time from education 33.65 days, while the median scores 17.5 days (Figure 2.3).

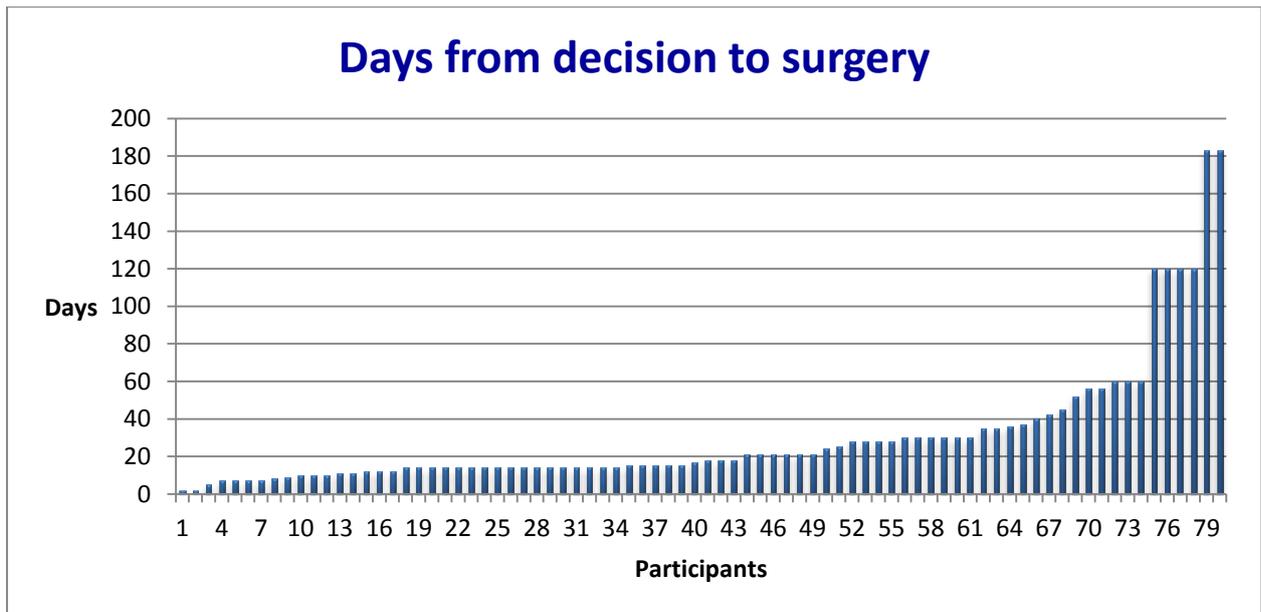


Figure 2.3: Estimated days between deciding to undergo LS and the actual LS

2.3.3 Hospital providing a structured preoperative program

Surgeons were asked to indicate if the hospitals or surgery centers they perform LS at, provided structured preoperative programs, and if they did, the average time such sessions lasted and if these sessions were mandatory. Based on the results of this survey most hospitals/surgery centers in the US do not have structured preoperative educational sessions for patients undergoing LS for radiculopathy. Additionally, if hospitals/surgery centers have such programs, the programs are not mandatory to attend and vary anywhere from 15 minutes in length to 1 hour in length.

2.3.3.1 Hospitals/surgery centers providing structured preoperative programs

Surgeons were asked to indicate if they were aware if the hospitals/surgery centers they perform LS at, provide formal, structured educational sessions for patients. Three quarters of the surgeons (75.31%) indicated that their facilities do not provide such a service.

2.3.3.2 Duration of the hospital/surgery center educational session

Additionally, surgeons who indicated their hospital/surgery center had a structured preoperative program ($n = 20$), were asked to estimate the duration of these classes (Figure 2.4). The highest number of surgeons ($n = 7$) estimated the education session lasting 1 hour, followed by 5 surgeons estimating 30 minutes.

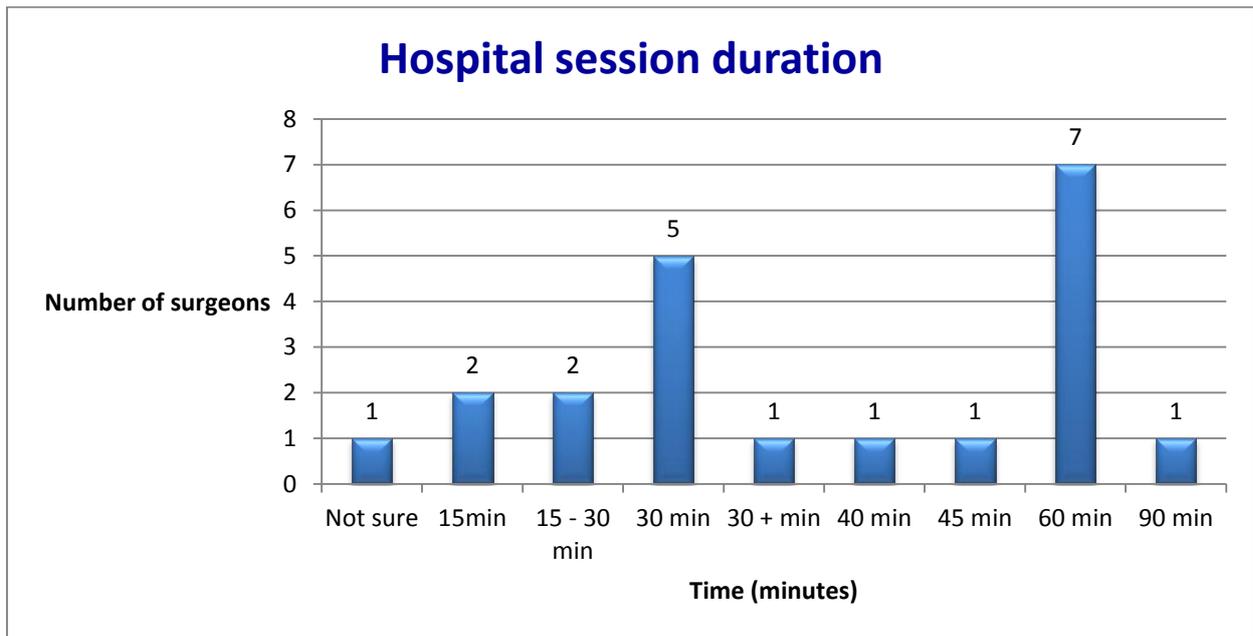


Figure 2.4: Duration of the educational sessions offered at the hospitals/surgery centers.

2.3.3.3 Mandatory hospital/surgery center educational session

Twenty surgeons indicated that the hospital/surgery centers they are associated with provide a structured preoperative educational session for LS. Seven of the twenty surgeons (35%) indicated that the educational sessions were considered mandatory prior to undergoing LS.

2.3.4 Importance of preoperative education

Surgeons in the US believe that preoperative education is very important for patients undergoing LS for radiculopathy, yet there is poor consensus as to why they rate preoperative education as important.

2.3.4.1 Is preoperative education important?

Surgeons were asked to rate, on a scale of 0 to 10 (0 being not important and 10 being extremely important) how important they rate preoperative education for LS. More than 85% of the surgeons (85.15%) rated the importance of preoperative education as 8 or higher on a scale of 0 to 10 (Figure 2.5). The mean score was 8.848 out of 10 with a standard deviation on 1.468.

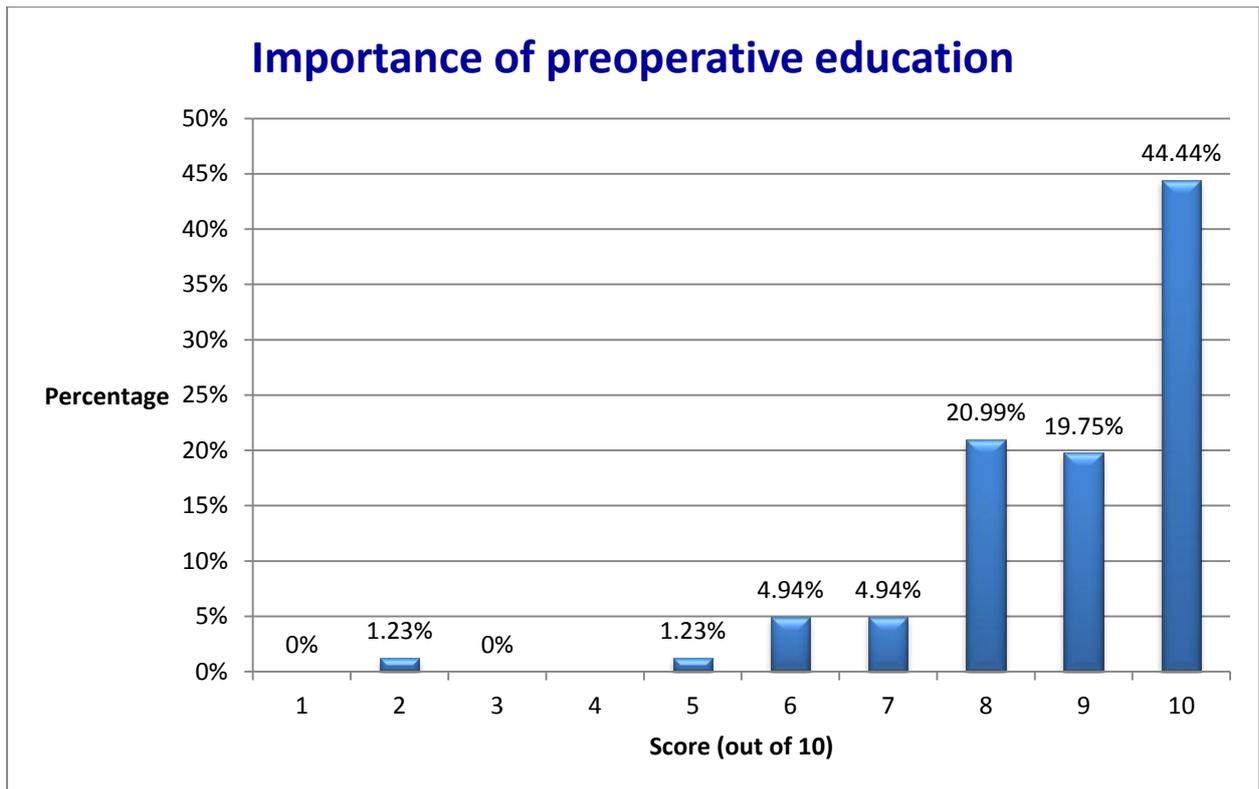


Figure 2.5: Importance of preoperative education for LS for radiculopathy as rated by surgeons who completed the SSEQ

2.3.4.2 Reason for inclusion of preoperative education

Surgeons were asked to choose from a list of options why they include preoperative education for LS. Apart from the 4 main choices (I am obliged to [ethically and/or legally]; it provides an opportunity to answer patient questions; it helps reduce anxiety prior to surgery and it provides “better” surgical outcomes), surgeons were also allowed to choose “other” and clarify their choice. Although 25 surgeons chose “other”, their choices were merely to indicate a combination of the 4 main choices. The results indicate that surgeons view all 4 answers as a reason as to why they provide preoperative education (Figure 2.6).

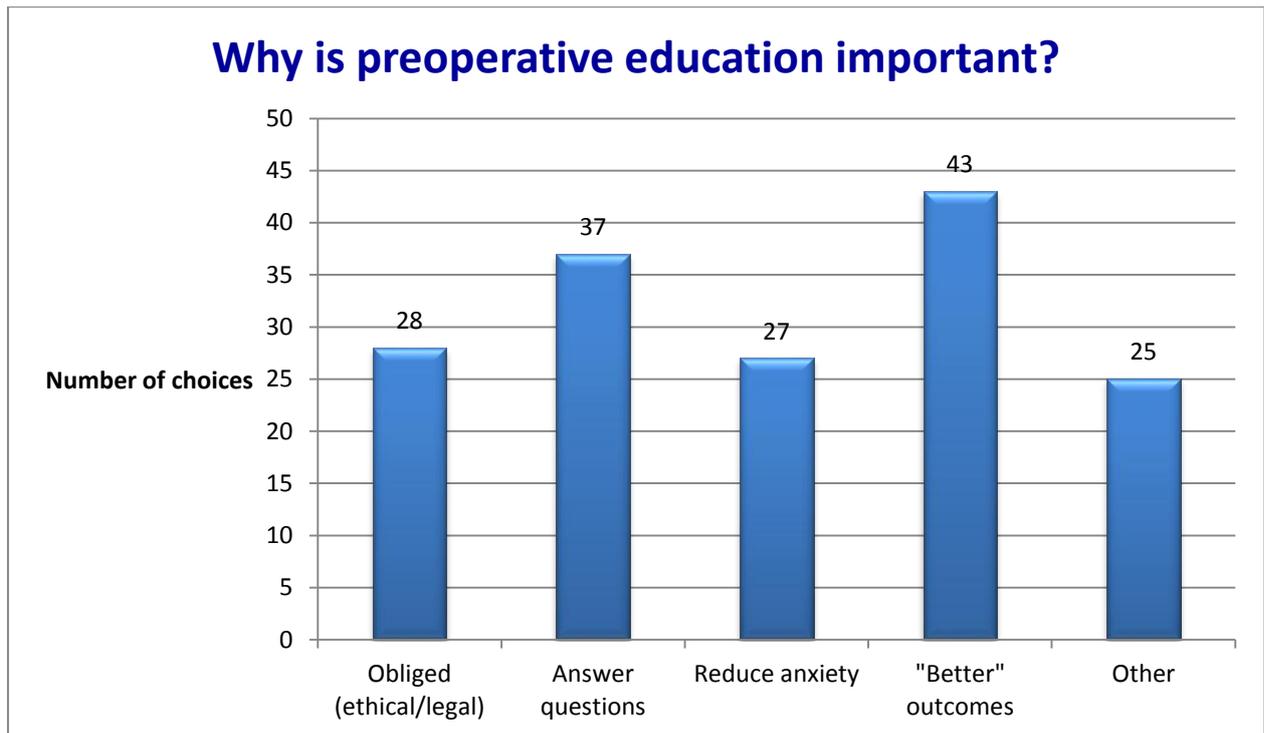


Figure 2.6: Reasoning for the importance of preoperative education

2.3.5. Content of the preoperative education

Surgeons cover a variety of topics prior to LS, mainly focusing on issues related to the surgical procedure, the risk/benefit ratio of the procedure and its impact on the patient’s pain, with overall approximately 20% of the time specifically dedicated to addressing pain.

2.3.5.1 Topics covered during preoperative education for lumbar surgery

Surgeons were provided an extensive list of topics related to LS. These topics, based on the development of the SSEQ and pilot study, are most often included in preoperative education for LS for radiculopathy. Surgeons were asked to indicate which topics they include in their preoperative education. Table 2.1 provides, in order (from highest to lowest) the inclusion percentages of surgeons related to topics covered in preoperative education.

Table 2.1 Topics included in preoperative education for LS

Topic	Yes	No
Surgical procedure	96.30%	3.70%
Complications	96.30%	3.70%
Outcomes/expectations	93.83%	6.17%
Anatomy	92.59%	7.41%
Amount of postoperative pain	90.12%	9.88%
Hospital stay	90.12%	9.88%
Surgery affecting pain	88.89%	11.11%
Consent	87.65%	12.35%
Precautions after surgery	86.42%	13.58%
Infection	85.16%	14.84%
Smoking	83.95%	16.05%
Physical therapy	74.07%	25.93%
Hospital issues (admissions, etc.)	69.14%	30.86%
Medicine use prior to surgery	64.20%	35.80%
Strategies to cope with pain	60.49%	39.51%
Blood work prior to surgery	58.02%	41.98%
Food intake prior to surgery	55.55%	44.45%
Biomechanics	48.15%	51.85%
Surgical scar	48.15%	51.85%

The topics listed in Table 2.1 are a complete list of included topics surgeons could choose from. These topics were part of five larger categories covered in LS – surgical procedures, medical care preoperatively, outcomes, legal and postoperative. The surgeons were provided with the 5 categories and asked to choose only 1 topic as the single most important aspect of that specific category.

2.3.5.2. Surgical procedures

Of the 3 topics of education listed under surgical procedure (anatomy, biomechanics, instrumentation), nearly three-quarters of surgeons (74.07%) rated anatomy as the single most important aspect to cover (Figure 2.7). Missing data n = 5 (6.17%).

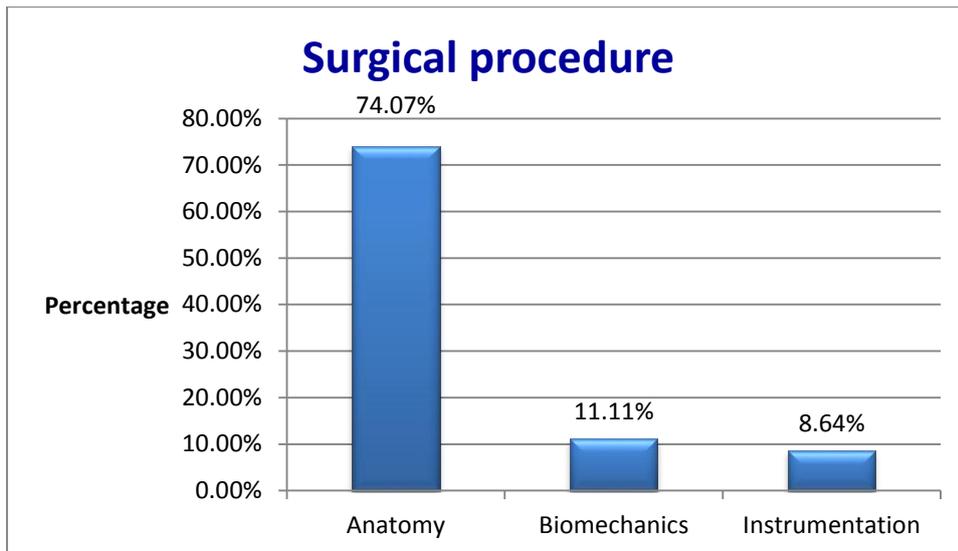


Figure 2.7: Importance of various topics covered under surgical procedure

2.3.5.3. Medical care preoperatively

Of the 4 topics listed under medical care preoperatively (blood work, medicine use, smoking and hospital admission) the largest percentage of surgeons (43.21%) rated addressing smoking as most important (Figure 2.8). Missing data n = 4 (4.94%).

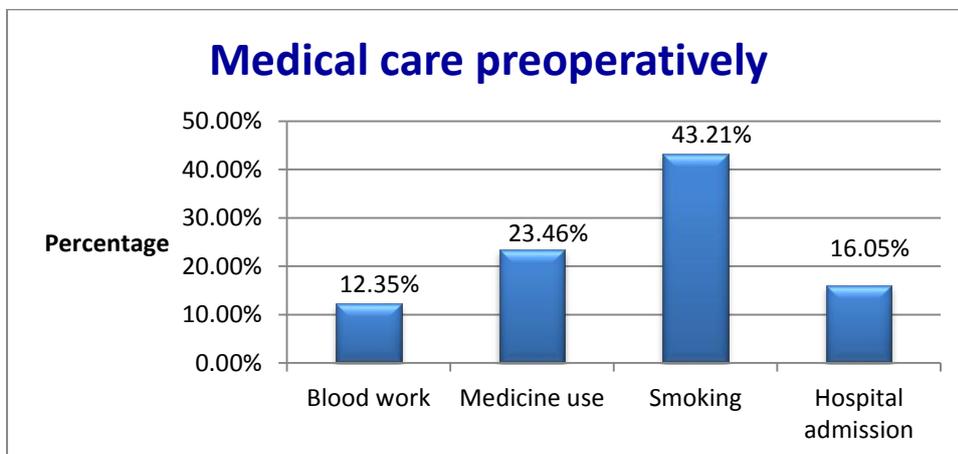


Figure 2.8: Importance of issues covered during education of medical care preoperatively

2.3.5.4. Outcomes

Of the 3 topics listed under outcomes (pain, function and strength), surgeons focused primarily on pain (54.32%) and function (43.21%) with no choices selecting strength issues related to outcomes. Missing data n = 2 (2.47%)

2.3.5.5. Legal

Of the 3 topics listed under legal (consent, possible complications and risk/benefit ratio), more than half the surgeons (55.55%) rated covering risk/benefit ratio as most important, followed by possible complications (24.69%) and consent (14.81%). Missing data n = 4 (4.94%).

2.3.5.6. Postoperative

Of the 3 topics listed under postoperative issues (physiotherapy, physician visit and limitations after surgery), more than half the surgeons (58.02%) rated covering limitations after surgery as most important, followed by issues related to physician visit (20.99%) and physiotherapy (13.58%). Missing data n = 6 (7.41%).

2.3.5.7. Pain

Surgeons were asked to estimate what percentage of their preoperative education session is dedicated specifically to addressing pain experienced by the patient. Of the 76 respondents (missing data n = 5), the median score was 20%, with 3% rated as the lowest and 80% as the highest (Figure 2.9).

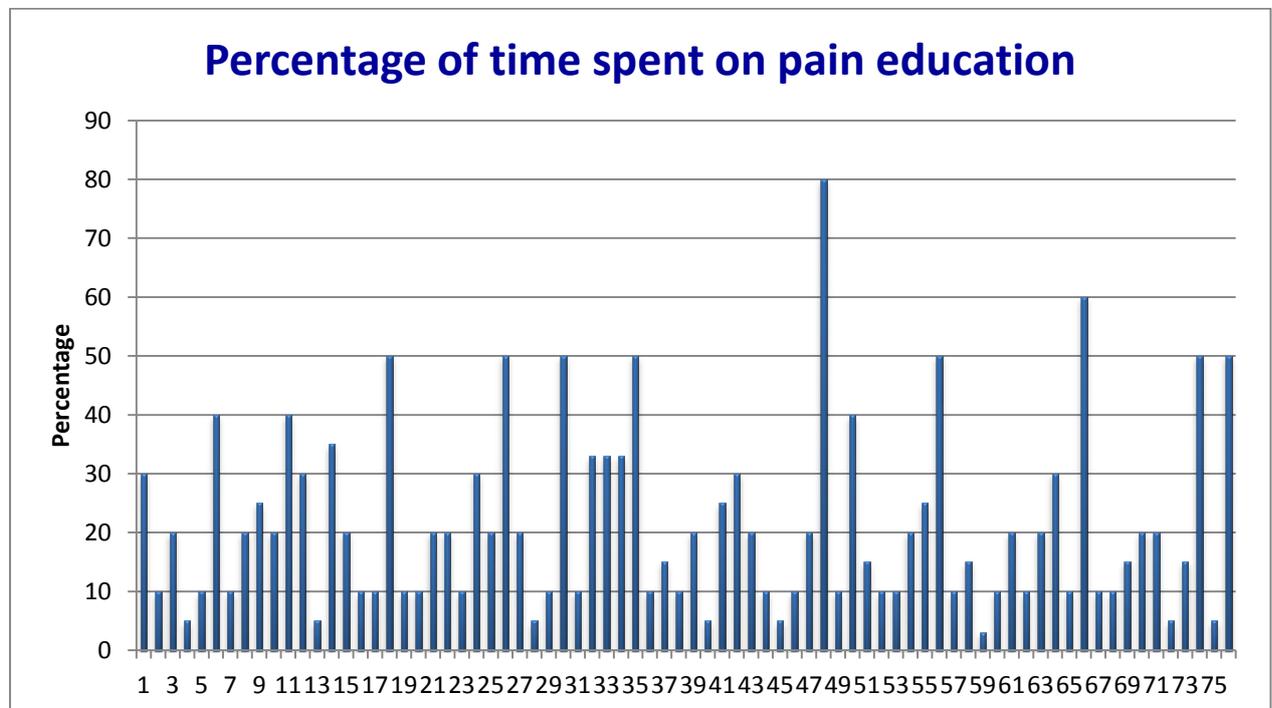


Figure 2.9: Estimated percentage of time spent specifically on pain education preoperatively

2.3.6 Educational tools

Surgeons mainly use verbal communication with the aid of a spine model conveying their educational message prior to LS, sometimes accompanied by a booklet containing images.

2.3.6.1 Educational tools used

Surgeons were provided an extensive list of topics related to tools/props used during education prior to LS. This list of tools/props was developed during the development of the SSEQ and pilot study. Surgeons were asked to indicate which tools/props they use during their preoperative education. Table 2.2 provides, in order (from highest to lowest) the inclusion percentages of tools/props used by surgeons. Nearly all surgeons (96.3%) indicated that they use verbal communication/discussion with the use of a spine model.

Table 2.2: Most commonly used tools/props by spine surgeons to educate patients prior to LS

Tools/props	Yes	No
Spine model and verbal	96.30%	3.70%
Booklet with images	51.85%	48.15%
Website	38.27%	61.73%
Only verbal	9.88%	90.12%
DVD/Video	6.17%	93.83%
Booklet with no images	1.23%	98.77%

Surgeons who indicated they referred patients to websites, were additionally asked to provide the web address of the website they routinely send patients. The most common websites listed were (in no particular order):

- spineuniverse.com
- spine-health.com
- understandingbacksurgery.com
- aaos.com
- EMMI on line
- orthospine.com
- kcneurosurgery.com
- svspine.com
- spine.org

2.3.7 Physiotherapy

Nearly two-thirds of surgeons report that they routinely send patients for rehabilitation in physiotherapy after LS for radiculopathy. The surgeons who indicate they do send patients to rehabilitation on average send 85% of the patients to physiotherapy. Surgeons were asked to answer “yes” or “no” if they routinely send patients to physiotherapy for rehabilitation following LS for radiculopathy. Fifty two of the 81 surgeons (64.2%) indicated that they routinely send patients to physiotherapy following LS for radiculopathy.

Surgeons who answered “yes” (n = 52), were then asked to estimate the percentage of their patients who undergo LS for radiculopathy they send to physiotherapy. The median score was 85%, with the lowest score rated as 20% and highest as 100%.

2.3.8 Analyses of variables

The data collected was further analyzed based on chosen variables that were thought to impact preoperative education for LS. Variables chosen were:

1. Surgeons actively teaching compared to surgeons not actively teaching (Section 2.3.8.1)
2. Surgeons who have obtained additional pain management training (residency/fellowship) compare to surgeons without additional training in pain management (Section 2.3.8.2)
3. Orthopedic surgeons compared to neurosurgeons (Section 2.3.8.3)
4. Surgeons who have personally undergone LS compared to surgeons who have not personally undergone LS (Section 2.3.8.4)
5. Experience of the surgeons (years practicing) (Section 2.3.8.5)

2.3.8.1 Surgeons actively teaching compared to surgeons not actively teaching

The data collected was further analyzed to determine in surgeons who were actively involved in teaching displayed a “different” education practice pattern compared to surgeons who do not actively teach. Thirty seven comparisons were made in five categories (demographics, educational session, content of the educational section, tools/props used for education and physiotherapy referral). In only two comparisons (‘family member having undergone surgery’ and ‘mandatory hospital class’) there was a statistically significant difference ($p < 0.05$). The results indicate, for the most part, that surgeons who actively teach, compared to surgeons who do not actively teach have very similar practice patterns. The comparisons between the actively teaching surgeons and not actively teaching surgeons can be found in Tables 2.3 to 2.7.

Table 2.3: Comparison between actively teaching surgeons versus not-actively teaching surgeons in the demographics section

Question	Pearson Chi-square
Orthopedic vs. Neurosurgeon	$p=0.85426$
Medical doctor (MD) vs. Osteopath (DO)	$p=0.62948$
Gender	$p=0.2995$
Extra training in pain management	$p=0.72708$
Number of surgeries per month	$p=0.09573$
Personally experienced LS	$p=0.58420$
Family member with LS	$p=0.02153^*$

* Denotes statistically significant difference ($p<0.05$)

The results indicate that there is an association between whether a family member has experienced LS and if the surgeon is actively involved in teaching. Surgeons who actively teach are more likely to have had an immediate family member undergo LS ($p<0.05$) compared to surgeons who do not actively teach.

Table 2.4: Comparison between actively teaching surgeons versus not-actively teaching surgeons in the educational session section

Question	Pearson Chi-square
Formal vs. Informal education type	$p=0.99040$
Educating at the last clinic consultation	$p=0.23736$
Hospital have a structured program	$p=0.25831$
Hospital class mandatory	$p=0.03192^*$

* Denotes statistically significant difference ($p<0.05$)

The results also indicate that there is an association between whether the facility that a surgeon performs surgery, makes it mandatory to attend a preoperative educational session ($p<0.05$), versus surgeon's who's facilities do not make it mandatory. Surgeons who actively teach are less likely to be associated with a hospital or surgery centre where it is mandatory to undergo a preoperative educational session.

Table 2.5: Comparison between actively teaching surgeons versus not-actively teaching surgeons in the educational content section

Question	Pearson Chi-square	Question	Pearson Chi-square
Anatomy	p=0.94731	Smoking	p=0.74733
Food intake prior to surgery	p=0.79394	Complications	p=0.19953
Outcomes/expectations for surgery	p=0.09337	Physiotherapy	p=0.22842
Surgery affecting pain	p=0.40881	Hospital stay	p=0.85426
Precautions after surgery	p=0.58420	Blood work prior to surgery	p=0.55500
Medicine use prior to surgery	p=0.99040	Consent	p=0.74563
Hospital issues	p=0.74542	Strategies to cope with pain	p=0.61187
Postoperative pain	p=0.16683	Biomechanics	p=0.82188
Infection	p=0.45020	Surgical scar	p=0.09994
Surgical procedure	p=0.19953		

Table 2.6: Comparison between actively teaching surgeons versus not-actively teaching surgeons in the tools/props section

Question	Pearson Chi-square
Booklet with images	p=0.80843
Booklet with no images	p=0.46455
DVD/Video	p=0.47950
Only verbal communication	p=0.08015
Website	p=0.27229
Spine model and verbal communication	p=0.19953

Table 2.7: Comparison between actively teaching surgeons versus not-actively teaching surgeons regarding physiotherapy after LS

Question	Pearson Chi-square
Sending patients to rehabilitation	p=0.61754

2.3.8.2 Additional training in pain management

The data collected was further analyzed to determine if surgeons who had additional training in pain management (residency/fellowship) displayed a “different” education practice pattern compared to surgeons who do not have additional training in pain management.

Thirty six comparisons were made in five categories (demographics, educational session, content of the educational section, tools/props used for education and physiotherapy referral). In four comparisons (personally undergone LS, family member having undergone LS, providing education during the last consultation and hospital providing a preoperative educational session) there was a statistically significant difference ($p < 0.05$). The results indicate, for the most part, that surgeons who have additional training in pain management, compared to surgeons who do not have additional training in pain management have very similar practice patterns. The comparisons between the surgeons with additional pain management training and surgeons with no additional pain management training can be found in Tables 2.8 to 2.12.

Table 2.8: Comparison between surgeons with additional training in pain management versus those with no additional pain training in the demographics section

Question	Pearson Chi-square
Orthopedic versus neurosurgeon	$p=0.35949$
Medical doctor versus osteopath (DO)	$p=0.39458$
Gender	$p=0.65963$
Actively teaching	$p=0.72708$
Personally undergone LS	$p=0.01800^*$
Family member having undergone LS	$p=0.00291^*$

* Denotes clinical significance ($p < 0.05$)

The results indicate that there is an association between whether a surgeon has experienced LS and if the surgeon has additional training in pain management. Surgeons who have additional training are more likely to have personally undergone LS ($p < 0.05$) compared to surgeons who have not obtained additional training in pain management.

The results indicate that there is an association between whether a family member has experienced LS and if the surgeon has additional training in pain management. Surgeons with additional training in pain management are more likely to have had an immediate family

member undergo LS ($p < 0.05$) compared to surgeons who do not have additional training in pain management.

Table 2.9: Comparison between surgeons with additional training in pain management versus those with no additional pain training in the education delivery section

Question	Pearson Chi-square
Formal versus informal education	$p = 0.68377$
Educate at the last clinical consultation	$p = 0.03071^*$
Hospital provide structured education	$p = 0.03724^*$
Mandatory hospital education	$p = 0.39458$

* Denotes clinical significance ($p < 0.05$)

The results indicate that there is an association between whether a surgeon provides education during the final clinical consultation and if the surgeon has additional training in pain management. Surgeons with additional training in pain management are less likely to deliver their preoperative educational session during the “last consultation at the clinic” ($p < 0.05$) compared to surgeons who do not have additional training in pain management. Conversely, surgeons with additional training in pain management are more likely to provide their educational session at “other” occasions.

The results indicate that there is an association between whether the hospital/surgery center provides a formal preoperative educational program prior to LS and if the surgeon has additional training in pain management. Surgeons with additional training in pain management are more likely to perform surgery at a hospital/surgery center that has a formal preoperative educational program ($p < 0.05$) compared to surgeons who do not have additional training in pain management.

Table 2.10: Comparison between surgeons with additional training in pain management versus those with no additional pain training in the education content section

Question	Pearson Chi-square	Question	Pearson Chi-square
Anatomy	p=0.46723	Smoking	p=0.89419
Food intake prior to surgery	p=0.37658	Complications	p=0.58723
Outcomes/expectations	p=0.47771	Physical therapy	p=0.28487
Surgery affecting pain	p=0.77977	Hospital stay	p=0.35949
Precautions after surgery	p=0.22578	Blood work prior to surgery	p=0.09854
Medicine use prior to surgery	p=0.67631	Consent	p=0.29888
Hospital issues	p=0.89072	Strategies to cope with pain	p=0.84951
Postoperative pain	p=0.35949	Biomechanics	p=0.76943
Infections	p=0.24835	Surgical scar	p=0.76943
Surgical procedure	p=0.58723		

Table 2.11: Comparison between surgeons with additional pain management training versus surgeons without additional pain training in the tools/props section

Question	Pearson Chi-square
Booklet with images	p=0.27813
Booklet with no images	p=0.75696
DVD/Video	p=0.47771
Only verbal communication	p=0.35949
Website	p=0.05899
Spine model and verbal communication	p=0.58723

Table 2.12: Comparison between surgeons with additional training in pain management versus those with no additional pain training regarding physiotherapy after LS

Question	Pearson Chi-square
Sending patients to rehabilitation	p=0.21790

2.3.8.3 Orthopedic versus neurosurgeon

The data collected was further analyzed to determine if orthopedic spine surgeons displayed a “different” education practice pattern compared to neurosurgeons performing LS.

Thirty six comparisons were made in five categories (demographics, educational session, content of the educational section, tools/props used for education and physiotherapy referral). In none of the categories were there a statistically significant difference ($p < 0.05$), indicating that orthopedic and neurosurgeons have similar practice patterns regarding preoperative education for LS for radiculopathy. The comparisons between the orthopedic surgeons and neurosurgeons can be found in tables 2.13 to 2.17.

Table 2.13: Comparison between orthopedic and neurosurgeons in the demographics section

Question	Pearson Chi-square
Medical doctor versus osteopath (DO)	$p=0.08283$
Gender	$p=0.05413$
Actively teaching	$p=0.85426$
Additional training in pain management	$p=0.35949$
Personally undergone LS	$p=0.23758$
Family member having undergone LS	$p=0.16683$

Table 2.14: Comparison between orthopedic and neurosurgeons in the education delivery section

Question	Pearson Chi-square
Formal versus informal education	$p=0.50201$
Educate at the last clinical consultation	$p=0.21041$
Hospital provide structured education	$p=0.39960$
Mandatory hospital education	$p=0.68248$

Table 2.15: Comparison between orthopedic and neurosurgeons in the education content section

Question	Pearson Chi-square	Question	Pearson Chi-square
Anatomy	p=0.39940	Smoking	p=0.46753
Food intake prior to surgery	p=0.27899	Complications	p=0.55902
Outcomes/expectations	p=0.4445	Physiotherapy	p=0.43135
Surgery affecting pain	p=0.29217	Hospital stay	p=0.79333
Precautions after surgery	p=0.92515	Blood work prior to surgery	p=0.21532
Medicine use prior to surgery	p=0.50201	Consent	p=0.25176
Hospital issues	p=0.70526	Strategies to cope with pain	p=0.90269
Postoperative pain	p=0.32399	Biomechanics	p=0.10935
Infections	p=0.84607	Surgical scar	p=0.39212
Surgical procedure	p=0.55902		

Table 2.16: Comparison between orthopedic and neurosurgeons in the tools/props section

Question	Pearson Chi-square
Booklet with images	p=0.91207
Booklet with no images	p=0.73906
DVD/Video	p=0.44475
Only verbal communication	p=0.13098
Website	p=0.41592
Spine model and verbal communication	p=0.55902

Table 2.17: Comparison between orthopedic and neurosurgeons regarding physiotherapy after LS

Question	Pearson Chi-square
Sending patients to rehabilitation	p=0.91598

2.3.8.4 Surgeons who have personally undergone LS

The data collected was further analyzed to determine if surgeons who have personally undergone LS displayed a “different” education practice pattern compared to surgeons who have not personally undergone LS.

Thirty six comparisons were made in five categories (demographics, educational session, content of the educational section, tools/props used for education and physiotherapy referral). In only one comparison (additional training in pain management) was there a statistically significant difference ($p < 0.05$). The results indicate, for the most part, that surgeons who have personally undergone LS, compared to surgeons who have not personally undergone LS have very similar practice patterns. The comparisons between the surgeons who have personally undergone LS, compared to surgeons who have not personally undergone LS, can be found in Tables 2.18 to 2.22.

Table 2.18: Comparison between surgeons who have personally undergone LS compared to surgeons who have not personally undergone LS in the demographics section

Question	Pearson Chi-square
Medical doctor versus osteopath (DO)	$p=0.22578$
Orthopedic surgeon or neurosurgeon	$p=0.23758$
Gender	$p=0.57026$
Actively teaching	$p=0.58420$
Additional training in pain management	$p=0.01800^*$
Family member having LS	$p=0.13397$

* Denotes clinical significance ($p < 0.05$)

The results indicate that there is an association between whether the surgeon has personally undergone LS and if they have additional training in pain management. Surgeons who have personally undergone LS are more likely to have additional training in pain management ($p < 0.05$) compared to surgeons who do not have additional training in pain management.

Table 2.19: Comparison between surgeons who have personally undergone LS compared to surgeons who have not personally undergone LS in the education delivery section

Question	Pearson Chi-square
Formal versus informal education	$p=0.18977$
Educate at the last clinical consultation	$p=0.55453$
Hospital provide structured education	$p=0.33419$
Mandatory hospital education	$p=0.27252$

Table 2.20: Comparison between surgeons who have personally undergone LS compared to surgeons who have not personally undergone LS in the education content section

Question	Pearson Chi-square	Question	Pearson Chi-square
Anatomy	$p=0.81860$	Smoking	$p=0.27533$
Food intake prior to surgery	$p=0.46831$	Complications	$p=0.30881$
Outcomes/expectations	$p=0.07503$	Physiotherapy	$p=0.91269$
Surgery affecting pain	$p=0.81860$	Hospital stay	$p=0.92515$
Precautions after surgery	$p=0.63178$	Blood work prior to surgery	$p=0.11737$
Medicine use prior to surgery	$p=0.16308$	Consent	$p=0.10547$
Hospital issues	$p=0.06740$	Strategies to cope with pain	$p=0.81860$
Postoperative pain	$p=0.92515$	Biomechanics	$p=0.64782$
Infections	$p=0.73525$	Surgical scar	$p=0.64782$
Surgical procedure	$p=0.30881$		

Table 2.21: Comparison between surgeons who have personally undergone LS compared to surgeons who have not personally undergone LS in the tools/props section

Question	Pearson Chi-square
Booklet with images	$p=0.13608$
Booklet with no images	$p=0.68998$
DVD/Video	$p=0.36014$
Only verbal communication	$p=0.92515$
Website	$p=0.88862$
Spine model and verbal communication	$p=0.48413$

There was no statistical correlation between surgeon who have personally undergone LS and referral patterns to rehabilitation after LS (Table 2.22)

Table 2.22: Comparison between surgeons who have personally undergone LS compared to surgeons who have not personally undergone LS regarding physiotherapy after surgery

Question	Pearson Chi-square
Sending patients to rehabilitation	p=0.52559

2.3.8.5 Experience of the surgeon

The data collected was further analyzed to determine if there was a difference in preoperative education provided by surgeons based on their years of experience as a spine surgeon.

Fourteen comparisons were made in five categories (demographics, educational session, content of the educational section, tools/props used for education and physical therapy referral). In only one comparison (pain versus function as an outcome) was there a statistically significant difference ($p < 0.05$). The results indicate, for the most part, that surgeons, despite their experience have very similar practice patterns. The comparisons based on experience of the surgeon can be found in Table 2.23.

Table 2.23: Differences between surgeons based on experience and various categories related preoperative education for LS

Question	Pearson Chi-square
Family member having undergone LS	p=0.72881
Formal versus informal educational session	p=0.65646
Hospital providing structured education	p=0.60225
Food intake prior to surgery	p=0.94292
Medicine use prior to surgery	p=0.84545
Hospital issues	p=0.57792
Physical therapy	p=0.45428
Blood work prior to surgery	p=0.35913
Strategies to cope with pain	p=0.80624
Biomechanics	p=0.95785
Surgical scar	p=0.41470
Pain versus function outcome	p=0.03955*
Referral to website	p=0.42953
Send patients to physiotherapy after surgery	p=0.10098

* Denotes statistical significance ($p < 0.05$)

The results indicate that there is an association between the experience of the surgeon and importance of pain versus function as an outcome following LS. Surgeons with more experience (practicing > 20 years) are less likely to rate pain as a more important outcome compared to function, compared to surgeons with less experience ($p < 0.05$).

2.4 Discussion

To our knowledge, this is the first study centered on determining the practice patterns of US spine surgeons related to preoperative education for LS for radiculopathy.

The results of this study indicate that spine surgeons in the US do utilize preoperative education before LS for radiculopathy. This finding concurs with other studies assessing preoperative education in orthopedics and spinal surgery^{17,49,52-54,56,57} and is in line with preoperative education in other surgical realms, such as orthopedic peripheral joint surgery,²²⁻²⁶ cardiac surgery,^{30,31,33,95,96} and abdominal surgery.^{36,37,85,97,98} The results from this study demonstrated that surgeons utilize preoperative education as a means of providing better outcomes, answering patient questions, covering legal and ethical requirements and reducing patient anxiety. These intentions correspond with studies demonstrating that preoperative education helped increase knowledge of the surgical procedure,^{23,41-43} reduced anxiety,^{30,36,44,45,99} reduced postoperative pain,^{36,49,50,52,100} decreased LOH stay^{23,25,50,101} and facilitated faster return to preoperative functional levels.^{25,51,52,95,100}

The majority of the content covered in preoperative education for lumbar radiculopathy addressed issues related to the outcome of the surgery. Outcomes related to LS have become a hotly debated topic in the literature.^{9,11,14,102-106} Studies indicate that patients often have high expectations of surgery and outcomes are often not met.^{102,107} Of all the topics covered in preoperative education for LS for radiculopathy, surgeons rated *surgical procedure* the highest. This finding correlates with previous studies which investigated surgeon practice patterns^{23,56,85,108} and indicated surgeons spent most of the time discussing the impending surgical procedure and anatomical reasoning behind the proposed surgery. Discussion of the surgical procedure is expected, as surgeons are often viewed as expert technicians and thus view spinal disorders from a technical point of view.¹⁰⁹⁻¹¹³ However, it is important to note that when patients were asked to rate the importance of various topics covered during preoperative education (in a survey of patients having undergone LS for radiculopathy), *surgical procedure* was only ranked number 9.⁵⁶ This survey showed that patients wanted to know how surgery would affect their symptoms (ranked 1), and may have had only a limited interest in a full

discussion of the surgical procedure.^{56,102} In addition, the survey showed that patients were interested in knowing more about pain issues related to their impending surgical intervention.

Several pain issues such as how pain would be affected by the surgery; complete loss of pain; preoperative pain and other pain was rated more important than *surgical procedure*.⁵⁶ In the current study, surgeons on average estimated they spent 20% of their educational session specifically addressing pain. Since surgery data indicate that the primary reason for LS is pain,^{11,56,57,102} this finding may demonstrate a shortcoming in the surveyed preoperative education by not adequately addressing a more detailed discussion of pain.⁵⁶ Although several studies have implicated unrealistic expectations on the patient's part and possible improper presentation of these expectations by the surgeon,^{51,107} it may also reflect the potential lack of provision of adequate information explaining in detail to patients their pain. A more comprehensive discussion of pain would imply use of a more elaborate biopsychosocial approach. Previous studies have implicated that psychosocial factors are powerful determinants in surgical outcome and need to be addressed prior to surgery, including the determination if surgery should even be performed.^{114,115} The results of the current survey portrays a traditional biomedical model focusing on the faulty tissue (*surgical procedure* ranked number 1 and *anatomy* ranked number 4 by surgeons), rather than a larger, more comprehensive biopsychosocial approach.^{114,116} Two recent studies highlighted the influence of psychological factors in spinal surgery and recommended these factors be addressed in preoperative education for LS.^{117,118}

Another interesting finding from this study is that surgeons, regardless of their training, academic involvement, personal and family history of spinal surgery, experience and additional pain management training, agreed on the topics needed for inclusion preoperatively as well as their ranking. Surgeons are known to have different viewpoints related to various topics, including the use of new technology, diagnostics, complications, outcomes and rehabilitation following LS.^{17,86,89,93,103,119} This study showed that despite considering a number of variables amongst spine surgeons thought to produce different results, it did not. The positive implication is that surgeons are mostly doing the same thing, because there seemed to be agreement as to what should be included in preoperative education for LS for radiculopathy, and this should benefit future studies that employ experimental designs to measure the effects of structured education programs on patient outcomes, knowing what constitutes usual care in preoperative education for LS in the US.⁸³ The negative implication of this finding is that if the preoperative educational program surgeons are using in the US is lacking in any way, the preoperative education that is provided may be universally suboptimal. In the current study, of the four main reasons surgeons felt the need to include in preoperative education, *reducing anxiety* was rated

least important, and nearly half of the surgeons in this study did not choose *strategies to cope with pain* as an option to include in their preoperative educational program. It is well established that the preoperative environment is associated with increased levels of anxiety and fear,^{33,38,120-124} which has the potential to negatively impact outcomes of surgery.^{114,115} Addressing fear and anxiety forms part of a true biopsychosocial approach,^{114,116,125} and several studies have shown that educational strategies aimed at reducing fear and anxiety have the potential to help ease patient fears and anxiety.^{24,53,121,126-128} This reflects a potential lack of applying a true biopsychosocial approach to preoperative education for LS for radiculopathy, in the US.

The choice of verbal one-on-one education by the surgeons concurs with other studies which indicate that surgeons tend to take the lead in providing the education prior to surgery.^{56,85} Mordiffi et al¹²⁹ investigated the preferred method of preoperative information delivery in 67 patients, and found that about 90% of the respondents preferred information to be delivered verbally by the surgeon. This finding is further validated by the fact that surgeons view preoperative education as a means for them to *answer patient questions*. Considering that surgeons rated *surgical procedure* as the highest factor to be included in preoperative educational sessions and that education delivery mainly consists of verbal one-on-one communication, it can be argued that the surgeon should perform the educational session, since he/ she will be performing the surgical procedure. Although the majority of surgeons indicated they perform the education and patients prefer surgeons to perform the educational session,⁵⁶ the results from this study showed that almost 25% of the education sessions were delivered by other healthcare professionals. Several studies have highlighted time constraints on physicians, especially surgeons.¹³⁰⁻¹³³ There has been a gradual increase in surgeons utilizing allied healthcare professionals such as physician assistants, nurses and nurse practitioners.^{23,134-138} Future studies should investigate this trend and its potential impact on preoperative education for LS.

The benefits of one-on-one verbal education seem to outweigh the potential shortcomings. One-on-one verbal education is what peers are using; patients request it; it provides a chance to answer patient's questions; is more personable and provides an ability to alter the message to meet the educational needs of the patient.^{85,129,139,140} Problems associated with one-on-one verbal-only communication include difficulty with limited recall, language barriers, learning disabilities, educational level, age and cultural considerations.^{85,141-143} Considering all the potential barriers to optimal learning, it becomes clear that one-on-one verbal education should also be accompanied with educational material which has shown to aid recall of information presented to the patient via one-on-one verbal communication.¹⁴⁴⁻¹⁴⁶ The results from this study showed that surgeons preferred to accompany their verbal one-on-one educational session with

the use of a spine model. This finding is not surprising, considering that surgeons rated *surgical procedure* (ranked number 1), *anatomy* (ranked number 4) and *surgery affecting pain* (ranked number 7) high in terms of content used to educate patients prior to LS for radiculopathy. The surgeon will thus utilize this information to describe to the patient, the anatomical reason for his/her pain and how the surgical procedure aims to correct the problem.^{107,147} This information is deemed necessary to help patients weigh risks and benefits from surgery and help establish realistic goals and expectations regarding their surgical outcome.¹⁰² This educational model is a true biomedical model with a heavy focus on anatomy and pathoanatomy.^{114,116} This finding is underscored by the fact that 96% of the surgeons in this study chose “*spine model and verbal communication*” compared to only a few choosing “*verbal only*.” The biomedical model assumes that the patient’s pain is a result of an anatomical problem, such as a herniated disc,^{103,147} spinal degeneration^{148,149} or stenosis.^{150,151} Surgical decompression aims to alleviate the irritation on the neuromeningeal tissues, thus alleviating the patient’s pain and neurological deficit, thus restoring function.^{103,107,147} Although it’s not argued that these interventions are beneficial for patients experiencing lumbar radiculopathy,¹⁰³ the demonstrated ‘usual care’ may not adequately include factors that have been shown to impact on surgical outcomes, such as fear, anxiety, expectations, coping skills and catastrophization.^{84,114,124,128,152,153}

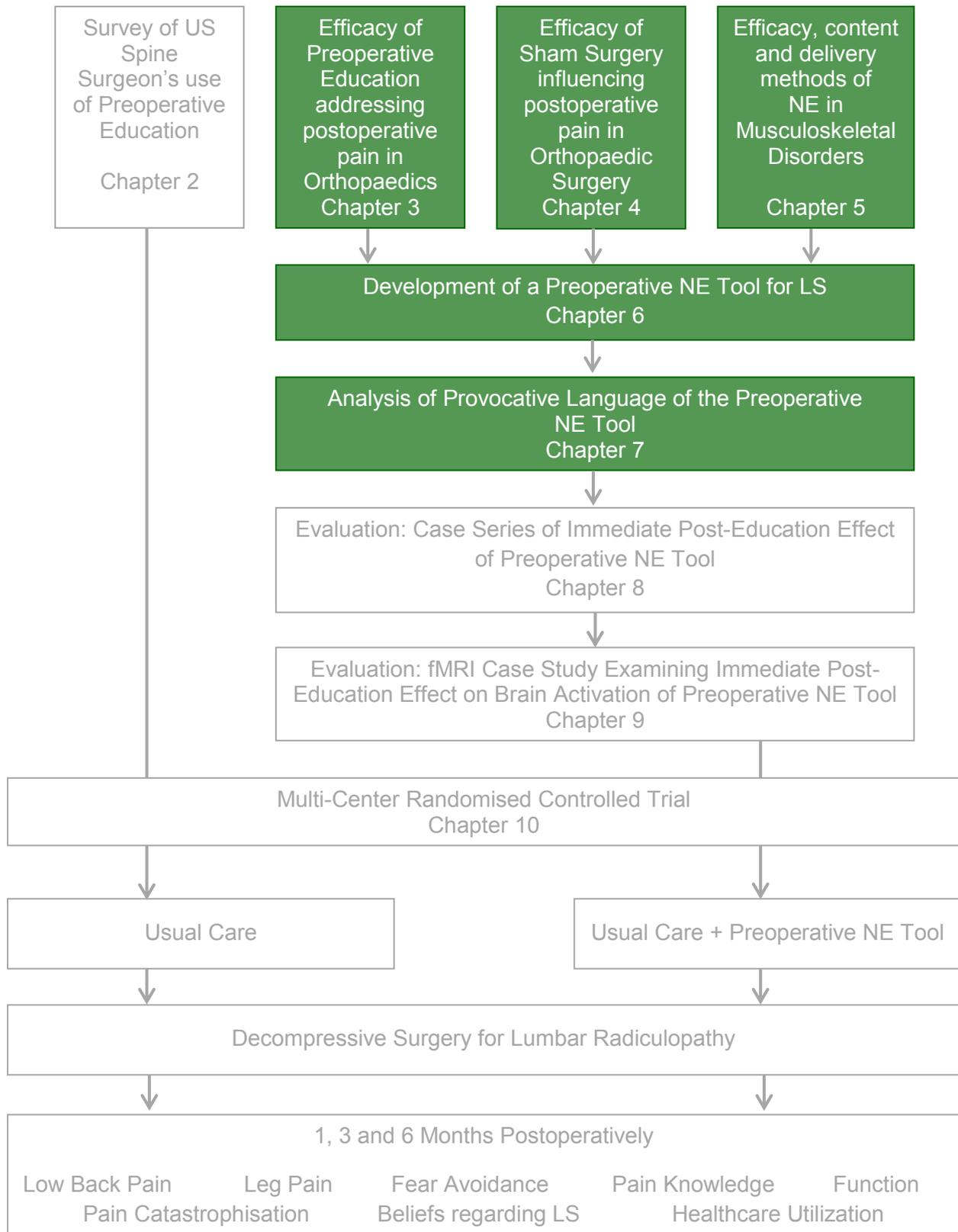
2.5 Conclusion

The results of this survey demonstrate that spine surgeons in the US regularly utilize preoperative education and believe it to be an important aspect in preparing patients for LS. Surgeons tend to utilize biomedical models in their preoperative education and focus on the surgical procedure rather than explaining the patients’ pain in a more comprehensive biopsychosocial approach. From a clinical perspective, it would be prudent for surgeons to balance the contemporaneous biomedical educational approach with a biopsychosocial approach to provide a more rounded and medico-legally defensible approach to patient management. The main study in this research project explored postoperative outcomes with the current preoperative education (biomedical model), compared to preoperative neuroscience education (biopsychosocial model) in LS for lumbar radiculopathy. The following chapters describe the development of such an education model.

Phase 2

Developing a preoperative neuroscience education tool for LS patients for radiculopathy

- **Chapter 3: Efficacy of Preoperative Education addressing Postoperative Pain in Orthopedics**
 - (Published Article – Appendix 3)
- **Chapter 4: Efficacy of Sham Surgery influencing Postoperative Pain in Orthopedics**
- **Chapter 5: Efficacy, content and delivery methods of Neuroscience Education for Chronic Musculoskeletal Disorders**
 - (Published Article – Appendix 4)
- **Chapter 6: Development of a Preoperative Neuroscience Educational Tool for Lumbar Surgery**
 - (Published Article – Appendix5)
- **Chapter 7: Analysis of Provocative Language of the Preoperative Neuroscience Educational Tool for Lumbar Surgery**



Chapter 3:

Preoperative education addressing postoperative pain in orthopedics: Review of content and education delivery methods

This chapter is adapted from: *Louw A, Diener I, Butler DS, Puentedura EJ. Preoperative education addressing postoperative pain in total joint arthroplasty: review of content and educational delivery methods. Physiotherapy Theory and Practice. Apr 2013;29(3):175-194.* The referencing format and headings/subheadings from the original publication have been modified and the headings within the chapter have been numbered for consistency throughout the thesis.

3.1 Introduction

A common issue that many surgical patients face is postoperative pain.^{36,47-50} In 1975 and 1978 two pioneer studies by Hayward and Boore^{20,21} demonstrated that structured preoperative education had an effect on postoperative pain, anxiety and recovery. Since then preoperative education has been used in several studies with the aim of alleviating postoperative complications, including cardiac surgery,²⁹⁻³³ abdominal surgery,^{20,34-37} dental surgery,³⁸⁻⁴⁰ surgery for cancer^{21,154,155} and anesthesia prior to surgery.^{21,43,45,156,157} These strategies incorporated various teaching strategies and tools, including DVD/video,^{34,45,126,158,159} audio cassettes,^{26,108,160} phone calls,^{28,29} the Internet^{42,161,162} and booklets/pamphlets.^{41,45,163,164} These educational sessions have been shown to help increase knowledge of the surgical procedure,^{23,41-43} reduce anxiety,^{30,36,44-46} reduce postoperative pain,^{36,47-50} decrease length of hospital (LOH) stay^{21,23,25,50} and reduce the time to return to preoperative functional levels.^{25,29,47,48,51}

In orthopedic surgery, also, several studies have shown that post-operative pain is a significant issue.¹⁶⁵⁻¹⁶⁹ High levels of postoperative pain and the limited effect of pain medication addressing postoperative pain^{170,171} have lead studies to investigate different ways to positively influence these issues in orthopedic surgery. One such strategy involves preoperative education. Several studies demonstrated that increased anxiety in the preoperative period is associated with increased postoperative pain.^{33,38,120-122,172} An aging United States (US) population¹⁷³ led to increased orthopedic surgeries such as total knee arthroplasty (TKA) and total hip arthroplasty (THA).^{119,174} Patients still experiencing pain after orthopedic surgery motivated a systematic review of the literature regarding the content and delivery methods of preoperative education addressing postoperative pain. This review will highlight the content and delivery methods used in preoperative education in an orthopedic surgery patient population,

and also analyze the design of different educational models and strategies to address postoperative pain in orthopedic surgery patients. The results from this review will be used in the development of a preoperative neuroscience educational tool for lumbar surgery for radiculopathy.

3.2 Methods

3.2.1 Definitions

The following terms and definitions were applied to the review:

- **Preoperative:** Care given before surgery when physical and psychological preparations are made for the operation, according to the individual needs of the patient. The preoperative period starts from the time a decision on surgery has been made and patient is admitted to the hospital or surgery center, to the time that the surgery begins.¹⁷⁵
- **Perioperative:** The period of time extending from when the patient goes into the hospital, clinic, or doctor's office for surgery until the time the patient is discharged home.¹⁷⁵
- **Patient education:** Any set of planned educational activities designed to improve a patient's health behaviors, health status or both. Such activities are aimed at facilitating the patient's knowledge base.^{20,140}
- **Pain:** Pain is an unpleasant sensory and emotional experience which follows actual or potential tissue damage or is described in terms of such damage.¹⁷⁶
- **Orthopedics:** The branch of surgery broadly concerned with the skeletal system.¹⁷⁵

3.2.2 Search strategy

An electronic search was performed in February 2011, covering the last two decades (1990 – 2011) of the following databases: Biomed Central, BMJ.com, CINAHL, the Cochrane Library, NLM Central Gateway, OVID, ProQuest (Digital Dissertations), PsycInfo, PubMed/Medline, ScienceDirect and Web of Science. Each database has its own indexing terms and functions, and therefore different search strategies were developed for each database by the authors. The main search items were *preoperative*, *perioperative*, *pre-admission*, *orthopedic*, *orthopedic surgery*, *arthroplasty*, *replacement*, *spine*, *education*, *instruction*, *advice*, *inform*, *consultation* and *pain*. In PubMed, medical subject headings (MeSH) terms were used where possible, with Boolean operators. The search strategies for remaining databases included synonyms of the main search items. Secondary searching (PEARLing) was undertaken, whereby reference lists of the selected articles were reviewed for additional references not identified in the primary search. The titles and abstracts of all the identified literature were screened by the one reviewer

(AL) using the inclusion criteria below. The full text of all potentially relevant articles were retrieved and screened by three reviewers (AL, ID and DB) using the same criteria, in order to determine the eligibility of the paper for inclusion in the review.

3.2.3 Inclusion criteria

All titles and abstracts were read to identify relevant papers. Papers were included in this systematic review if they met the inclusion criteria listed in Table 3.1. When there was uncertainty regarding the eligibility of the paper from the abstract, the full text version of the paper was retrieved and evaluated against the inclusion criteria. The full text version of all papers that met the inclusion criteria were retrieved for data extraction.

Table 3.1: Inclusion criteria used in the systematic review: Preoperative education in orthopedics

Criterion	Justification
English Language	Major journals in this area are published in this language
1990 – 2011	Twenty years captures the most recently used treatments in clinical practice
Humans over 18 years of age	This increased the homogeneity of participants between studies and educational needs are different for infants, adolescents and teenagers ¹⁷⁷
Randomized controlled trials (RCTs)	RCT's provide high levels of evidence. Study designs other than RCT were not included in this review because of the low level of evidence they provide
Patient education	No limitations were set on the content or methods used in patient education, since it was one of the aims of this review to source the content and education delivery methods
Outcomes: Postoperative pain	The primary outcome measure chosen for this review was postoperative pain. No limitations were set on the measurement tool used to examine the effect of preoperative education on postoperative pain
Preoperative	All studies that intervened with an educational strategy prior to the surgical procedure were included. No limitations were set on the timing of the education prior to surgery

3.2.4 Quality assessment

Critical appraisal of each included study was conducted by determining the level of evidence on the Australian National Health and Medical Research Council (NHMRC) Hierarchy of Evidence (Australian National Health and Medical Research Council, 1999) (Table 3.2). This provides a broad indication of bias based on study design. Studies higher on the hierarchy potentially contain less bias than those that are lower on the hierarchy.

Table 3.2: Hierarchy of evidence; Study design, based on the Australian National Health and Medical Research Council Hierarchy of Evidence (Australian National Health and Medical Research Council, 1999)

Level	Definition	Studies reviewed
I	Evidence obtained from a systematic review of all relevant randomized controlled trials	
II	Evidence obtained from at least one properly-designated randomized controlled trial	Beaupre et al. 2004; Clode-Baker et al. 1997; Daltroy et al. 1998; Doering et al. 2000; Ferrara et al. 2008; Giraudet-Le Quintrec et al. 2003; Gocen et al. 2004; Lilja et al. 1998; McDonald et al. 2001; McGregor et al. 2004; Sjoling et al. 2003; Vukomanovic et al. 2008
III-1	Evidence obtained from well-designed pseudo-randomized controlled trials (alternate allocation or some other method)	Gammon and Mulholland, 1996
III-2	Evidence obtained from comparative studies (including systematic reviews of such studies) with concurrent controls and allocation not randomized, cohort studies, case-control studies, or interrupted time series with a control group	
III-3	Evidence obtained from comparative studies with historical control, two or more single arm studies, or interrupted time series without a parallel control group	
IV	Evidence obtained from case series, either post-test or pre-test/post-test	

3.2.5 Data extraction

Data were extracted by the authors using the PICO approach.¹⁷⁸

- **Participants:** type of surgical intervention; age and gender
- **Interventions:** type; intensity; duration; educational tools/props; in combination or stand-alone education
- **Comparison:** to another treatment, no treatment or “usual” treatment
- **Outcomes:** domains and tools used to measure the effects of the intervention. Outcomes chosen for this review is pain

3.3 Results

3.3.1 Search strategy yield

Initially, 1901 hits were gained from databases and secondary searches. After review of the titles and abstracts, those articles that did not meet the inclusion criteria were removed. After reviewing 265 abstracts, the full text of 51 articles were reviewed. Upon further review, duplicates were removed, leaving 13 studies for the systematic review. This systematic review is therefore based on these 13 published studies (Table 3.3 and Figure 3.1)

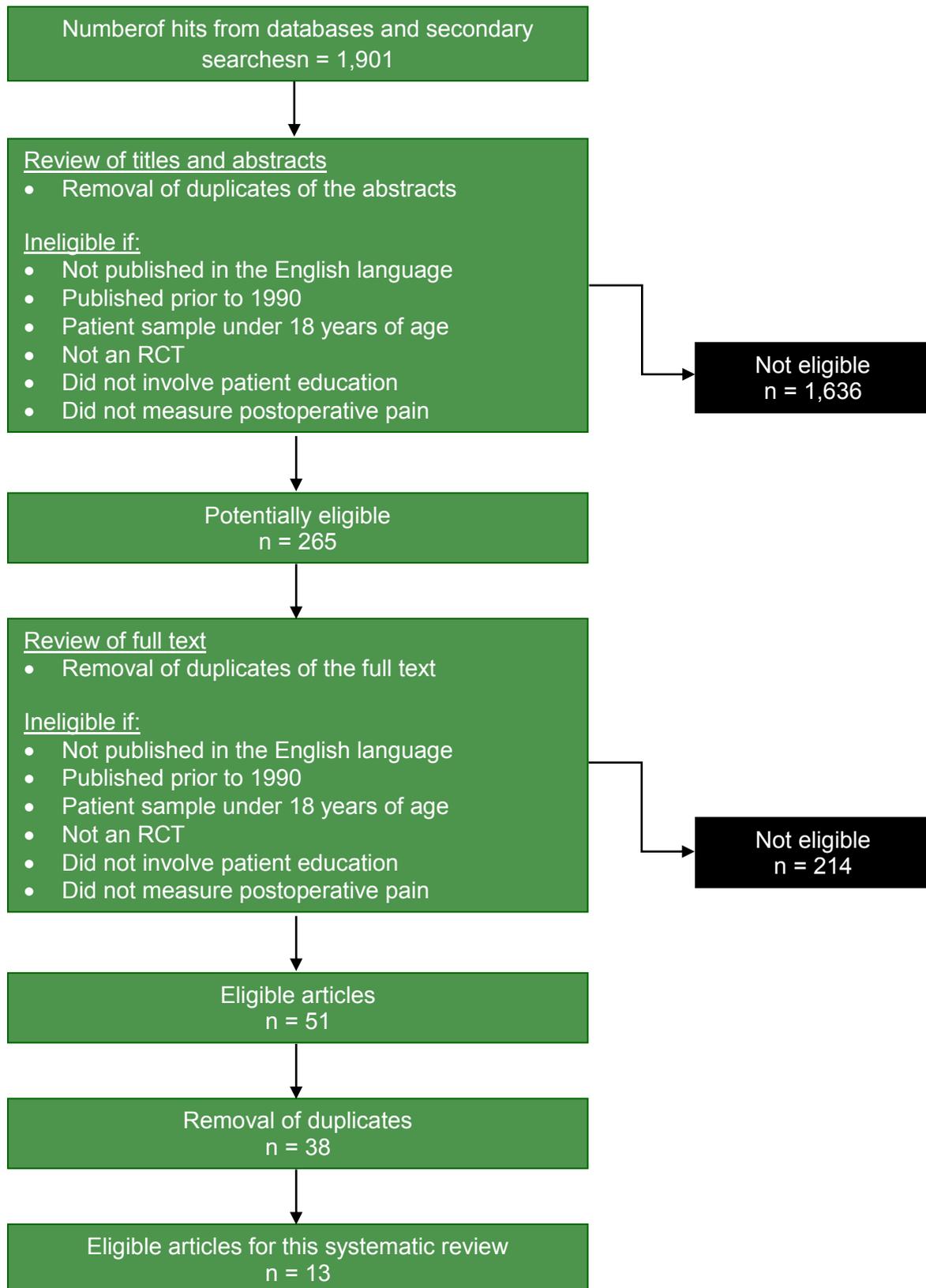


Figure 3.1: Retrieval and review process: Preoperative orthopedic education

Table 3.3: Studies (alphabetically listed) included in this systematic review: Preoperative orthopedic education

Author	Year	Journal	Title
1. Beaupre et al.	2004	J Rheumatology	<i>The effects of a preoperative exercise and education program on functional recovery, health related quality of life, and health service utilization following primary total knee arthroplasty</i>
2. Clode-Baker et al.	1997	J Health Psychol	<i>Preparing patients for total hip replacement: A randomized controlled trial of a preoperative educational intervention</i>
3. Daltroy et al.	1998	Arthritis Care & Research	<i>Preoperative education for total hip and knee replacement in patients</i>
4. Doering et al.	2000	Psychosomatic Medicine	<i>Videotape preparation of patients before hip replacement surgery reduces stress</i>
5. Ferrara et al.	2008	Clinical Rehabilitation	<i>Effect of pre-operative physiotherapy in patients with end-stage osteoarthritis undergoing hip arthroplasty</i>
6. Gammon and Mulholland	1996	Int. J Nurs. Studies	<i>Effect of preparatory information prior to elective total hip replacement on post-operative physical coping outcomes</i>
7. Giraudet-Le Quintrec et al.	2003	Clinical Orthopaedics and Related Research	<i>Positive effects of patient education for hip surgery: A randomized controlled trial</i>
8. Gocen et al.	2004	Clinical Rehabilitation	<i>The effect of preoperative physiotherapy and education on the outcome of total hip replacement: a prospective randomized controlled trial</i>
9. Lilja et al.	1998	Intensive and Critical Care Nursing	<i>Effects of extended preoperative information on perioperative stress: an anesthetic nurse intervention for patients with breast cancer and total hip replacement</i>
10. McDonald et al.	2001	Research in Nursing & Health	<i>Testing a preoperative pain management intervention for elders</i>
11. McGregor et al.	2004	The Journal of Arthroplasty	<i>Does preoperative hip rehabilitation advice improve recovery and patient satisfaction?</i>
12. Sjoling et al.	2003	Patient Education and Counselling	<i>The impact of preoperative information on state anxiety, postoperative pain and satisfaction with pain management</i>
13. Vukomanovic et al.	2008	Vojnosanit Pregl	<i>The effects of short-term preoperative physical therapy and education on early functional recovery of patients younger than 70 undergoing total hip arthroplasty.</i>

3.3.2 Critical appraisal

3.3.2.1 Hierarchy of Evidence

There were 12 RCTs (Beaupre et al.²⁷; Clode-Baker et al.¹⁷⁹; Daltroy et al.²⁶; Doering et al.¹⁸⁰; Ferrara et al.¹⁸¹; Giraudet-Le Quintrec et al.¹²⁸; Gocen et al.¹⁸²; Lilja et al.¹⁸³; McDonald et al.¹⁸⁴; McGregor et al.²⁵; Sjoling et al.¹⁸⁵; Vukomanovic et al.¹⁸⁶) and one pseudo randomized controlled trial (Gammon and Mulholland¹⁸⁷).

3.3.3 Patient characteristics

In this review, preoperative education was administered to 1017 patients with two-thirds of the patients undergoing total THA. Five hundred and ninety one patients (58%) were female. The average age of the patients ranged from 55.5 ± 14.44 years¹⁸² to 74.62 years¹⁸⁴ with a mean age (calculated as the mean of the mean reported ages) of the patients receiving preoperative education addressing pain as 63.68 years of age.

3.3.4 Content of educational sessions

Details of the specific content of the educational sessions used in the studies are found in Table 3.4. In summary, preoperative education session contents in orthopedics addressing pain included discussion of:

- Mobility (crutches, bed mobility, transfers, etc.)^{25,27,128,180-183,186,187}
- Range of motion (ROM)^{27,128,180,182}
- Preadmission procedures (hospital/administrative)^{26,128,179,180,183,185,187}
- Preparation procedures for surgery^{25,26,179,180,183-185,187}
- Surgery^{25,26,128,179,180,183,186,187}
- Hospital stay^{26,128,179,180,185,187}
- Postoperative procedures^{25,26,179,180,183,184,187}
- Anatomy of normal joints^{128,179}
- Pathoanatomy of arthritic joints^{128,179}
- Advice from past joint replacement patients^{179,180}
- Frequently asked questions^{25,128,179}
- Staff and their roles^{26,128,185}
- Stressful scenarios associated with surgery (pain, immobility, noises, etc.)^{26,180,183,187}
- Complications (blood clots, bleeding, death, etc.)¹²⁸

- Anesthesia and medication^{128,183,184}
- Reassurance^{26,180,183,185,187}
- Milestones²⁶
- Movements to avoid^{128,181,182,186}
- Posture^{181,182}
- Activities of daily living (ADL)^{128,181,182}
- Pain education (pain overview, pain management – pharmacological and non-pharmacological, pain communication)^{184,185}

Table 3.4: Participants, interventions, controls and outcomes for the studies included in the systematic review: Preoperative education for orthopedics

Authors	Participants			Intervention	Control	Outcomes		
	n	Sample	Surgery			Instruments	Follow up	Main Results
Beaupre et al, 2004	131	<p>Experimental group (EG) (n = 66): 67±7 years of age; 39 female;</p> <p>Control group (CG) (n = 65): 67±6 years of age; 33 female;</p>	TKA*;	<p>Educator: Physiotherapist</p> <p>Six weeks prior to surgery = exercise/ education program.</p> <p>Education:</p> <ul style="list-style-type: none"> • Instruction on crutch walking; stairs; bed mobility and transfers; postoperative range of motion (ROM) routine <p>Exercises:</p> <ul style="list-style-type: none"> • Stretches and strengthening with warm-up and cool down periods • Program applied 3 x /week for 4 weeks for 12 visits. 	Continue with their regular activities during the last 6 weeks prior to TKA;	<ul style="list-style-type: none"> • Western Ontario McMaster Osteoarthritis Index (WOMAC) <ul style="list-style-type: none"> • Pain • Stiffness • Function • ROM (Goniometer) • Quadriceps and hamstring strength (hand-held dynamometer) • Medical Outcome Study Short Form (SF-36) • Overall health status • Health service utilization 	Pre-operatively; 3, 6 and 12 months	<p>No difference in strength;</p> <p>No difference in ROM;</p> <p>No difference in pain; No difference in function;</p> <p>No difference on health related quality of life</p> <p>EG = fewer postoperative visits and decreased length of hospital (LOH) stay</p>
Clode-Baker et al, 1997	78	<p>EG (n = 41)</p> <p>CG (n = 37)</p>	THA**	<p>Educator: None</p> <p>One month prior to surgery; Video; booklet and set of plastic models;</p>	No booklet, video or joint models	<ul style="list-style-type: none"> • Hip function evaluation • Nottingham Health Profile 	Pre-operatively; Each day of the first	<p>No difference between EG and CG for:</p> <ul style="list-style-type: none"> • HAD

	<p>52 females; 26 males – no indication which numbers in EG or CG</p> <p>No age mean age provided by the authors</p>	<p>Mailed to patients with letter encouraging them to use the information; (92% reported that they reviewed the information prior to surgery)</p> <p><u>20 minute video:</u></p> <ul style="list-style-type: none"> • Progress of a patient having a THA; • Arriving at the hospital • Going to the operating theatre • Returning to the ward • Postoperative recovery • Exercise • Visiting home showing benefit of having surgery <p><u>Booklet:</u></p> <ul style="list-style-type: none"> • Arthritis • THA • Hospital stay • Postoperative exercise • Advice from previous THA patients • Frequent questions and answers <p><u>Plastic models (life-size) of the hip:</u></p> <ul style="list-style-type: none"> • Normal hip joint • Osteoarthritis • THA joint 		<ul style="list-style-type: none"> • Hospital Anxiety and Depression Scale (HAD) • Stress Arousal Checklist • Postoperative pain (descriptive ordinal scale) • Sleep disturbance • Satisfaction questionnaire • Length of hospital stay 	<p>seven post-operative days</p>	<ul style="list-style-type: none"> • Nottingham Health Profile • Stress Arousal Checklist <p>EG: More satisfied with information provided prior to surgery than CG;</p> <p>EG: Less confronted by information upon arrival at the hospital</p> <p>No difference between EG and CG in postoperative pain</p> <p>No difference in</p>
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				<ul style="list-style-type: none"> • Separate THA prosthesis • Photographs of the models included in the booklets • Demonstrations using the models used in the video. 				<p>sleep disturbance</p> <p>No difference in LOH</p>
Daltroy et al, 1998	222	<p>Total sample:</p> <ul style="list-style-type: none"> • Female 66% (n = 146) • Mean age 64 ± 12 • THA: 47% (n = 104) • TKA: 53% (n = 118) <p>CG: n = 54</p> <p>Relaxation only: n = 58</p> <p>Information only: n = 58</p>	THA and TKA	<p>Educator: Research Assistant</p> <p><u>Information only:</u></p> <ul style="list-style-type: none"> • 12-minute audiotape slide program • Research assistant 1-day prior to surgery at bedside • Program designed by multidisciplinary team • Orient to hospital • Orient to staff and their roles • Events of surgery and rehabilitation • Life in the hospital • Pictures from the patient's viewpoint • Told of various stressful aspects of hospitalization, including pain, immobility, work involved in rehabilitation, lights and noises, altered sleep schedule and dietary and smoking restrictions. • Reassured various sensations, emotions and difficulties will pass. • Information used in addition to usual preoperative information, i.e., 	None	<ul style="list-style-type: none"> • LOH • Pain (Pain medication use) • State Anxiety • Mental State (Mini Mental State Exam) • Frequency of use of interventional tools 	<p>LOH – time of discharge or more surgery</p> <p>Pain, anxiety and mental state in the first 4 days post-operatively</p>	<p><u>Relaxation:</u> No change in postoperative outcomes</p> <p><u>Information only:</u> Decreased LOH; reduced anxiety and cognitions.</p> <p>No change in postoperative pain ratings for any intervention</p>

		Information and relaxation n = 52		<p>coughing.</p> <ul style="list-style-type: none"> • Booklet left with patient describing milestones <p><u>Relaxation only:</u></p> <ul style="list-style-type: none"> • Oral and written instructions • 18-minute audio tape, portable tape player and headphones • Instructed in the relaxation the day prior to surgery and encouraged to practice <p><u>Information plus relaxation:</u></p> <ul style="list-style-type: none"> • Combination of the above • Relaxation taught after informational session 				
Doering et al, 2000	100	<p>EG (n = 46) Age 58.7 ± 10.8 Female n = 21 (46%)</p> <p>CG (n = 54) Age 60.4 ± 8.7 Female n = 17 (31%)</p>	THA	<p>Educator: Psychologist or physician;</p> <p>12-minute video tape the evening prior to surgery depicting a 55-year old man with osteoarthritis of the hip undergoing the THA process. Film from the patient's perspective. Original dialogue; Narrator provides procedural information and reports on the patient's feelings and thoughts. <u>Scenes:</u></p> <ul style="list-style-type: none"> • Entering the hospital room • In bed evening prior to surgery • Morning of the surgery receiving 	Usual preoperative care with no video presentation	<ul style="list-style-type: none"> • Anxiety (STAI) • Pain (VAS) • Intraoperative heart rate • Intraoperative blood pressure • Postoperative use of pain medication • Urinary levels of cortisol, epinephrine and nor epinephrine 	Five consecutive days starting on the pre-operative day	<p>EG showed less anxiety the morning of the surgery and first 2 days after surgery compared to CG</p> <p>EG had decreased blood pressure compared to CG</p>

				<p>preoperative medication</p> <ul style="list-style-type: none"> • Narrator describes purpose of medication and catheter • Patient wheeled to the operating room • Preparation procedures – monitors, equipment, infusion, spinal anesthesia, disinfecting and covering the patient • Patient move to the operating room • Patient listening to music with headphones • Noises heard and explained by the narrator • After the operation patient receives transfusion and brought back to the ward • Visited by surgeon and anesthetist • Getting up for the first time with help from the physiotherapist • Climbing stairs • Discharge from the hospital 				<p>No difference in pain ratings</p> <p>EG used less pain medication compared to CG</p> <p>EG had less secreted cortisol compared to CG</p> <p>No change in catecholamines</p>
Ferrara et al, 2008	23	EG n = 11; 7 females; 64%; mean age 63.82 ± 9.01; CG n = 12; 7	THA	<p>Educator: Physiotherapist</p> <p>Educational and physiotherapy program one month prior to surgery</p> <ul style="list-style-type: none"> • Group and individual exercises five days/week 	No exercise or advice prior to surgery	<ul style="list-style-type: none"> • Barthel Index • SF-36 • WOMAC • Hip Harris Score • Pain (VAS) • British Medical 	1 month prior to surgery; the day prior to surgery; 15	<p>No difference between EG and CG in Barthel</p> <p>No difference between EG and</p>

		females; 58%; Mean age 63.08 ± 6.89;		<ul style="list-style-type: none"> • Sessions lasted 60 minutes/day • Small group exercises lasted 40 minutes and individual lasted 20 minutes • Strength and flexibility programs • Exercise bike and cardiovascular exercises • Postural exercise <p>Advice:</p> <ul style="list-style-type: none"> • Movements that should be avoided to prevent dislocation • Use of assistive devices • Posture • Activities of daily living 		Research Council (BMRC) measures of strength and ROM	days after surgery; 4 weeks after surgery and 3 months after surgery	CG in SF-36 No difference between EG and CG in WOMAC No difference between EG and CG in HHS No difference between EG and CG in pain ratings after surgery
Gammon and Mulholland 1996	82	EG: (n = 41); Female 66% (n = 27); CG: (n = 41); Female 71% (n = 29); Age range 44 – 82 years	THA	<p>Educator: Nurse</p> <p>Day before surgery - Patient teaching and preparatory information; Two parts:</p> <ul style="list-style-type: none"> • Pre-operative information - Early afternoon • Postoperative information - 4-6 hours later <p>Educational program:</p> <ul style="list-style-type: none"> • Procedural information • Sensory information 	Usual preoperative care without additional teaching program	<ul style="list-style-type: none"> • Physical Indicators of Coping Questionnaire • Linear Analogue Coping Scale • Oral analgesia • Intramuscular analgesia • LOH • Movement 	Day of discharge	<p>No difference in oral analgesia to manage pain</p> <p>EG used less intramuscular analgesia compared to the CG</p> <p>EG were able to mobilize sooner</p>

			<ul style="list-style-type: none"> • Coping information • Checklist to ensure all information was covered • Booklet reinforcing information provided <p>Postoperatively: Patients visited twice weekly to reinforce the message and address problems; Prior to discharge, patients received second educational session regarding issues at home. Information reinforced with a booklet.</p> <p><u>Education content:</u></p> <ul style="list-style-type: none"> • Preoperative information: <ul style="list-style-type: none"> ○ Hospital; surgical and anesthesia procedural information ○ Sensory information including feelings experienced ○ Coping information including relaxation and distraction • Postoperative information: <ul style="list-style-type: none"> ○ Postoperative procedural information ○ Postoperative sensory information ○ Coping information 			<p>than the CG</p> <p>EG performed breathing and leg exercises more frequently than the CG</p> <p>EG had shorter LOH compared to CG</p> <p>No difference in postoperative complications</p>
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				<p>postoperatively</p> <ul style="list-style-type: none"> • Discharge information: <ul style="list-style-type: none"> ○ Procedural – movement, limitations; positions; functional activities ○ Sensory information – weakness, fatigue ○ Coping information – family support and displacement 				
Giraudet-Le Quintrec et al, 2003	100	<p>EG (n = 48); Mean age 62.7 ± 8.8; Female 50% (n = 24)</p> <p>CG (n = 52); Mean age 64.3 ± 9.5; Female 38% (n = 20)</p>	THA	<p>Educator: Multidisciplinary team – rheumatologist; orthopedic surgeon; anesthetist; physiotherapist; psychiatrist</p> <p>Usual verbal information and informational leaflet</p> <p><u>Multidisciplinary information session 2-6 weeks before surgery</u></p> <ul style="list-style-type: none"> • Invited to bring a spouse, relative or significant other • Three to six patients per session • Session lasted half a day • Overhead transparencies • Multidisciplinary team varied on different days, but consisted of: <ul style="list-style-type: none"> ○ Surgeon ○ Anesthetist 	Usual verbal information from the surgeon and anesthetist and the standard leaflet	<ul style="list-style-type: none"> • State Anxiety Inventory (SAI) • Pain: Use of pain medication • Rehabilitation • LOH 	Prior to education; Just before surgery; 1 and 7 days after surgery	Pain and anxiety was decreased prior to surgery, but no difference between EG and CG after surgery

			<ul style="list-style-type: none"> • Questions and answers • Pamphlet reinforced traditional verbal communication <p><u>Content:</u></p> <ul style="list-style-type: none"> • Osteoarthritis of the hip - Rheumatologist's part (half an hour): Presentation of the team; normal anatomy of the hip and osteoarthritis of the hip; explanation of the disease, risk factors, disease process, and its consequences; principle and benefit of total hip arthroplasty; duration of hospitalization, sequence of events associated with hospitalization; practical details concerning hospitalization (telephone numbers, furniture, contention, socks, crutches, discharge arrangements, what to bring to the hospital); patient's questions • Surgery - Orthopedic surgeon's part (half an hour): Surgical replacement procedure: prosthesis used, technique (trochanteric osteotomy), and demonstration of materials, radiographs; duration of the surgery; 				
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				<p>potential complications and risks of the surgery (dying, dislocation, infection, nerve injury, loosening, heterotopic ossification) and prevention; scar, wound precautions; time that it takes before the hip surgery ceases to be the focus of the patient's life; the importance of regular follow up with the surgeon (loosening and wear); protection against infection; patient's questions</p> <ul style="list-style-type: none"> • Anesthesia - Anesthetist's part (half an hour): Preparation for anesthesia (autologous blood transfusion, laboratory tests, cardiac preparation, avoiding drugs); pre-anesthesia visit, postoperative course, and monitoring equipment; post-anesthesia care unit; the anesthetic procedure: type of anesthesia; anesthetic drugs, duration, loss of control; potential complications and risks (dying, cardiac, pulmonary, brain injuries, bleeding, pain); postoperative pain control; unpleasant side-effects (bed rest, sleeping difficulties, nausea, suction, bladder catheter); deep vein 				
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				<p>thrombosis prevention; postoperative drugs (pain medication, non-steroidal anti-inflammatory drugs, anticoagulation therapy, precautions); nutrition and blood sample; patient's questions</p> <ul style="list-style-type: none"> • Rehabilitation - Physiotherapist's part (half an hour): Rehabilitation procedure (bed rest, sitting up, exercises, beginning to walk, walker, dangerous movements, stair climbing); rehabilitation period (going home or to a specific center: necessity, duration, physiotherapy); the role of social workers; bathing, driving, sports participation; sexual activities; patient's questions • Patients' questions - Psychiatrist's and rheumatologist's part: Discussion with the patients: personal patient wait, physical and emotional preparation, benefits of total hip arthroplasty, personal or collective problems, and long-term precautions 				
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Gocen et al, 2004	60	<p>EG (n = 30): 46.93 ± 11.48 years of age; 16 female</p> <p>CG (n = 30): 55.5 ± 14.44 years of age; 22 female</p>	THA	<p>Educator: Physiotherapist</p> <p>Education:</p> <ul style="list-style-type: none"> • Advice on movements that need to be avoided • Use of assistive devices • Posture • Lifting and carrying • Washing/bathing <p>Exercise:</p> <ul style="list-style-type: none"> • Straight leg raising exercise; hamstring stretches; hip flexor stretches; Upper extremity strengthening; <p>Exercises done for 8 weeks prior to surgery; Instructed to do exercises 3x/day; 10 repetitions each; Exercise monitored by a physiotherapist at 2-week intervals;</p>	No treatment	<ul style="list-style-type: none"> • Harris Hip Score • Visual Analogue Scale (VAS) • Days till: <ul style="list-style-type: none"> ○ Walking ○ Climbing stairs ○ Transfers 	At discharge; 3 months and 2 years	No difference in Harris Hip Score; No difference in VAS
Lilja et al, 1998	50	<p>THA patient median age 65</p> <p>EG: n = 22; Female n = 9; 41%</p> <p>CG: n = 28; Female n = 8; 29%</p>	THA	<p>Educator: Anesthetic nurses</p> <p>Preoperative and postoperative routines instructed by the ward nurse</p> <p>Extended formulized information</p> <ul style="list-style-type: none"> • Additional information regarding anesthesia 	Preoperative and postoperative routines instructed by the ward nurse	<ul style="list-style-type: none"> • Cortisol • Pain (VAS) • Anxiety: Hospital Anxiety and Depression Scale (HADS) 	Cortisol: Day before surgery; day of surgery; first and third post-operative	No change in anxiety; No changes in cortisol; No difference in pain ratings

			<ul style="list-style-type: none"> • 30 minute session • Day prior to surgery <p>Content:</p> <ul style="list-style-type: none"> • Participation: The importance to the recovery of patient participation in the planning of care before, during and after operation • Information: About anesthesia and the surgical procedure • Education: To explain the importance of preoperative patient preparation and to motivate postoperative interventions • Support: To support the patient before and during the anesthesia and to attend to the patient's needs • Environment: To describe the operating theatre • General Care: To inform about care in relation to anesthesia and operation • Training: Mobilization after surgery • Observation: To explain observation procedures during anesthesia • Special care: To discuss the pre-medication • Continuity: That the same 			<p>day.</p> <p>HADS: Day before surgery and day of surgery</p> <p>VAS: First 3 post-operative days</p>	
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				<p>anesthetic nurse meets the patient in the operating theatre</p> <ul style="list-style-type: none"> • Coordination: Scheduling 				
McDonald et al, 2001	31	<p>Mean age 74 ± 6.16</p> <p>Females n = 23 (74.2%)</p>	THA and TKA	<p>Educator: Nurse</p> <p>Preoperative joint replacement class – preparation prior to surgery and what to expect following surgery; exercise; discharge planning; typical postoperative pain management – PCA and medication</p> <p>Pain Education</p> <ul style="list-style-type: none"> • PowerPoint slide show • Basic pain management and communication skills <p>Pain Management Education Content:</p> <ul style="list-style-type: none"> • General pain overview: defining pain; understanding the causes of pain; pain assessment and use of pain-rating scales for communicating pain; using preventative approach to control pain • Pharmacological management of pain: overview of drug management for pain; myths about addiction; controlling unpleasant side effects • Non-pharmacological management of 	<p>Preoperative joint replacement class – preparation prior to surgery and what to expect following surgery; exercise; discharge planning; typical postoperative pain management – PCA and medication</p> <p>Slide show reviewing the 0-10 and Wong-Baker</p>	<ul style="list-style-type: none"> • McGill Pain Questionnaire Short Form (MPQ-SF) 	<p>Night of the surgery; post-operative days 1 and 2</p>	<p>EG reported less pain at all intervals postoperatively compared to the CG</p>

				<p>pain: Importance of non-pharmacological management of pain; use of non-pharmacological strategies in conjunction with medication; use of previously successful pain interventions; description of massage, relaxation and distraction</p> <p>Pain Communication education content:</p> <ul style="list-style-type: none"> • Interpersonal control strategies: The person as the expert of his or her own pain experience; responsibility for reporting pain and the response to treatment; importance of teamwork in decreasing pain • Interpretability strategies: Describing your pain using the pain-intensity scales; describing your pain using pain location; describing your pain using pain sensation; evaluating and describing changes; determining if the health provider understood your message • Discourse management strategies: How to introduce the pain/pain management topic (ineffective pain relief, unpleasant medication side 	<p>pain intensity scales; (time = 10 minutes)</p>			
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				<p>effects, use of complimentary pain treatments, pain goals); promoting an effective response by your health care provider; actively participating in the pain management discussion; efficient use of time during the pain management discussion</p> <ul style="list-style-type: none"> • Approximation strategies: Some basics about how people communicate (speech rate, eye contact, nonverbal); adjusting the way you talk and the effect that may have on the other person <p>Colorhand-out with large face type summarizing key points of the slides; Seventh-grade reading level;</p> <p>Total time = 30 minutes</p>				
McGregor et al, 2001	35	<p>EG: n = 15; Mean age 70.8 ± 9.3</p> <p>CG: n = 20; Mean age 72.8 ± 10.1</p>	THA	<p>Educator: Not stated</p> <p>Rehabilitation program and booklet</p> <p>Preoperative hip class 2-4 weeks prior to surgery and an informational booklet; Preoperative class reinforced the booklet and ensure all patients could do the</p>	Standard pathway of care – including description of surgery; risks; estimated LOH	<ul style="list-style-type: none"> • Western Ontario and McMaster Universities Index (WOMAC) • Harris Hip Score • Barthel Activities of Daily Living Index • Pain (VAS) 	Admission; Before discharge and 3 months post-operatively	<p>EG reported higher levels of satisfaction at discharge and 3 months post-surgery</p> <p>EG had a</p>

		25 females (71%) Mean age 71.9 ± 9.3;		<p>exercises and how to use walking aids postoperatively; Ensured patient knew about adaptations needed to be made at home;</p> <p>Booklet:</p> <ul style="list-style-type: none"> • Information on the surgery • All preoperative and postoperative stages • Rehabilitation stages including exercise regimens • Series of answers to commonly asked questions regarding THA 		<ul style="list-style-type: none"> • Positive Affect Negative Affect Scale • Helplessness short subscale of the Rheumatology Attitudes Index • Cantril Life Satisfaction Ladder • VAS for fatigue • Economic Analysis 		<p>shorter LOH compared to the CG</p> <p>EG reduced cost associated with THA compared to CG</p> <p>EG had more realistic expectations compared to CG</p> <p>No difference between EG and CG in pain</p> <p>No difference in functional levels between EG and CG</p>
Sjoling et al, 2003	60	EG (n = 30); Females 60%; n = 18; Mean age 71	TKA	<p>Educator: Nurse</p> <p>One to four days prior to surgery; Positive way as to not increase fear; Personal, private educational sessions; Education lasted 20-40 minutes; Routine</p>	One to four days prior to surgery; Positive way as to not	<ul style="list-style-type: none"> • Pain (VAS) • State and trait Anxiety • Satisfaction with pain management 	Pain measured pre-operatively; every 3	No difference between EG and CG in VAS scores

		CG (n = 30) Females 60%; n = 18; Mean age 71	<p>preoperative information written and verbally; Information were mainly procedural – what happens before surgery; blood samples; machines; people they will meet; VAS scale</p> <p>Additional information (verbal and leaflet):</p> <ul style="list-style-type: none"> • Emphasize patient's own role in pain management • Improved knowledge • Being active in their own treatment – asking for help with pain management • Benefits of well-treated postoperative pain • Physiotherapy crucial for recovery • Easier to prevent pain than treat existing pain • Use of basic medication prior to exercise • Ask questions about pain management in hospital stay 	<p>increase fear; Personal, private educational sessions; Education lasted 20-40 minutes; Routine preoperative information written and verbally; Information were mainly procedural – what happens before surgery; blood samples; machines; people they will meet; WAS scale</p>	<ul style="list-style-type: none"> • Satisfaction with nursing care 	<p>hours for the first 3 post-operative days</p>	<p>No difference between EG and CG in terms of oral analgesics</p> <p>No difference in LOH</p> <p>No difference in anxiety</p> <p>EG group was more satisfied than the CG regarding information provided</p>
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Vuko- manovic et al, 2008	45	EG (n = 23): 60.05 ± 11.01 years of age; 14 females CG (n = 22): 56.2 ± 18.45 years of age; 16 females	THA	<p>Physiatrist (education); Physiotherapist (exercise)</p> <p>Education:</p> <ul style="list-style-type: none"> • Information about the surgery • Precautions • Postoperative rehabilitation following THA; • Physiatrist performed education once • Brochure <p>Exercise:</p> <ul style="list-style-type: none"> • Instruction by physiotherapist - twice • Postoperative program prior to surgery; • Bed mobility; crutch use; transfers; stairs 	No education or exercise	<ul style="list-style-type: none"> • Visual analogue scale (VAS) • ROM (goniometry) <ul style="list-style-type: none"> ○ Hip flexion ○ Hip abduction • Harris Hip Score • Hip score of the Japanese Orthopedic Association (JOA) • Oxford hip score 	Pre-admission; discharge; 15 months after surgery;	EG climbed stairs, used a toilet and used a chair earlier than the CG; EG increased independence regarding ADL's after surgery compared to CG; EG had better endurance than the CG; EG needed less postoperative physiotherapy visits
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* TKA = Total knee arthroplasty

** THA = Total hip arthroplasty

3.3.5 Educational delivery methods

3.3.5.1 Professionals performing preoperative education in orthopedics

Several healthcare providers provided the preoperative education (Table 3.4). Preoperative education in orthopedics is mostly performed by physiotherapists and nurses. The complete list (in order of most utilized to least) includes:

1. Physiotherapist^{27,128,181,182,186}
2. Nurse^{183-185,187}
3. Psychologist/psychiatrist^{128,180,186}
4. Physician^{128,180}
5. None¹⁷⁹
6. Research assistant²⁶
7. Multidisciplinary team¹²⁸
8. Rheumatologist¹²⁸
9. Anesthetist¹²⁸
10. Not specified²⁵

3.3.6 Timing and duration of preoperative education

The timing and duration of the preoperative educational sessions were varied. Preoperative education was provided as long as 6 weeks prior to surgery²⁷ and as short as the day prior to surgery.^{26,183,185,187} The remaining studies performed the preoperative education anywhere between 2 to 4 weeks prior to surgery.^{25,128,179,181} The duration of the educational sessions also varied considerably (Table 3.4), with educational sessions (video) lasting as short as 12 minutes,¹⁸⁰ while interdisciplinary educational sessions lasted as long as a half a day (4 hours).¹²⁸ The median time spent on education in the studies that reported the duration of the sessions was 30 minutes. The duration of the educational sessions are listed below:

- Not specified²⁷
- Video session lasted 20 minutes¹⁷⁹
- Video lasted 12 minutes¹⁸⁰
- Half day¹²⁸
- 30 minutes^{183,184}
- 20-40 minutes¹⁸⁵

3.3.7 Educational format

The format in which the preoperative education was delivered was primarily by means of either one-on-one verbal communication^{27,128,181,185,186} or group sessions with several patients.^{25,128,181,184} One study delivered the preoperative education via video and a booklet only, with no personal communication.¹⁷⁹

3.3.8 Educational tools

Details of the specific educational sessions are found in Table 3.4. In summary, preoperative educational sessions addressing pain are accompanied by:

- No additional tools²⁷
- Video^{179,180}
- Booklet^{25,26,179,186,187}
- Set of anatomy models¹⁷⁹
- Joint prosthesis¹⁷⁹
- Audio tapes²⁶
- Pictures from the patient's viewpoint²⁶
- Information leaflet^{128,184,185}

3.3.9 Adjunct treatment to the preoperative education

Several different research designs are included in this review. In some studies, patients received various forms of other therapeutic interventions along with the preoperative education addressing pain. The therapeutic activities that accompanied preoperative education included either exercise^{25,27,181,182} or relaxation.²⁶

3.3.10 Control Groups

In the majority of the studies, the researchers compared the experimental protocol (preoperative education) to usual preoperative care^{25,128,180,183,185,187} or asked patients to continue with regular activities/no treatment.^{26,27,179,181,182,186} The exceptions were studies comparing the preoperative educational programs to standard preoperative joint replacement class¹⁸⁴ (without pain management education content) and fear reducing strategies¹⁸⁵ (without additional coping strategies).

3.3.11 Outcome Measures

The studies in this review utilized a wide variety of outcomes measures (Table 3.5). Outcome measures mainly assessed the effect of preoperative education on issues related to function; pain; range of motion; strength; psychological issues; general health; health care utilization; compliance; and satisfaction (Table 3.5).

Table 3.5: Outcomes measures used to assess preoperative education in orthopedics for postoperative outcomes

Function	<ul style="list-style-type: none"> Western Ontario McMaster Osteoarthritis Index (WOMAC) – Pain, stiffness and function^{25,27,181} Hip function evaluation¹⁷⁹ Hip Harris Score^{25,181,182,186} Barthel Activities of Daily Living Index²⁵ Days till walking, climbing stairs and transfers¹⁸² Hip Score of the Japanese Orthopedic Association (JOA)¹⁸⁶ Oxford Hip Score¹⁸⁶ Barthel index¹⁸¹
Pain	<ul style="list-style-type: none"> Postoperative pain (descriptive ordinal scale)¹⁷⁹ Pain medication use^{26,128,180,187} Visual Analogue Scale (VAS)^{25,180-183,185,186} McGill Pain Questionnaire Short Form (MPQ-SF)¹⁸⁴
Range of Motion	<ul style="list-style-type: none"> Range of motion (ROM) – goniometer^{27,186} British Medical Research Council (BMRC) measures of ROM¹⁸¹ Movement¹⁸⁷
Strength	<ul style="list-style-type: none"> Quadriceps and hamstring strength – handheld dynamometer²⁷ British Medical Research Council (BMRC) measures of strength¹⁸¹
Psycho-logical	<ul style="list-style-type: none"> Hospital Anxiety and Depression Scale (HADS)^{179,183} Stress Arousal Checklist¹⁷⁹ State Anxiety^{26,128,180,185} Mental State (Mini Mental State Exam)²⁶ Urinary levels of cortisol, epinephrine and nor epinephrine^{180,183} Physical Indicators of Coping Questionnaire¹⁸⁷ Linear Analogue Coping Scale¹⁸⁷ Positive and negative affect scale²⁵ Helplessness short subscale of the Rheumatology Attitudes Index²⁵ Cantril Life Satisfaction Ladder²⁵
General Health	<ul style="list-style-type: none"> Medical Outcome Study Short Form (SF-36)²⁷ Nottingham Health Profile¹⁷⁹ Sleep disturbance¹⁷⁹ Intraoperative heart rate¹⁸⁰ Intraoperative blood pressure¹⁸⁰ VAS for fatigue²⁵
Healthcare Utilization	<ul style="list-style-type: none"> Healthcare utilization – length of hospital stay (LOH)^{26,27,128,179,187} Economic Analysis²⁵
Compliance	<ul style="list-style-type: none"> Frequency of use of interventional tools²⁶ Rehabilitation¹²⁸
Satisfaction	<ul style="list-style-type: none"> Satisfaction with pain management¹⁸⁵ Satisfaction with nursing care¹⁸⁵

3.3.12 Outcome intervals

The effect of preoperative education for orthopedic surgery patients were examined at various time intervals (Figure 3.2):

- Preoperatively^{27,128,179,181,183,185,186}
- Day of surgery^{183,184}
- Each day of the first seven postoperative days¹⁷⁹
- 1 day after surgery^{128,183,184}
- Second postoperative day¹⁸⁴
- Third postoperative day¹⁸³
- 7 days after surgery¹²⁸
- First 4 days postoperatively^{26,185}
- First 5 postoperative days¹⁸⁰
- Till time of discharge or more surgery^{25,26,182,186,187}
- 15 days after surgery¹⁸¹
- 4 weeks after surgery¹⁸¹
- 3 months postoperatively^{25,27,181,182}
- 6 months postoperatively²⁷
- 12 months postoperatively²⁷
- 15 months postoperatively¹⁸⁶
- 24 months postoperatively¹⁸²

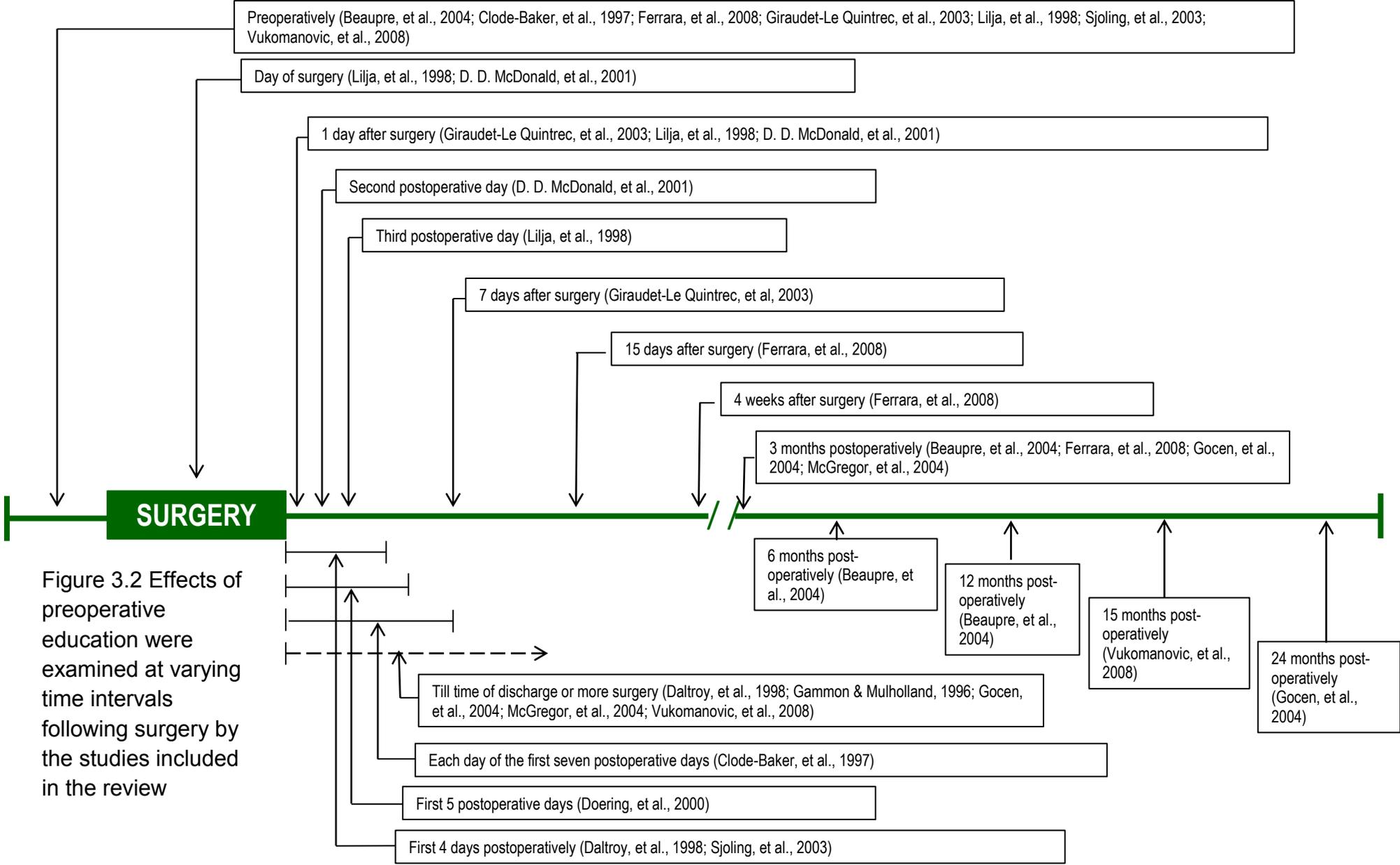


Figure 3.2 Effects of preoperative education were examined at varying time intervals following surgery by the studies included in the review

3.3.13 Outcomes related to pain

Although the review did not aim to determine the efficacy of preoperative education addressing pain, Table 3.6 provides a summary of the outcomes related to pain from the studies in this review.

Table 3.6: Main findings related to postoperative pain

Study	Positive effect	Neutral	Negative effect
1. Beaupre et al, 2004		No difference in pain ratings	
2. Clode-Baker et al, 1997		No difference in postoperative pain (POP)	
3. Daltroy et al, 1998		No difference in POP	
4. Doering et al, 2000		No difference in POP	
5. Ferrara et al, 2008		No difference in POP	
6. Gammon and Mulholland, 1996	Experimental group used less intramuscular analgesia compared to the control group	No difference in oral analgesia intake	
7. Giraudet-Le Quintrec et al, 2003		No difference in POP	
8. Gocen et al, 2004		No difference in POP	
9. Lilja et al, 1998		No difference in POP	
10. McDonald et al, 2001	Experimental group reported less pain in all intervals postoperatively compared to the control group		
11. McGregor et al, 2004		No difference in POP	
12. Sjoling et al, 2003		No difference in POP	
13. Vukomanovic et al, 2008		No difference in POP	

3.4 Discussion

3.4.1 Efficacy of preoperative education in orthopedics

In the orthopedic domain, most studies on preoperative education have been conducted on patients undergoing hip replacement²²⁻²⁶ and knee replacement,^{23,24,26-28} and a handful of studies have been conducted on preoperative education for patients undergoing spinal surgery.^{23,47,49,188,189} In 2004 and 2005, two systematic reviews evaluated the efficacy of preoperative education for total knee and total hip arthroplasty.^{23,174} The review by Johansson, et al²³ reported on 11 randomized controlled trials involving 1044 hip and knee arthroplasty patients. This review provided a detailed description of the educational interventions, which varied widely, and showed that preoperative education has a positive effect on preoperative anxiety levels and patient knowledge, but no changes in postoperative outcomes including pain, ROM, function or length of hospitalization (LOH). The second review (Cochrane) conducted by McDonald, et al,¹⁷⁴ consisted of 9 studies involving 782 patients with knee or hip arthroplasty. The results from the review concurred with Johansson, showing a wide variety of content and educational tools and the authors concluded that there is little evidence that preoperative education provides superior results in regards to pain, functioning and LOH when compared to “usual care” in total hip and knee replacement patients. The Cochrane review¹⁷⁴, however, did show that preoperative education has a modest effect in decreasing anxiety prior to surgery, which concurs with the Johansson, et al²³ review. Since these 2 reviews, several RCTs have been published evaluating the effect of preoperative education in orthopedic surgery.^{25,27,42,137,158,181,182,186,190-194} Although the current review primarily aimed to source the content and educational delivery methods utilized in orthopedic surgery to address postoperative pain, the results concur with previous systematic reviews showing that preoperative education classes (as applied in the reviewed studies) did not help alleviate postoperative pain following orthopedic surgery.

3.4.2 Education Delivery Methods

The educational delivery methods described in this review concur with studies examining preoperative education in other surgical realms, such as cardiac surgery,^{29,30,33,195} dental surgery³⁸⁻⁴⁰ or general surgery.^{20,21,127} Considering that preoperative education in orthopedics is shown to have limited efficacy in addressing pain and yet educational delivery methods are similar to non-orthopedic surgical procedures, it may imply that the educational delivery

methods may not be a source of the inability of preoperative education to address postoperative pain in orthopedics. This conclusion is underscored by the fact that one study in this review, McDonald et al.,¹⁸⁴ was the only study to show a positive effect on postoperative pain at all intervals postoperatively compared to the control group, yet the educational delivery methods (nurse educator; one-on-one education lasting 30 minutes; hand-out to support the verbal communication) were similar to the other studies in this review.

3.4.3 Content of preoperative education in orthopedic surgery addressing pain

The content covered in preoperative education in orthopedics was vast; however, of all the topics covered by the various studies, only two topics covered were unique to a single study, indicating that more than 90% of the topics listed were covered by more than one study. This finding may indicate a potential agreement amongst the various authors on the content of preoperative education in orthopedic surgery. The content of the educational sessions concur with other surgical procedures ensuring a description of preoperative preparation; hospital stay; surgical procedure; immediate/ intermediate experiences and expectations following surgery; rehabilitation; encouragement/ reassurance; and answering common questions associated with the surgical experience.^{20,21,23,24} In order to gain a deeper insight into the possible reason for preoperative education not positively affecting postoperative pain in orthopedics, the content needs further exploration. The study by McDonald, et al.¹⁸⁴ was the only study that showed a positive effect for preoperative education on pain, even though the educational delivery methods concurred with all the other studies in this review. McDonald's study however, was unique in that its content was different from the other studies in this review and also different from all the systematic reviews done previously. McDonald, et al showed that an experimental group of elderly patients undergoing joint arthroplasty who were taught basic pain management information and communication skills regarding pain prior to surgery, compared to a similar control group who did not receive such an intervention had less pain on the day of surgery and day 1 and day 2 postoperatively. Although the authors were unable to determine independently if the communication skills or the content was the reason for the reduced postoperative pain, the authors concluded that *"...the pain difference between the groups may be a result of the pain management education alone."*¹⁸⁴ The study by McDonald et al¹⁸⁴ and discussion of pain education in non-surgical orthopedic cases highlights another possible reason why the other studies in this review failed to provide a favorable outcome in postoperative pain. Traditional educational models are based on a biomedical model discussing anatomy, biomechanics and pathoanatomy.^{114,196-198} Not only have these models shown limited efficacy in minimizing

pain and disability, but they may in fact enhance fear.^{199,200} All the other studies in this review, and several studies in the two mentioned systematic reviews, indicate that anatomical, pathoanatomical and surgical “correction” of such pathoanatomy is discussed at length with patients. It could be argued that such discussions may in fact increase anxiety and fear, thus negatively influence postoperative pain.

Patients are interested in pain⁵⁶ and recent studies in groups of non-surgical orthopedic patients with chronic low back pain^{79,201,202} and whiplash associated disorders²⁰³ have shown that patients are able to take on pain education. Furthermore, education regarding pain is associated with decreased pain, increased function, increased movement and changes in cognitions. These studies, which taught patients more about pain and pain processing, rather than tissue models describing pathology, concur with the content described by McDonald et. al.¹⁸⁴ It is therefore proposed that educational programs that aim to increase a patient’s understanding of pain and the biological processes behind the pain experience may be of benefit to patients undergoing orthopedic surgery, to affect postoperative pain. The proposed mechanism and future interest in developing a pain-based educational model in orthopedics may be due to such educational strategies’ resulting in enhancing the patient’s ability to down-regulate input from the affected surgical area.^{204,205} Even though patients are anesthetized during surgery and therefore unlikely to be aware of any sensory stimuli from the surgical site during the surgery, the central nervous system continues to receive an enormous barrage from the surgical site due to tissue trauma generated by the surgeon.²⁰⁶⁻²⁰⁸ The sensory inflow generated by this noxious stimulus will produce central sensitization, an enhanced state of excitability within the nervous system.^{208,209} When the surgery is complete and the patient awakens, likely with no recollection of the surgery, the nervous system has, in a sense, a recollection or memory of the surgery in that it is hyper-excitabile. The exaggerated sensitivity the patient experiences postoperatively is a reflection of this altered state of excitability. This postoperative pain is managed primarily via administration of drugs aimed at counteracting the pain.^{170,210} It is proposed, however, that increasing a patient’s knowledge of pain may, in effect, alter their perception of threat and patients may thus experience less fear and anxiety. Additionally, the increased knowledge and understanding of pain may help modulate the pain experience. In a case study of a patient with chronic LBP, a single pain education session lead to a significant reduction in cortical activation of various areas associated with processing pain on a functional magnetic resonance imaging (fMRI) study.⁸² Considering that pain education can lead to changes in pain beliefs, such as a reduction in the conviction that pain is associated with harm and tissue damage and that pain is necessarily associated with disability,^{82,202} it seems most likely that these observed changes in brain activation reflect reduced threat.

3.5 Limitations

This systematic review has limitations that need to be acknowledged. The review is limited by the number of studies. The review aimed to source the content and educational delivery methods and its assessment of efficacy of preoperative education by itself is limited. The review contains primarily patients with TKA and THA, and carry-over to other orthopedic surgeries are limited. Additional limitations include English-only studies and patient populations as well as excluding younger patients.

3.6 Conclusion

From the results of the reviewed studies, preoperative education in the reported studies has little effect on postoperative pain in orthopedics. Even though educational delivery methods utilized in preoperative education is similar to other non-orthopedic surgeries, it is suggested that content focusing on a biomedical model of anatomy, biomechanics and pathoanatomy is limited in affecting postoperative pain. Educational sessions with a biopsychosocial approach may help patients experience less fear and anxiety, and ultimately help alleviate postoperative pain.

Chapter 4:

No brain – no pain.

The efficacy of sham surgery in orthopedics: A Systematic Review

4.1 Introduction

Pain and cognitions are inter-related^{79,211,212}. What a patient thinks and believes about the health of their tissues and pain will significantly influence the outcome of a proposed treatment, including surgery^{102,211}. This correlation between pain, cognitions and a proper view of the status of the health of a patient's tissues are also at the core of neuroscience education (NE)^{82,202,213}. Researchers utilizing NE have proposed that changing a patient's beliefs about their pain, from a neurophysiological and neurobiological perspective result in the proposed benefits of NE^{82,202,213}. To truly establish the ability of cognitions altering pain in a patient population such as lumbar surgery (LS), it could be argued a true test may involve a study of sham surgery. Sham or placebo surgery is quite rare.²¹⁴⁻²¹⁶ The earliest report of a sham surgical procedure in 1959 reported that patients undergoing ligation of the internal mammary artery did no better than patients in the control (sham) surgery group receiving only a skin incision under local anesthesia without the ligation procedure.²¹⁷ Since then, only 8 sham or placebo surgical interventions have been published for Parkinson's disease,^{215,218} Meniere's disease,²¹⁹⁻²²¹ knee arthroscopy²²² and vertebroplasty.^{223,224}

The proposed mechanism behind sham surgery and its efficacy is the possible placebo effect; hence, the term placebo surgery would be the most appropriate term.^{218,225} If patients believe they are receiving a surgical procedure, they will report improvement in symptoms and dysfunction as if the underlying pathology or disease state has been changed. Placebo can be seen as a change in the brain's perception of the underlying pathology or disease state, with the procedure not directly affecting the proposed pathology or disease state.^{222,223} Sham surgery is very controversial and has opponents for and against it.^{214,226-228} The proponents for sham surgery argue that only true, placebo-controlled trials can validate the efficacy of a surgical intervention, comparable to the placebo-controlled trials used in pharmaceutical research.^{226,228} The opponents of sham surgery argue the ethical issues of withholding surgery from patients as well as the true definition of the placebo effect, stating there are too many variables to control and demonstrate that the sham procedure truly resulted in a placebo effect.^{216,229-231}

Orthopedics is deeply rooted in a biomedical model focusing on tissues and tissue injury.^{114,196,197} The biomedical model seeks to find the anatomy or biomechanics at fault. If

the faulty biomechanics or pathoanatomy are corrected, in this case surgically, it is expected that pain and disability will be improved.^{114,196,197} Not only has this model shown limited efficacy in decreasing pain and disability, but it may in fact increase fear in patients, which in turn may increase their pain.^{199,200} Pain is complex and recent authors have highlighted the fact that pain could possibly be a better measure of potential threat, rather than true tissue health.^{67,82,232,233} The larger the threat, the higher the pain perceived.⁸²

Considering that the biomedical model proposes a direct relationship between pathoanatomy and pain and the brain's perception of tissue injury and pain, the objective of this systematic review was to evaluate the efficacy of sham surgery in orthopedics. The results from this review may further underscore the need of enhanced cognitive strategies such as NE to help patients experience less pain and disability following surgery, such as LS.

4.2 Methods

4.2.1 Search strategy

An electronic search was performed between May 2011 and July 2011 from the following databases with no limitations on time frame: Biomed Central, BMJ.com, CINAHL, the Cochrane Library, NLM Central Gateway, OVID, ProQuest (Digital Dissertations), PsycInfo, PubMed/Medline, ScienceDirect and Web of Science. Each database has its own indexing terms and functions, and therefore different search strategies were developed for each database by the authors. The main search items were *joint*, *orthopedic*, *orthopedic*, *placebo*, *procedure*, *sham* and *surgery*. In PubMed, medical subject headings (MeSH) terms were used where possible, with Boolean operators. The search strategies for the remaining databases included synonyms of the main search items. Secondary searching (Pearling) was undertaken, whereby reference lists of the selected articles were reviewed for additional references not identified in the primary search.

4.2.2 Inclusion criteria

All titles and abstracts were read to identify potentially relevant papers. Papers were included if they met the inclusion criteria listed in Table 4.1. When there was uncertainty regarding the eligibility of the paper from the abstract, the full text version of the paper was retrieved and evaluated against the inclusion criteria. The full text version of all papers that met the inclusion criteria were retrieved for quality assessment and data extraction.

Table 4.1: Inclusion criteria used in the systematic review: Sham surgery in orthopedics

Criterion	Justification
English Language	Major journals in this area are published in this language.
No time limit	Given the limited number of sham surgeries it was decided to set no time limit.
Humans	Since the objective of the study was to determine true placebo effect and change in perception and to make findings clinically meaningful, animal studies were excluded.
No age limit	Given the limited number of sham surgeries it was decided to set no age limit.
Randomized controlled trials (RCTs)	Randomized controlled trials were chosen because of their high levels of evidence and to pool results.
Sham (placebo) surgery	This review focused on surgical interventions where one patient group in the RCT did not receive the actual surgical intervention but a procedure mimicking the actual surgical interventions.
Outcomes	No limitations were set on the outcomes measures used in the RCT's mainly due to the limited studies in the area.

4.2.3 Quality assessment

Critical appraisal of each included study was conducted by determining:

- The level of evidence on the Australian National Health and Medical Research Council (NHMRC) Hierarchy of Evidence (Australian National Health and Medical Research Council, 1999). This provides a broad indication of bias based on study design. Studies higher on the hierarchy potentially contain less bias than those that are lower on the hierarchy.
- The methodological quality of each study was assessed using the Critical Review Form – Quantitative studies.²³⁴ This tool can be used to appraise all types of quantitative studies ranging from RCTs to case series. Thus, all quantitative studies on sham surgery in orthopedics were included in this review and evaluated for quality using the same tool. This made the quality results comparable between the different study designs.²³⁵

Standardized guidelines on the interpretation and scoring of each item were used.²³⁶ Items were scored as 1 (completely fulfills the criterion) or 0 (does not completely fulfill the criterion). The scores of the 16 closed ended questions were totaled to provide an overall score of quality where the maximum score of 16 indicated excellent quality.²³⁷ Three researchers (AL, ID and DB) independently scored the studies and where disagreement occurred, consensus was achieved by discussion. Quality scores were arbitrarily divided into 5 categories: poor (score ≤ 8), fair (score = 9–10), good (score = 11–12), very good (score = 13–14) and excellent (score = 15–16).²³⁸ The Critical Review Form – Quantitative studies²³⁴ includes 17 of the 22 items that are contained in the CONSORT statement.^{239,240} It does not include items 1 (study design stated in title or abstract), 8, 9 and 10 (randomization: sequence generation, allocation concealment and implementation respectively) or 19 (adverse events). The CONSORT statement was not designed to evaluate methodological quality.²³⁹ However, in this review, it was documented whether these 5 CONSORT criteria were fulfilled by the included RCTs. This step provides further methodological quality information.

4.2.4 Outcome assessment

To determine the efficacy of sham surgery in orthopedics, results were posted in narrative form and outcomes were defined as positive (experimental group obtained a significantly greater improvement compared to the control group); neutral (there were no statistically significant differences between the groups); or negative (the control group obtained a significant greater improvement compared to the experimental group). An alpha of $p < .05$ was used to define a significant outcome measure. This method, used in previous systematic reviews, is based on 4 levels of scientific evidence on the quality and the outcome of the trials:^{241,242}

1. *Strong evidence*: multiple, relevant, high-quality randomized controlled trials with generally consistent outcomes.
2. *Moderate evidence*: one relevant, high-quality randomized controlled trial AND one or more relevant, low quality randomized controlled trials with generally consistent outcomes.
3. *Limited evidence*: one relevant, high-quality randomized controlled trial OR multiple relevant low-quality randomized controlled trials with generally consistent outcomes.
4. *Inconclusive evidence*: only one relevant, low quality randomized controlled trial, no relevant randomized controlled trials or randomized trials with inconsistent outcomes.

A study was considered “relevant” when at least one of the outcome measures concerned pain or disability. For being “generally consistent,” at least 75% of the trials that analyzed the same sham surgery had to have the same result (positive, neutral, or negative).

4.2.5 Data extraction

Data were extracted by the authors using the PICO approach.¹⁷⁸

- *Participants*: diagnosis treated; age; sex; duration of the symptoms; type of referral source and diagnostic criteria
- *Interventions*: type of surgery
- *Comparison*: description of the placebo procedure
- *Outcomes*: domains and tools used to measure the effects of the intervention.

Data on the effectiveness of the sham surgery for orthopedics were also extracted for each study. To determine the effect of the sham surgery on each outcome measure, the mean and 95% confidence interval (CI) for the between-group differences was calculated for RCTs, based on the results provided in each article.²⁴³ Moreover the mean change between pre- and post-treatment (and 95% CI) was calculated for the RCTs. Pain reduction of more than 20%, irrespective of the measurement tool, was considered clinically worthwhile.^{244,245} It was expected that there would be heterogeneity in participants, interventions, comparisons and outcomes. Therefore the results of the studies were synthesized in a narrative format.

4.3 Results

4.3.1 Search strategy yield

Initially 12,673 hits were gained from databases and secondary searches. After review of the titles and abstracts, those articles that did not meet the inclusion criteria were removed. After reviewing 471 abstracts, the full text of 46 articles were retrieved. Upon further review of the 46 articles, duplicates were removed, non-orthopedic and non-RCT studies excluded, leaving only 3 studies for the systematic review. This systematic review is thus based on 3 published studies (Figure 4.1)

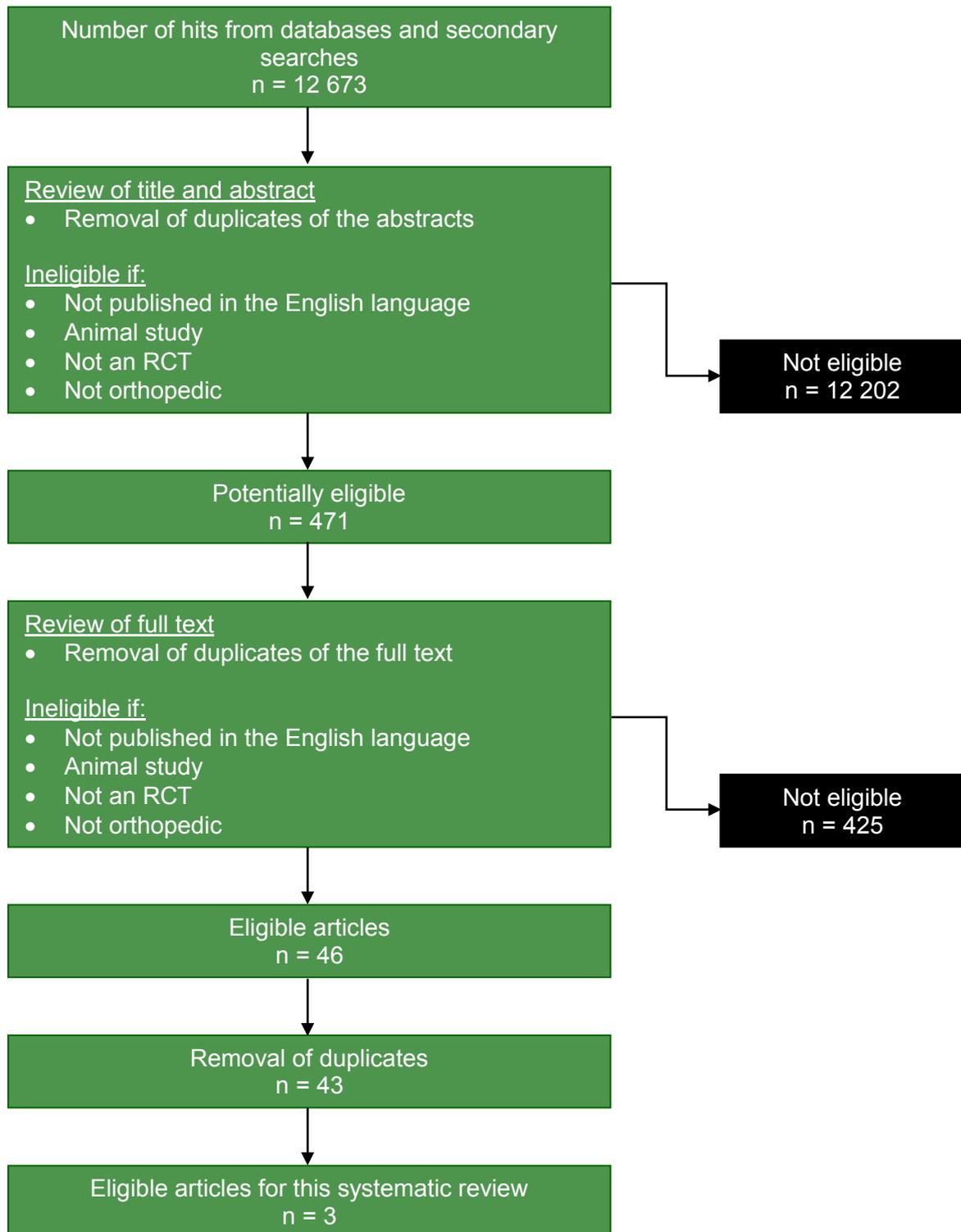


Figure 4.1 Retrieval and review process: Sham surgery in orthopedics

4.3.2 Critical appraisal

4.3.2.1 Hierarchy of Evidence

All 3 studies included in this review were RCTs.²²²⁻²²⁴

4.3.2.2 Methodological quality

There was 100% agreement in scoring between the researchers conducting the systematic review. Scoring in methodological quality was noted (Table 4.2), with scores rated as 14 in all 3 studies (very good). Table 4.2 provides details regarding the criteria that were fulfilled on the Critical Appraisal Form – Quantitative studies.²³⁴ All 3 studies failed to provide adequate description of sample size calculation (criterion 6) and no mention of the validity of the outcomes measures chosen to report results (criterion 8).

4.3.2.3 CONSORT criteria 1, 8, 9, 10 and 19

Table 4.2 also provides details regarding the fulfillment of the CONSORT criteria. All but one study reported all the criteria of the CONSORT criteria 1, 8, 9, 10 and 19, with the study by Moseley²²² failing to report on the adverse events (criteria 19) following knee arthroscopy, lavage and placebo.

4.3.2.4 Patient characteristics

Sham surgery was performed on 163 orthopedic patients of whom 48.47% were female. The average age of the patients ranged from 52.0 ± 11.1 years²²² to 78.9 ± 9.5 years²²³ with a mean age (calculated as the mean of the mean reported ages) of 68.4 years of age. Three sham-controlled trials are included in this review, with two on vertebroplasty for osteoporotic compression fractures^{223,224} and one on arthroscopic debridement for osteoarthritis of the knee joint.²²² The average duration of symptoms for the osteoporotic compression fractures ranged from 9.5²²³ to 20 weeks.²²⁴ The study by Moseley²²² did not report the average duration of knee symptoms due to osteoarthritis but exclusion criteria indicate symptoms to be present > 6 months.

Table 4.2 Study quality of the RCT's (n=3) using the CONSORT statement

#	Criterion – Critical Review Form	Moseley, 2002	Buchbinder, et al 2009	Kallmes, et al 2009	Total
1	Purpose clearly stated	1	1	1	3
2	Literature review relevant	1	1	1	3
3	Study design appropriate to study design aims	1	1	1	3
4	No biases present	1	1	1	3
5	Sample description in detail	1	1	1	3
6	Sample size justified	0	0	0	0
7	Informed consent gained	1	1	1	3
8	Validity of outcome measures used	0	0	0	0
9	Reliability of outcome measures used	1	1	1	3
10	Intervention described in detail	1	1	1	3
11	Statistical reporting of results	1	1	1	3
12	Appropriate statistical analysis	1	1	1	3
13	Clinical importance reported	1	1	1	3
14	Appropriate conclusions	1	1	1	3
15	Clinical implications reported	1	1	1	3
16	Study limitations acknowledged	1	1	1	3
	TOTAL	14	14	14	
	Quality category*	Very Good	Very Good	Very Good	
	Criterion – CONSORT statement**				
1	Study design stated in the title or abstract	√	√	√	
8	Randomization: sequence generation	√	√	√	
9	Randomization: allocation concealment	√	√	√	
10	Randomization: implementation	√	√	√	
19	Adverse events	X	√	√	

* Quality category: poor (score ≤ 8); fair (score = 9-10); good (score = 11-12); very good (score = 13-14) and excellent (score = 15 – 16)

** √ = criterion fulfilled; x = criterion not fulfilled

4.3.2.5 Sham Surgery Procedure

Details of the specific content of the sham surgery procedures used in the studies are found in Table 4.3. In summary, the authors used similar procedures and sham surgery in orthopedics included:

- Mimicking the actual surgical procedure²²²⁻²²⁴
- Skin incisions²²²⁻²²⁴
- Use of the same surgical equipment²²²⁻²²⁴
- Sounds to mimic the real surgical procedure²²²⁻²²⁴
- Smells to mimic the real surgical procedure²²²⁻²²⁴
- Similar postoperative instructions and management as the real surgical procedure²²²⁻²²⁴
- Similar time in the operating room as real surgical procedure²²²⁻²²⁴
- No penetration of the joint structure containing the presumed pathoanatomical cause of pain²²²⁻²²⁴

Table 4.3: Participants, interventions, controls and outcomes in the reviewed studies: Sham surgery in orthopedics

Author	Participants		Interventions		Outcomes		
	n	Sample characteristics	Diagnostic criteria	Treatment	Placebo Surgery	Outcome instruments	Time of assessment
Moseley, 2002 New England Journal of Medicine	180	<p>Knee arthroscopy</p> <p>Osteoarthritis (OA) of the knee; Moderate knee pain ≥ 4 on an visual analogue scale (VAS) > 6 months of medical treatment</p> <p>Placebo group (n=60): Ave age 52.0 ± 11.1 years; 93.3% males</p> <p>Lavage group (n=61): Ave age 51.2 ± 12.2 years; 88.5% males</p>	<p>Defined by the American College of Rheumatology</p> <p>Radiological (scale 0-4) of 3 knee compartments for a total of 12; ≥ 9 out of 12 for the study</p>	<p><u>Lavage</u>: Diagnostic arthroscopy followed by a joint lavage of at least 10 liters of fluid. Anything that could be flushed out through arthroscopic opening was removed. No mechanical tools to debride or remove tissues, except mechanically important, unstable meniscus tears were removed and the meniscus was trimmed to smooth out the firm the rim.</p> <p><u>Debridement</u>: Diagnostic arthroscopy followed by 10 liters of fluid lavage. Rough articular cartilage was shaved (chondroplasty), loose</p>	<p><u>Placebo</u>: Standard arthroscopic debridement simulated. Knee prepped and draped followed by three 1 centimeter (cm) incisions in the skin. Surgeon asked for all the instruments and manipulated the knee as if the arthroscopy was performed. Saline was splashed to simulate lavage sounds. No instruments entered the portholes. Patient kept in the operating room for the same time required for a debridement. Patient spent the night after the surgery in the hospital and cared for nurses unaware of the treatment assignment. Same postoperative</p>	<p><u>PAIN</u>:</p> <ul style="list-style-type: none"> • Knee Specific Pain Scale (KSPS) • Arthritis pain: Arthritis Impact Measurement Scale (AIMS2-P) • Body pain: (SF-36). <p><u>FUNCTION</u>:</p> <ul style="list-style-type: none"> • 5-item walking–bending subscale from the AIMS2 (AIMS2-WB) • SF-36 (As an objective measure, they devised the Physical Functioning Scale (PFS) to record the amount of time in seconds that a patient required to walk 30 m (100 ft.) 	<ul style="list-style-type: none"> • 2 weeks • 6 weeks • 3 months • 6 months • 12 months • 18 months • 24 months

		Debridement group (n=59): Ave age 53.6 ± 12.2 years; 96.6% males		debris was removed; all torn or degenerated meniscal fragments were trimmed and the remaining meniscus was smoothed to a firm and stable rim. No abrasion arthroplasty or microfracture. Typically no bone spurs were removed.	protocol of walking aids, exercises and analgesics.	and to climb up and down a flight of stairs as quickly as possible. Longer times indicate poorer functioning.	
Buchbinder R, Osborne RH, Ebeling PR, Wark JD, Mitchell P, Wriedt C, Graves S, Staples MP, Murphy B. 2009 New England Journal of Medicine	78	Vertebroplasty Back pain < 12 months; 1 or 2 recent vertebral fractures; vertebral collapse; edema, a fracture line or both on magnetic resonance imaging (MRI) Vertebroplasty (n=38): Age 74.2 ± 14.0 years; 82% female;	Vertebral collapse of grade 1 or higher on the grading system by Genant et al.	<u>Vertebroplasty:</u> The left pedicle of the fracture site was identified with the use of a metallic marker. A 25-gauge needle was used to infiltrate the skin overlying the pedicle, and a 23-gauge needle was used to infiltrate the periosteum of the posterior lamina. An incision was made in the skin, and a 13-gauge needle was placed posterolaterally relative to the eye of the pedicle. Gentle tapping guided the needle through the pedicle	<u>Placebo:</u> Participants who were assigned to the sham intervention underwent the same procedures as those in the vertebroplasty group up to the insertion of the 13-gauge needle to rest on the lamina. The central sharp stylet was then replaced with a blunt stylet. To simulate vertebroplasty, the vertebral body was gently tapped, and PMMA was prepared so that its smell permeated the room.	<u>PAIN:</u> <ul style="list-style-type: none"> Numeric Rating Scale (NRS) Pain at rest and pain in bed at night <u>QUALITY OF LIFE:</u> <ul style="list-style-type: none"> Quality of Life Questionnaire of the European Foundation for Osteoporosis (QUALEFFO), Assessment of Quality of Life (AQoL) 	<ul style="list-style-type: none"> 1 week 1 month 3 months 6 months

	<p>Duration of back pain (median) = 9.0 weeks</p> <p>Placebo (n=40): Age 78.9 ± 9.5 years; 78% female; Duration of back pain (median) = 9.5 weeks</p>		<p>into the anterior two thirds of the fractured vertebral body. Anterior–posterior and lateral images were recorded with the needle in the correct position. Prepared polymethylmethacrylate (PMMA) (approximately 3 ml) was slowly injected into the vertebral body, and satisfactory infiltration of the vertebral body was confirmed radiographically. A bipedicular approach was used only if there was inadequate instillation of cement with the unipedicular approach. Injection was stopped when substantial resistance was met or when the cement reached the posterior quarter of the vertebral body; injection was also stopped if</p>	<p>After the intervention, all participants received usual care. Analgesia was given according to standard practice.</p>	<ul style="list-style-type: none"> • European Quality of Life–5 Dimensions (EQ–5D) scale <p><u>DISABILITY:</u></p> <ul style="list-style-type: none"> • Modified 23-item version of the Roland–Morris Disability Questionnaire <p><u>PERCEIVED RECOVERY:</u></p> <ul style="list-style-type: none"> • With respect to pain, fatigue, and overall health was measured on 7-point ordinal scales ranging from “a great deal worse” to “a great deal better.” Responses of “moderately better” or “a great deal better” were classified as 	
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				cement leaked into extraosseous structures or veins. All participants in the vertebroplasty group received cephalothin, administered intravenously immediately after PMMA injection.		successful outcomes. <u>ADVERSE EVENTS:</u> <ul style="list-style-type: none"> Adverse events, including incident clinical fractures, were assessed at each time point with the use of open-ended questions. 	
Kallmes DF, Comstock BA, Heagerty PJ, Turner JA, Wilson DJ, Diamond TH, Edwards R, Gray LA, Stout L, Owen S, Hollingworth W, Ghdoke B, Annesley-Williams DJ, Ralston SH, Jarvik JG.	131	Vertebroplasty Patients 50 years or older; One to three painful osteoporotic vertebral compression fractures between T4 and L5; inadequate relief of pain from standard medical care and pain at least 3 on a scale of 0 to 10.	MRI or bone scan	<u>Vertebroplasty:</u> Patients were brought to the fluoroscopy suite, where conscious sedation was induced and sterile preparation for surgery was performed. Using fluoroscopic guidance, the practitioner infiltrated the skin and subcutaneous tissues overlying the pedicle of the target vertebra or vertebrae with 1% lidocaine and infiltrated the periosteum of the pedicles with 0.25%	<u>Placebo:</u> Patients were brought to the fluoroscopy suite, where conscious sedation was induced and sterile preparation for surgery was performed. Using fluoroscopic guidance, the practitioner infiltrated the skin and subcutaneous tissues overlying the pedicle of the target vertebra or vertebrae with 1% lidocaine and infiltrated the periosteum of the pedicles with 0.25% bupivacaine. During the	<u>DISABILITY:</u> <ul style="list-style-type: none"> Modified Roland Morris Disability Questionnaire (RDQ). <u>PAIN:</u> <ul style="list-style-type: none"> NRS – ratings of average back-pain intensity during the preceding 24 hours Pain Frequency Index Pain 	<ul style="list-style-type: none"> 3 days 14 days 1 month 3 months

<p>2009</p> <p>New England Journal of Medicine</p>	<p>Fractures less than 1 year old based on pain. Fractures on uncertain age required marrow edema on MRI or increased vertebral-body uptake on bone scan.</p> <p>63 placebo 74.3 ± 9.6; female = 73% 20 weeks mean pain duration</p> <p>68 vertebroplasty 73.4 ± 9.4; female = 78% 16 weeks pain duration</p>		<p>bupivacaine. 11-gauge or 13-gauge needles were passed into the central aspect of the target vertebra or vertebrae. Bariumopacified PMMA was prepared on the bench and infused under constant lateral fluoroscopy into the vertebral body. Infusion was stopped when the PMMA reached to the posterior aspect of the vertebral body or entered an extraosseous space, such as the intervertebral disk or an epidural or paravertebral vein.</p>	<p>placebo intervention, verbal and physical cues, such as pressure on the patient's back, were given, and the methacrylate monomer was opened to simulate the odor associated with mixing of PMMA, but the needle was not placed and PMMA was not infused.</p> <p>After the procedure, both groups of patients were monitored in the supine position for 1 to 2 hours before discharge.</p>	<p>Bothersomeness Index</p> <ul style="list-style-type: none"> The use of opioid medication <p><u>FUNCTION:</u></p> <ul style="list-style-type: none"> Study of Osteoporotic Fractures–Activities of Daily Living (SOF–ADL) scale. <u>QUALITY OF LIFE:</u> The European Quality of Life–5 Dimensions (EQ–5D) scale <u>GENERAL HEALTH:</u> Physical Component Summary (PCS) subscale of the self-administered Medical Outcomes Study 36-Item Short- 	
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						<p>Form General Health Survey (SF-36), version 2.</p> <ul style="list-style-type: none">• Mental Component Summary (MCS) subscale of the self-administered Medical Outcomes Study 36-Item Short-Form General Health Survey (SF-36), version 2.	
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4.3.2.6 Professionals performing sham surgery

Sham surgery in orthopedics was performed by a radiologist (vertebroplasty)²²³ and a single orthopedic surgeon (knee arthroscopy).²²² One study failed to identify the professionals who performed the surgery.²²⁴

4.3.2.7 Use of control groups

All 3 RCT's provided detailed descriptions of the surgical procedures which were compared to the sham surgery. The control group surgeries can be summarized as:

- Skin incision²²²⁻²²⁴
- Penetration of the anatomical structure containing the proposed pathoanatomical structures causing the pain and dysfunction²²²⁻²²⁴
- Use of surgical instruments²²²⁻²²⁴
- Correction of pathoanatomical cause of the structured involved in the patient's pain and disability²²²⁻²²⁴

4.3.2.8 Outcome measures

There was great variability in outcome measurements across the studies in terms of the number and type used and the number of occasions they were used (Table 4.3). Researchers and clinicians utilizing sham surgery were mainly interested in determining if sham surgery affected issues related to pain,²²²⁻²²⁴ function,^{222,224} quality of life,^{223,224} disability,^{223,224} adverse events,²²³ perceived recovery²²³ and general health.²²⁴

The tools used to measure outcomes were varied and consisted of tools for:

- Pain:
 - Knee Specific Pain Scale (KSPS) 0 – 100 with higher scores indicating more severe pain²²²
 - Arthritis pain: Arthritis Impact Measurement Scale (AIMS2-P) – a four item pain sub-scale²²²
 - Body pain: Medical Outcomes Study36-item Short-Form General Health Survey (SF-36-P).²²²
 - Numeric Rating Scale (NRS): Pain (over the course of the previous week) as measured on a scale of 0 to 10 (0: no pain, 10: maximum imaginable pain, and 1.5 as the minimal clinically important difference)²²³

- Pain at rest and pain in bed at night (NRS)²²³
- NRS – ratings of average back-pain intensity during the preceding 24 hours (on a scale of 0 to 10, with higher scores indicating more severe pain). Measures of pain intensity, which was the minimal change on each scale that was considered to be clinically important.²²⁴
- Pain Frequency Index²²⁴
- Pain Bothersomeness Index²²⁴
- The use of opioid medication²²⁴

- Function:
 - 5-item walking–bending subscale from the AIMS2 (AIMS2-WB) transformed into scores on a scale from 0 to 100, with higher scores indicating more limited function²²²
 - 10-item physical function subscale from the SF-36 (SF-36-PF) transformed into scores on a scale from 0 to 100, with higher scores indicating better function. As an objective measure, they devised the Physical Functioning Scale (PFS) to record the amount of time in seconds that a patient required to walk 30 m (100 ft) and to climb up and down a flight of stairs as quickly as possible. Longer times indicate poorer functioning.²²²
 - Study of Osteoporotic Fractures–Activities of Daily Living (SOF–ADL) scale.²²⁴

- Quality of life:
 - Quality of Life Questionnaire of the European Foundation for Osteoporosis (QUALEFFO), a 41-item vertebral-fracture–specific and osteoporosis-specific questionnaire (in which scores range from 0 to 100, with lower scores indicating a better quality of life).²²³
 - Assessment of Quality of Life (AQoL) questionnaire, a well-validated instrument that is sensitive to changes in the frail elderly (scores range from 0 to 1, with 1 indicating perfect health and 0.06 representing the minimal clinically important difference).²²³
 - European Quality of Life–5 Dimensions (EQ–5D) scale (scores range from 0 to 1, with 1 indicating perfect health and 0.074 representing the minimal clinically important difference).^{223,224}

- Disability:
 - Modified 23-item version of the Roland–Morris Disability Questionnaire (RDQ) in which scores range from 0 to 23, with higher numbers indicating worse physical

functioning, and 2 to 3 points representing the minimal clinically important difference.^{223,224}

- Adverse events:
 - Adverse events, including incident clinical fractures, were assessed at each time point with the use of open-ended questions.²²³

- Perceived recovery:
 - Self-report scale: With respect to pain, fatigue, and overall health was measured on 7-point ordinal scales ranging from “a great deal worse” to “a great deal better.” Responses of “moderately better” or “a great deal better” were classified as successful outcomes.²²³

- General health:
 - Physical Component Summary (PCS) subscale of the self-administered Medical Outcomes Study 36-Item Short-Form General Health Survey (SF-36) version 2. The PCS assesses limitations in self-care and physical, social, and role activities; bodily pain and perceived health.²²⁴
 - Mental Component Summary (MCS) subscale of the self-administered Medical Outcomes Study 36-Item Short-Form General Health Survey (SF-36), version 2. The MCS provides an indication of psychological distress and social and role disability because of emotional problems.²²⁴

The 3 outcomes measures of pain, disability and quality of life used the same measurement tools. Although 2 studies utilized the NRS to measure pain, the studies varied in their report of the pain rating period, over the course of a previous week²²³ to average back-pain intensity during the preceding 24 hours,²²⁴ thus nullifying the ability to compare the outcomes of the 2 studies.

The initiation, frequency and duration of the measurements of the outcomes varied considerably between the studies. Outcomes measures were initiated as soon as 3 days after surgery²²⁴ and as late as 2 weeks after surgery.²²² Moseley obtained outcomes more frequently with 7 measurements over a 2 year span²²², while the 2 vertebroplasty studies reported on measurements at 4 intervals.^{223,224} The duration of outcome measure reporting ranged from 3 months²²⁴ to 2 years.²²²

4.3.2.9 Effectiveness of sham surgery in orthopedics

Data gained from the RCTs could not be pooled because of the heterogeneity of the outcome measures and comparison groups. Results are reported in narrative form and summarized in Table 4.4.

Table 4.4: Efficacy of sham surgery in orthopedics

Outcome	Moseley 2002	Buchbinder, et al. 2009	Kallmes, et al. 2009
Decrease pain ratings	N	N	N
Improve function	N	NA	N
Improve quality of life	NA	N	N
Decrease disability	NA	N	N
Adverse events	NA	N	NA
Increase perceived recovery	NA	N	NA
Improve general health	NA	NA	N



Indicates sham surgery was superior to real surgical procedure



Indicates sham surgery and the real surgical procedure has similar outcomes



Indicates real surgical procedure was superior to sham surgery

NA Not applicable

All 3 studies in this review examined sham surgery's effect on pain.²²²⁻²²⁴ Methodological quality of the 3 studies addressing pain was scored at 14 out of 16 (very good).

- A sham knee arthroscopy is just as effective as lavage and debridement in reducing knee pain at 1 and 2 years after the surgery (mean [±SD] KSPS scores) 48.9±21.9, 54.8±19.8, and 51.7±22.4, respectively; P=0.14 for the comparison with the lavage group, and P=0.51 for the comparison with the debridement group or at 2 years (mean KSPS scores) 51.6±23.7, 53.7±23.7, and 51.4±23.2, respectively; P=0.64 and P=0.96, respectively.²²²

- A sham knee arthroscopy is just as effective as lavage ($P=0.37$) and debridement ($P=0.75$) in reducing arthritis pain (AIMS2-P) two years after surgery.²²²
- In patients undergoing vertebroplasty for osteoporotic fracture, sham vertebroplasty surgery is just as effective as the actual vertebroplasty in reducing overall pain rating 3 months following the surgery.²²³ Mean reductions in the score for overall pain in the vertebroplasty and placebo groups were 2.6 ± 2.9 and 1.9 ± 3.3 , respectively (adjusted between-group difference, 0.6; 95% confidence interval, -0.7 to 1.8). This finding is supported by the fact that the second RCT comparing sham vertebroplasty to actual vertebroplasty similarly showed no difference in pain ratings 3 months post intervention ($P = 0.19$).²²⁴
- In patients with osteoporotic fractures, undergoing sham vertebroplasty or actual vertebroplasty, there was a decrease use of opioid medication with no significant between-group differences: at 1 week, 1 month, 3 months and at 6 months following surgery.²²³

Two of the 3 studies in this review examined sham surgery's effect on function.^{222,224} Methodological quality of the 2 studies addressing function was scored at 14 out of 16 (very good).

- Sham knee arthroscopy is just as effective as lavage ($P=0.13$) or debridement ($P=0.11$) in improving function in patients undergoing arthroscopy at 2-year follow-up.²²²
- There is no significant difference between the sham knee arthroscopy and either lavage or the debridement in the self-reported ability to walk and bend at one year (mean AIMS2-WB scores, 49.4 ± 25.5 , 49.6 ± 29.1 , and 56.4 ± 28.4 , respectively; $P=0.98$ for the comparison with the lavage group, and $P=0.19$ for the comparison with the debridement group) or at two years (mean AIMS2-WB score, 53.8 ± 27.5 , 51.1 ± 28.3 , and 56.4 ± 29.4 , respectively; $P=0.61$ and $P=0.64$, respectively).²²²
- Objectively measured walking and stair climbing is shown to be poorer in arthroscopic debridement than in sham knee arthroscopies at two weeks (mean PFS score, 56.0 ± 21.8 vs. 48.3 ± 13.4 ; $P=0.02$) and one year (mean PFS score, 52.5 ± 20.3 vs. 45.6 ± 10.2 ; $P=0.04$) and shows a trend toward worse functioning at two years (mean PFS score, 52.6 ± 16.4 vs. 47.7 ± 12.0 ; $P=0.11$).²²²

Two of the 3 studies in this review examined sham surgery's effect on quality of life.^{223,224} Methodological quality of the 2 studies addressing quality of life was scored at 14 out of 16 (very good). Although quality of life measurements between sham vertebroplasty and actual vertebroplasty fail to reach clinically important difference (95% CI), one week after sham

vertebroplasty, patients in the sham surgery group rate their quality of life (QUALEFFO) better than patients having undergone the actual vertebroplasty procedure.²²³

Two studies examined the effect of sham surgery on disability.^{223,224} Methodological quality of the 2 studies addressing disability was scored at 14/16 (very good). Sham vertebroplasty is just as effective as actual vertebroplasty in decreasing disability. The mean (\pm SD) RDQ score in the vertebroplasty group was 12.0 ± 6.3 , as compared to 13.0 ± 6.4 in the control group (adjusted treatment effect, 0.7; 95% confidence interval [CI], -1.3 to 2.8; $P = 0.49$).²²⁴ Furthermore, the two groups did not differ in the post-specified proportion of patients who had clinically meaningful improvement in physical disability related to back pain at 1 month (40% of patients in the vertebroplasty group and 41% of patients in the control group, $P = 0.99$). There was a trend toward a higher rate of clinically meaningful improvement in pain in the vertebroplasty group than in the control group (64% vs. 48%, $P = 0.06$).²²⁴

Only one study examined the adverse events following sham surgery.²²³ Methodological quality of the study addressing disability was scored at 14 out of 16 (very good). Patients receiving sham vertebroplasty for osteoporotic fractures compared to actual vertebroplasty had no meaningful different rates in adverse events. Seven participants (three in the vertebroplasty group and four in the placebo group) reported an incident clinical vertebral fracture within 6 months after the study intervention. Three participants (one in the vertebroplasty group and two in the placebo group) reported new rib fractures at 1 week.²²³

Only one study reported on perceived recovery following sham surgery.²²³ Methodological quality of the study addressing perceived recovery was scored at 14 out of 16 (very good). No difference was found between the sham vertebroplasty procedure and actual vertebroplasty procedure.²²³

Only one study examined general health following sham surgery.²²⁴ Methodological quality of the study addressing general health was scored at 14 out of 16 (very good). No difference was found in general health between sham vertebroplasty and actual vertebroplasty.²²⁴

4.4 Discussion

Sham surgery is quite rare and marred with ethical considerations.^{214,228,230,246} To our knowledge, this is the first systematic review of the efficacy of sham surgery in orthopedics.²⁴⁶ Although care should be taken to extrapolate findings from three RCT's consisting of only two types of orthopedic surgeries, the results from this review, albeit a heterogeneous and small sample, indicate that, for orthopedic surgeries included in this review, in comparison to real surgery, sham surgery provides similar results in pain and disability. The results indicate that sham surgery in orthopedics lead to real changes in patients, similar to the real surgical intervention. For the 163 patients involved in the 3 separate studies, those who underwent a sham orthopedic procedure reported outcomes similar to those who had the real surgical intervention. The findings from this review concurs with findings in sham surgery for ligation of the internal mammary artery,²¹⁷ Parkinson's disease^{215,218} and Meniere's disease.²¹⁹⁻²²¹

Orthopedics is based on a biomedical model focusing on tissues and tissue injury.^{114,196,197} The biomedical model seeks to find the anatomy or biomechanics at fault. If the faulty biomechanics or pathoanatomy are corrected, in this case surgically, it is expected that the pain and disability will be resolved.^{114,196,197} In all 3 studies included in this review, the authors described detailed procedures to ensure patients would not become aware they were in the sham surgery group, including sounds, duration of procedures, smells and rehabilitation. Apart from the apparent process of ensuring blinding, it could also be argued that the sounds, smells and experiences were interpreted by the patients as actual parts of the procedure correcting the anatomical fault implicated in their pain; in this case, debridement of a painful knee or providing support to osteoporotic vertebral bodies with the injection of polymethylmethacrylate (PMMA).

Pain is complex and recent authors have highlighted the fact that pain could possibly be a better measure of potential threat, rather than true tissue health.^{67,82,232,233} The larger the threat, the higher the pain perceived.⁸² Since patients view pain traditionally as an indicator of tissue health and the potential that activity may further damage their tissue and thus increase pain, decreased physical movements may be seen as a logical protective mechanism.²³³ The surgical experience may likely be interpreted by the patient's brain as the process of correcting faulty tissue, thus upon completion, the perception of a painful, movement limiting fracture or arthritic knee is re-evaluated by the brain, resulting in decreased pain and increased function. The hypothesis that sham surgeries in this review likely altered a patient's perception of the health of their tissues concurs with a study where

patients undergoing lumbar discectomy who were shown and given the disc fragment had superior postoperative results compared to traditional discectomy.²⁴⁷ The authors reasoned that patients who saw the disc fragment received visual confirmation that the surgery was successful, not unlike the visual, auditory and sensory and physical stimuli produced during the sham procedures, thus providing perception of a technically successful surgery. Furthermore, the finding of this review is supported by recent research evaluating the effect of a cognitive educational approach of explaining pain and pain processing to patients utilizing neurobiology and neurophysiology.^{67,202,212} These sessions, by focusing on and explaining peripheral and central sensitization, nociception and pain processing, aim to alter a patient's view of his or her tissues.^{67,202,212} This reconceptualization of pain and the health of their tissues allow patients to report less pain, improve movement, decrease fear and decrease brain activity.^{67,202,212} This finding is strengthened by the fact that patients report change in pain and move physically better after education only with no physical interventions.⁷⁹

4.5 Limitations

This systematic review has limitations that need to be acknowledged. The review is limited by the number of studies. Furthermore, this review contains patients having undergone knee arthroscopy and vertebroplasty, and carry-over of the results to other more comprehensive and common orthopedic surgeries such as knee and hip replacement or rotator cuff repairs are limited. The heterogeneous nature of studies in this review precluded true meta-analyses, which would have been helpful to determine the effectiveness of sham surgery in orthopedics. Additional limitations could be that English-only studies and specific patient populations were included, as well as excluding younger patients.

4.6 Conclusion

The results of this systematic review provide preliminary evidence that sham surgery in orthopedics may provide results similar to the actual surgical interventions.²²²⁻²²⁴ Even though sham surgery remains controversial; the fact that sham surgery yields similar results to real surgery in orthopedics highlights the powerful contributions of the brain to pain modulation. Orthopedics follow a biomedical model of pain, thus having patients believe that altered anatomy or biomechanics will alter pain and disability. Sham surgery tests this hypothesis successfully, showing that patients who gain a belief that faulty tissues have been surgically corrected, experience the same relief as patients who undergo real surgical correction of proposed altered tissues.

Chapter 5:

Systematic Review: The Effect of Neuroscience Education on Pain, Disability, Anxiety, and Stress in Musculoskeletal Pain

This chapter is adapted from: Louw A, Diener I, Butler DS, Puentedura EJ. *The effect of neuroscience education on pain, disability, anxiety, and stress in chronic musculoskeletal pain. Archives of Physical Medicine and Rehabilitation. Dec 2011;92(12):2041-2056.* The referencing format and headings/subheadings from the original publication have been modified and the headings within the chapter have been numbered for consistency throughout the thesis.

5.1 Introduction

Pain is a powerful motivating force that guides treatment-seeking behaviors in patients.^{56,248,249} Patient education has long been explored in the management of pain, anxiety and stress associated with low back pain (LBP).⁵⁹⁻⁶² In the orthopedic domain, there are a number of studies on the effect of patient education on pain with outcomes ranging from “excellent”⁶³ to “poor.”^{64,65} The study by Udermann et al⁶³ demonstrated that introduction of an individualized educational booklet on back biomechanics can result in decreased pain and frequency of LBP episodes in patients with chronic LBP (CLBP). In contrast to those findings, two systematic reviews on the effect of individualized and/or group education for LBP and mechanical neck pain showed little efficacy for such education.^{64,65}

Most education programs used in orthopedic patient populations utilized anatomical and biomechanical models for addressing pain,^{59,66,67,79,250} which not only has shown limited efficacy,^{59,66,69,70,250} but may even have increased patient fears, anxiety and stress, thus negatively influenced their outcomes.^{66,71-73} Several educational strategies are advocated for patients with LBP, including biomechanical/back school type of education; evidence-based guideline education (i.e., the Back Book²⁵¹), cognitive behavioral therapy (CBT) and recently, neuroscience education (NE).

NE can be best described as an educational session/s describing the neurobiology and neurophysiology of pain, and pain processing by the nervous system. Instead of a traditional model of connecting tissue injury or nociception and pain, NE aims to describe how the nervous system, through peripheral nerve sensitization, central sensitization, synaptic activity and brain processing interprets information from the tissues and that neural activation, as either up-regulation or down-regulation, has the ability to modulate the pain

experience. Patients are thus educated that the nervous system's processing of their injury, in conjunction with various psycho-social aspects, determines their pain experience and that pain is not a true representation of the status of the tissues. By reconceptualizing their pain as the nervous system's interpretation of the threat of the injury, rather than an accurate measure of the degree of injury in their tissues, the patient may be more inclined to move, exercise and push into some discomfort. Depending upon the timing of its administration, NE may be viewed as a preventative measure in acute pain situations and as a treatment/rehabilitation intervention in chronic pain situations.

Research into educational strategies for patients with CLBP shows an increased use of NE.^{77,79,82,202} NE, a cognitive based education intervention aiming to reduce pain and disability by helping patients gain an increased understanding of the biological processes underpinning their pain state,²⁵² differs from traditional education strategies such as back school and biomechanical models, by not focusing on anatomical or biomechanical models, but rather on neurophysiology, neurobiology and the processing and representation of pain.^{82,212,252} Patients are interested in knowing more about pain,⁵⁶ and it has been demonstrated that patients are capable of understanding the neurophysiology of pain, while professionals have underestimated patients' ability to understand the "complex" issues related to pain.²⁵³ Studies which utilized NE have been shown to decrease fear and positively change a patient's perception of their pain⁷⁷ and have an immediate effect on improvements in patients' attitudes about pain.⁶⁷ This education intervention also resulted in improvements in pain, cognition and physical performance,⁷⁹ increased pain thresholds during physical tasks,²⁰² improved outcomes of therapeutic exercises,⁸¹ and significant reduction in widespread brain activity characteristic of a pain experience.⁸² In one NE study, results extended beyond the short term and were maintained at one-year follow-up.⁸¹

Despite the proposed positive effects reported as a result of NE and the apparent increased use of NE, no published review could be found on the efficacy, content and delivery methods of NE. Therefore, the objective of this systematic review was to source and critically evaluate NE. The results of this review could be used to make evidence-based recommendations regarding the utilization of NE for pain, disability, anxiety and stress in musculoskeletal (MSK) pain. Additionally, the summary of the content and delivery methods from this review pertaining to NE will be utilized to develop the preoperative neuroscience educational tool for LS in the final trial of this research study.

5.2 Methods

5.2.1 Search strategy

An electronic search was performed between February 2010 and July 2010, covering the last decade (1999 – 2010) from the following databases: Biomed Central, BMJ.com, CINAHL, the Cochrane Library, NLM Central Gateway, OVID, ProQuest (Digital Dissertations), PsycInfo, PubMed/Medline, ScienceDirect and Web of Science. Each database has its own indexing terms and functions, and therefore different search strategies were developed for each database by the authors. The main search items were *neuroscience, neurobiology, neurophysiology, pain, pain education, pain science, education, stress* and *anxiety*. In PubMed, medical subject headings (MeSH) terms were used where possible, with Boolean operators. The search strategies for remaining databases included synonyms of the main search items. Secondary searching (PEARLing) was undertaken, whereby reference lists of the selected articles were reviewed for additional references not identified in the primary search. The titles and abstracts of all the identified literature were screened by one primary reviewer using the inclusion criteria below. The full text of all potentially relevant articles were retrieved and screened by two reviewers using the same criteria, in order to determine the eligibility of the paper for inclusion in the review.

5.2.2 Inclusion criteria

All titles and abstracts were read to identify relevant papers. Papers were included in this systematic review if they met the inclusion criteria listed in Table 5.1. Although outcome measures aimed at addressing MSK pain, disability, anxiety and stress were included, no parameters were set on the exact measurement tools used to assess the effect of NE on pain, disability, anxiety, and stress, since a wide variety of outcome measures were used in the studies. When there was uncertainty regarding the eligibility of the paper from the abstract, the full text version of the paper was retrieved and evaluated against the inclusion criteria. The full text version of all papers that met the inclusion criteria were retrieved for quality assessment and data extraction.

Table 5.1: Inclusion criteria used in the systematic review: Neuroscience education

Criterion	Justification
English Language	Major journals in this area are published in this language.
1999 – 2010	Ten years captures the most recently used treatments in clinical practice. First such study to be published was by Moseley in 2002. ²⁷
Humans over 18 years of age	This increased the homogeneity of participants between studies and educational needs are different for infants, adolescents and teenagers. ^{49,188}
Musculoskeletal pain	This increased the homogeneity of conditions being managed with educational strategies incorporating NE.
Quantitative study design including randomized controlled trials (RCTs), non-randomized clinical trials or case series	Study designs other than RCT were included in this review as they provide complimentary and relevant clinical detail to the current state of our knowledge and its limitations. ^{254,255} Single case studies were not included because of the low level of evidence they provide.
Neuroscience Education (NE)	Patient education is widely used to address pain, anxiety, and stress, but this review focused on educational strategies incorporating NE.
Outcomes: Pain, Disability, Anxiety and Fear	The primary outcome measures chosen for this review were pain, disability, anxiety, and fear. No limitations were set on the measurement tool used to examine the effect of NE on pain, disability, anxiety, and fear.

5.2.3 Quality assessment

Critical appraisal of each included study was conducted by determining:

- The level of evidence on the Australian National Health and Medical Research Council (NHMRC) Hierarchy of Evidence (Australian National Health and Medical Research Council, 1999). (Table 5.2) This provides a broad indication of bias based on study design. Studies higher on the hierarchy potentially contain less bias than those that are lower on the hierarchy.

Table 5.2: Hierarchy of evidence; Study design, based on the Australian National Health and Medical Research Council Hierarchy of Evidence (Australian National Health and Medical Research Council, 1999)

Level	Definition	Studies
I	Evidence obtained from a systematic review of all relevant randomized controlled trials	
II	Evidence obtained from at least one properly-designated randomized controlled trial	Ryan, et al ²⁵² ; Meeus, et al ²¹² ; Moseley ⁷⁹ ; Moseley, et al ²⁰² ; Moseley ⁸¹ ; Moseley ⁷⁷
III-1	Evidence obtained from well-designed pseudo-randomized controlled trials (alternate allocation or some other method)	Moseley ²⁵³
III-2	Evidence obtained from comparative studies (including systematic reviews of such studies) with concurrent controls and allocation not randomized, cohort studies, case-control studies, or interrupted time series with a control group	
III-3	Evidence obtained from comparative studies with historical control, two or more single arm studies, or interrupted time series without a parallel control group	Van Oostervijk, et al. ²⁰³
IV	Evidence obtained from case series, either post-test or pre-test/post-test	

- The methodological quality of each study was assessed using the Critical Review Form – Quantitative studies.²³⁴ This tool can be used to appraise all types of quantitative studies ranging from RCTs to case series. Thus all quantitative studies on NE for pain, disability, anxiety, and stress were included in this review and evaluated for quality using the same tool. This made the quality of results comparable between the different study designs.²³⁵ Standardized guidelines on the interpretation and scoring of each item were used.²³⁶ Items were scored as 1 (completely fulfills the criterion) or 0 (does not completely fulfill the criterion). The scores of the 16 closed-ended questions were tallied to provide an overall score of quality, where the maximum score of 16 indicated excellent quality.²³⁷ Two researchers independently scored the studies and where disagreement occurred, consensus was achieved by discussion. Quality scores were arbitrarily divided into 5 categories: poor (score ≤ 8), fair (score = 9–10), good (score = 11–12), very good (score

= 13–14) and excellent (score ≥ 15).²³⁸ The Critical Review Form – Quantitative studies²³⁴ includes 17 of the 22 items that are contained in the CONSORT statement.^{239,240} It does not include items 1 (study design stated in title or abstract), 8, 9 and 10 (randomization: sequence generation, allocation concealment and implementation respectively) or 19 (adverse events). The CONSORT statement was not designed to evaluate methodological quality.²³⁹ However, in this review, it was documented whether these 5 CONSORT criteria were fulfilled by the RCTs. This step provides further methodological quality information.

5.2.4 Outcome assessment

To determine the possible influence of NE on pain, disability, anxiety, and stress for MSK pain, results were posted in narrative form and outcomes were defined as “positive” (experimental group obtained a significantly greater improvement than the control group); “neutral” (there were no statistically significant differences between the groups); or “negative” (the control group obtained a significant greater improvement than the experimental group). An alpha of $p < .05$ was used to define a significant outcome measure. This method, used in previous systematic reviews, demonstrated 4 levels of scientific evidence on the quality and the outcome of the trials.^{241,242}

- *Strong evidence*: multiple, relevant, high-quality randomized controlled trials with generally consistent outcomes.
- *Moderate evidence*: one relevant, high-quality randomized controlled trial AND one or more relevant, low-quality randomized controlled trials with generally consistent outcomes.
- *Limited evidence*: one relevant, high-quality randomized controlled trial OR multiple relevant low-quality randomized controlled trials with generally consistent outcomes.
- *Inconclusive evidence*: only one relevant, low-quality randomized controlled trial, no relevant randomized controlled trials or randomized trials with inconsistent outcomes.

A study was considered “relevant” when at least one of the outcome measures concerned pain or disability. For being “generally consistent,” at least 75% of the trials that analyzed the same NE had to have the same result (“positive”, “neutral”, or “negative”).

5.2.5 Data extraction

Data were extracted by the authors using the PICO approach.¹⁷⁸

- *Participants*: diagnosis treated; age; sex; duration of the symptoms; type of referral source and diagnostic criteria.
- *Interventions*: type; intensity; duration; educational tools/props; in combination or stand-alone physiotherapy.
- *Comparison*: to another treatment, no treatment or “usual” treatment.
- *Outcomes*: domains and tools used to measure the effects of the intervention. Outcomes chosen for this review included pain, disability, anxiety, and stress.

Data on the effectiveness of the NE were also extracted for each study. To determine the effect of the NE on each outcome measure, the mean and 95% confidence intervals for the between-group differences were calculated for RCTs and comparative studies, based on the results provided in each article.²⁴³ Moreover the mean changes between pre- and post-treatment (and 95% confidence intervals) were calculated for the RCTs and comparative studies. Pain reduction of more than 20%, irrespective of the measurement tool used, was considered clinically worthwhile.^{244,245} It was expected that there would be heterogeneity in participants, interventions, comparisons, and outcomes. Therefore the results of the studies were synthesized in a narrative format.

5.3 Results

5.3.1 Search strategy yield

Initially 15,382 hits were gained from databases and secondary searches. After review of the titles and abstracts, those articles that did not meet the inclusion criteria were removed. After reviewing 779 abstracts, the full text of 43 articles were reviewed. Upon further review, duplicates were removed, leaving 8 studies for the systematic review. This systematic review is based on 8 published studies.^{77,79,81,202,203,212,252,253} (Figure 5.1)

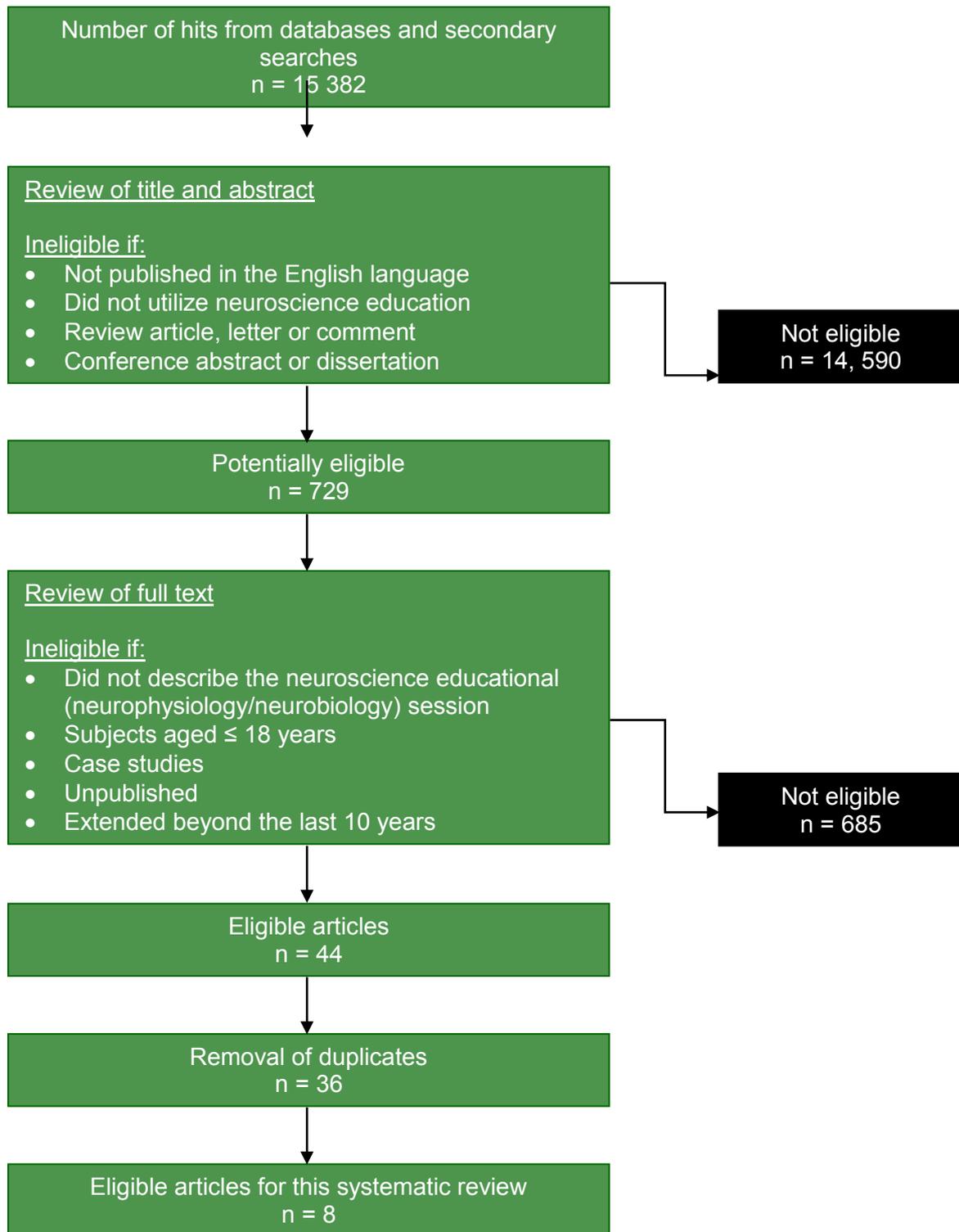


Figure 5.1 Retrieval and review process: Sham surgery in orthopedics

5.3.2 Critical appraisal

5.3.2.1 Hierarchy of Evidence

There were 6 RCTs,^{77,79,81,202,212,252} 1 pseudo-randomized controlled trial²⁵³ and 1 comparative study.²⁰³ (Table 5.2)

5.3.2.2 Methodological quality

There was 100% agreement in scoring between the researchers conducting the systematic review. Variation in methodological quality was noted (Table 5.3), with scores ranging from 11 to 15 (mean = 13/16). The majority of papers were “good” in quality; two were “very good” and two were “excellent”. No papers were rated as “poor” or “fair”. Table 5.3 provides details regarding the criteria that were fulfilled on the Critical Review Form – Quantitative studies.²³⁴ It demonstrated that all studies provided adequate detail to allow for reproduction of their intervention (criterion 10). Six studies reported on the reliability of all their measurement tools (criterion 9), and 1 justified sample size (criterion 6). All studies were free from major biases (criterion 4) and 5 studies reported on the validity of all their measurement tools (criterion 8).

5.3.2.3 CONSORT criteria 1, 8, 9, 10 and 19

Table 5.3 also provides details regarding the fulfillment of the CONSORT criteria. Only about half of the studies complied with item 9 by reporting the method used to implement random allocation sequence. Four studies^{81,202,212,252} complied with item 10 by reporting who generated the allocation sequence, enrolled participants and assigned participants to their groups. No studies complied with item 19 by reporting whether there were any adverse events in the intervention group.

Table 5.3 Study quality of the randomized controlled trials (n = 8) using the CONSORT statement^{239,240}

#	Criterion – Critical Review Form	Moseley 2002	Moseley 2003	Moseley 2003b	Moseley 2004a	Moseley et al 04b	Ryan et al 2010	Meeus et al 2010	Van Ooster-vijk et al 2011	Total
1	Purpose clearly stated	1	1	1	1	1	1	1	1	8
2	Literature review relevant	1	1	1	1	1	1	1	1	8
3	Study design appropriate to study design aims	1	1	1	1	1	1	1	1	8
4	No biases present	0	0	0	0	0	0	0	0	0
5	Sample description in detail	1	1	1	1	1	1	1	1	8
6	Sample size justified	0	0	0	0	0	0	1	0	1
7	Informed consent gained	0	1	0	1	0	1	1	0	4
8	Validity of outcome measures used	0	0	0	1	1	1	1	1	5
9	Reliability of outcome measures used	0	0	1	1	1	1	1	1	6
10	Intervention described in detail	1	1	1	1	1	1	1	1	8
11	Statistical reporting of results	1	1	1	1	1	1	1	1	8
12	Appropriate statistical analysis	1	1	1	1	1	1	1	1	8
13	Clinical importance reported	1	1	1	1	1	1	1	1	8
14	Appropriate conclusions	1	1	1	1	1	1	1	1	8
15	Clinical implications reported	1	1	1	1	1	1	1	1	8
16	Study limitations acknowledged	1	1	1	1	1	1	1	1	8
	TOTAL	11	12	12	14	12	15	15	13	
	Quality category*	Good	Good	Good	Very good	Good	Excellent	Excellent	Very Good	
	Criterion – CONSORT statement**									
1	Study design stated in the title or abstract	X	X	X	X	√	√	√	X	
8	Randomization: sequence generation	√	X	X	X	√	√	X	X	
9	Randomization: allocation concealment	√	X	√	X	√	√	√	X	
10	Randomization: implementation	√	X	X	X	√	√	√	X	
19	Adverse events	X	X	X	X	X	X	X	X	

* Quality category: poor (score ≤ 8); fair (score = 9-10); good (score = 11-12); very good (score = 13-14) and excellent (score = 15 – 16).²³⁸

** √ = criterion fulfilled; x = criterion not fulfilled

5.3.2.4 Naming the intervention

NE is new and described as an educational intervention which aims to reduce pain and disability by explaining the biology of the pain experience to a patient.^{82,252} In this review, it is noteworthy that the intervention of explaining the biological process behind a patient's pain state is described differently by the different authors:

- *Neurophysiology of pain* education^{81,202,253}
- *Pain physiology* education^{77,79,212}
- *Pain biology* education²⁵²
- *Pain neurophysiology* education²⁰³

5.3.2.5 Patient characteristics

In this review, NE was administered to 401 patients, of which 63% were women (n = 252). The average age of the patients ranged from 24 ± 10 years²⁰² to 45.5 ± 9.5 years²⁵² with a mean age (calculated as the mean of the mean reported ages) of the patients receiving NE as 38.2 years. NE was applied to patients with LBP, chronic fatigue syndrome (CFS), widespread pain and chronic whiplash associated disorders (WAD). The LBP studies primarily focused on CLBP, with average duration of symptoms ranging from 13.7 ± 10.2 months²⁵² to 48 ± 18 months,²⁵³ with an average duration (calculated as a mean of the mean scores) of 31.2 months.

5.3.2.6 Content of NE

Details of the specific content of the educational sessions used in the studies are found in Table 5.4. In summary, NE session contents included:

- Neurophysiology of pain^{77,79,81,202,203,212,252,253}
- No reference to anatomical or pathoanatomical models^{81,202}
- No discussion of emotional or behavioral aspects of pain²⁰²
- Nociception and nociceptive pathways^{79,202,203}
- Neurons^{79,203}
- Synapses^{79,202,203}
- Action potential^{79,203}
- Spinal inhibition and facilitation^{79,202,203}
- Peripheral sensitization^{79,202,203}
- Central sensitization^{79,202,203}
- Plasticity of the nervous system^{202,203}

It is also noteworthy that 4 studies^{79,203,212,252} refer directly to the text, *Explain Pain*, as a source of the content of the NE utilized in their studies.

Table 5.4: Participants, interventions, controls and outcomes in the reviewed studies: Neuroscience education

Author	Participants			Interventions		Outcomes	
	n	Sample characteristics	Diagnostic criteria	Treatment	Control	Outcome instruments	Time of assessment
Moseley 2002	57	<ul style="list-style-type: none"> • LBP > 2 months; • Women = 59%; • Age (years): EG* 43 ± 7 and CG** 38 ± 7; • Duration of symptoms (months): EG = 39 ± 18 and CG 37 ± 12. 	NA	<p>Two physiotherapy sessions per week for 4 weeks; Manual therapy including mobilization and manipulation, soft tissue massage, muscle and neural-mobilization techniques, but no electrophysical modalities; Specific trunk stabilization program; Maintain home exercises indefinitely;</p> <p>One hour educational session once a week for four weeks; One-on-one education format by an independent therapist; Content = neurophysiology of pain with no reference to lumbar spine; Accompanied by workbook with one page of revision material and three comprehensive exercises per day for 10 days.</p>	<p>Ongoing medical care as advised by their general practitioner.</p> <p>No attendance of physiotherapy;</p>	<ul style="list-style-type: none"> • Numeric rating scale (NRS); meaningful difference set at 2 points; • Roland Morris Disability; Questionnaire (RMDQ); meaningful difference set at 4 points; • Numbers needed to treat (NNT) 	<p>Baseline; one month after intervention and one year after intervention</p>

Moseley 2003a	276	<p><u>Patients:</u></p> <ul style="list-style-type: none"> • Women = 61% (trained group); women = 68% (untrained group); • Age (years): trained group 43 ± 9 and untrained group 37 ± 17. • Duration of pain (years): trained group = 4 ± 1.5 and untrained group = 3 ± 1 	NA	<p><u>Patients:</u> Direct lecture from a specifically trained physiotherapist; Hand-drawn images; Neurophysiology of pain; <u>Professionals:</u> Seminar on neurophysiology of pain – 3 hours in AV format provided by a physiotherapist;</p>	None	<ul style="list-style-type: none"> • Neuro-physiology of pain questionnaire 	<p><u>Trained group:</u> Immediately following the educational session; <u>Untrained group:</u> questionnaire before and after the educational session.</p>
	288	<p><u>Professionals:</u></p> <ul style="list-style-type: none"> • 21 exercise therapists; • 30 medical practitioners; • 36 nurses; • 44 occupational therapists; • 44 psychologists; • 57 physiotherapists • 28 rehabilitation counselors. 					

Moseley 2003b	41	<ul style="list-style-type: none"> • LBP > 3 months • Women = EG 67% and CG = 60%. • Age (years): EG = 40 ± 7 years and CG = 42 ± 7 years. • Duration of symptoms (months): EG = 33 ± 11 and CG = 30 ± 14 	NA	Individual 4 x 1 hour educational session on the physiology of pain and injury by a physiotherapist; Additionally received 2 physiotherapy sessions per week for 4 weeks focusing on spinal stabilization exercises	Group session involved a single 4-hour session with a group of 7 – 10 patients provided by a physiotherapist; Physiology of pain and injury; Additionally received 2 physiotherapy sessions per week for 4 weeks focusing on spinal stabilization exercises	<ul style="list-style-type: none"> • Numeric rating scale (NRS) • Roland Morris Disability Questionnaire (RMDQ) • Numbers needed to treat (NNT) 	Baseline; One month following “ongoing medical treatment” and 1 month and 2 months after educational and physiotherapy sessions
Moseley 2004a	121	<ul style="list-style-type: none"> • LBP > 4 months. • Women: EG 50% and CG 65%. • Age (years): EG 36 ± 6 and CG 35 ± 7 	NA	Single one-on-one educational session by a physiotherapist; Physiology of pain and nociception; <ul style="list-style-type: none"> - The neuron: receptor; axon; terminal - The synapse: neurotransmitters; chemically driven ion channel; post-synaptic membrane potential; action potential - Spinal and descending inhibition and facilitation - Peripheral sensitization - Central sensitization: potentiation of the post-synaptic membrane; altered genetic expression and receptor field growth. 	Single one-on-one educational session by a physiotherapist: Anatomy and physiology of the lumbar spine; <ul style="list-style-type: none"> - The intervertebral disc: structure and physiology and the effect of aging; - Vertebral canal and intervertebral foramen: thecal sac, spinal nerve root, ligamentum flavum - The facet joint: anatomy and biomechanics - The muscles: anatomy, 	<ul style="list-style-type: none"> • Brief survey of pain attitudes (SOPA(R)) • Pain catastrophizing scale (PCS) • Straight leg raise (SLR) (inclinometer) • Forward bending test (tape measure – longest finger to floor in flexed position) 	Baseline data; Pre-education and immediate post-education

				<p>Lectures accompanied by hand-drawings and prepared pictures with interactive commentary.</p> <p>Sessions lasted approximately 3 hours.</p>	<p>physiology, antagonist and synergistic roles</p> <p>- Spinal biomechanics: curvatures, posture and ergonomics.</p> <p>Lectures accompanied by hand-drawings and prepared pictures with interactive commentary.</p> <p>Sessions lasted approximately 3 hours.</p>		
Moseley et al 2004b	58	<ul style="list-style-type: none"> • LBP > 6 months; • Age (years): EG = 24 ± 10 and CG = 45 ± 6 • Duration of pain (months): EG = 18 ± 11 and CG = 20 ± 11 	NA	<p>Education session by a physiotherapist in 1-to-1 seminar format; Session lasted 3 hours; Diagrams and hypothetical examples used as teaching tools; At conclusion: Workbook with 10 sections; Patients asked to read one section per day and answer 3 questions on each session;</p> <p><u>Neurophysiology Education:</u></p> <p>No specific application was made to the lower back, or to emotional and behavioral patterns commonly associated with chronic pain such as catastrophic thought processes or fear avoidance.</p>	<p>Education session by a physiotherapist in 1-to-1 seminar format; Session lasted 3 hours; Diagrams and hypothetical examples used as teaching tools; At conclusion: Workbook with 10 sections; Patients asked to read one section per day and answer 3 questions on each session;</p> <p><u>Back Education:</u></p> <p>Anatomy and physiology of the bones and joints of the lumbar spine; the</p>	<ul style="list-style-type: none"> • Roland Morris Disability Questionnaire (RMDQ) • Brief Survey of Pain Attitudes (revised) (SOPA(R)) • Pain Catastrophization Scale (PCS) • Straight Leg Raise (SLR) (inclinometer) • Forward Bending Range 	Pre-treatment; 3 weeks;

			<p>The Nervous System</p> <p>Presentation of the basic structure of the nervous system, with a focus on the components of the nociception/pain pathways. This section included an outline of the functional significance of each component.</p> <p>Synapses</p> <p>Presentation of how nerves “talk to each other,” including the concept of “chemicals” (neurotransmitters), postsynaptic receptors, and a conceptual “volume knob” (postsynaptic excitation and inhibition), with a special focus on the “danger messenger nerve” (second order nociceptive neuron).</p> <p>Plasticity of the Nervous System</p> <p>The adaptability of the nervous system including: afferent and efferent pathways; the variable state of neural structures including normal state, peripheral, and central sensitization; receptor synthesis; axonal sprouting; the neural response to inactivity; and movement control.</p>	<p>intervertebral disc; the trunk and back muscles; normal spinal curves; posture and movements, including analysis of postures and activities according to intra-discal pressures and joint forces; lifting techniques and lifting loads; lifting aids and ergonomics advice; principles of stretching; and strength, endurance, and fitness training. It did not include information about the nervous system, except for outlining the location and course of the spinal cord and the spinal nerve roots. It was similar to education material that has been researched elsewhere and the education components of back schools and functional restoration programs.</p>	<p>(Distance from longest finger to floor)</p> <ul style="list-style-type: none"> • Abdominal Draw In Task (ADIT) 	
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<p>Ryan et al 2010</p>	<p>38</p>	<ul style="list-style-type: none"> • LBP > 3 months; <p><u>Education group:</u></p> <ul style="list-style-type: none"> • (n = 18) • 11 women; • Age (years) = 45.5 ± 9.5 • Duration of pain (months) = 13.7 ± 10.2; <p><u>Education and exercise group:</u></p> <ul style="list-style-type: none"> • (n = 20) • 14 women; • Age (years) 45.2 ± 11.9 • Duration of pain (months) = 7.6 ± 7. 	<p>NA</p>	<p><u>Pain Biology Only:</u></p> <p>2.5 hour pain biology education session;</p> <p>Cognitive behavioral intervention focused on reshaping the participant's beliefs and attitudes about their back pain, attempting to decrease fear avoidance and harm beliefs, increase self-efficacy, and decrease avoidance behavior.</p> <p>The biology of pain;</p> <p>Verbal communication, prepared diagrams and free-hand drawings;</p> <p>Additionally, all participants received "The Back Book"</p>	<p><u>Pain Biology and Exercise:</u></p> <p>2.5 hour pain biology education session;</p> <p>Cognitive behavioral intervention focused on reshaping the participant's beliefs and attitudes about their back pain, attempting to decrease fear avoidance and harm beliefs, increase self-efficacy, and decrease avoidance behavior.</p> <p>The biology of pain;</p> <p>Verbal communication, prepared diagrams and free-hand drawings;</p> <p>Additionally, all participants received "The Back Book"</p> <p><u>Exercise component:</u></p> <p>"Back to Fitness exercise classes"; Six classes, one a week for six weeks. The classes involved circuit based, graded, aerobic exercise with some core</p>	<ul style="list-style-type: none"> • Roland Morris Disability Questionnaire (RMDQ) • Numeric Rating Scale (NRS) • Repeated sit-to-stand test • The fifty foot walk test • 5 minute walk test • Tampa Scale of Kinesiophobia (TSK-13) • Pain Self Efficacy Questionnaire (PSEQ) • Step count (activPAL™ activity monitor) 	<p>Pre-treatment and eight weeks later;</p> <p>Three months later;</p>
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					<p>stability exercises.</p> <p>The classes involved a warm-up phase (10 min), an aerobic phase (20-30 min), and a warm-down phase (10-15 min). The aerobic phase involved circuit based exercise.</p> <p>For most exercises there was an easy, moderate, and hard version, and the participant could choose which version to perform.</p>		
Meeus et al 2010	46	<ul style="list-style-type: none"> • Chronic fatigue syndrome and widespread pain; • Women: EG = 22 and CG = 18; • Age (years): EG = 38.3 ± 10.6 and CG = 42.3 ± 10.2 	1994 Centers for Disease Control and Prevention criteria for CFS ²⁵⁶	<p>Pain Physiology:</p> <p>One 30 minute interactive session; Physiology of the nervous system in general and of the pain system in particular.</p> <p>The theoretic information was illustrated with pictures and examples.</p> <p>The objective of the education was to teach patients the function, mechanisms, and modulation of (chronic) pain, and so forth.</p>	<p>Pacing and Self-Management: One 30 minute interactive session;</p> <p>Pacing and self-management education was provided to all participants in the control group. Pacing is a strategy in which patients are encouraged to achieve an appropriate balance between activity and rest in order to avoid exacerbation and to set</p>	<ul style="list-style-type: none"> • Neurophysiology of Pain Test; • Pain Catastrophization Scale (PCS) • Pain Coping Inventory (PCI) • Tampa Scale of Kinesiophobia (TSK) • Pain Threshold Assessment (Fisher) 	Pre-treatment and immediately post-treatment

					realistic goals for increasing activity. Following this energy management strategy, patients should avoid activities at an intensity that exacerbates symptoms, or they should intersperse activities with periods of rest.	algometer)	
Van Ooster-vijk et al 2011	6	<ul style="list-style-type: none"> • Whiplash Associated Disorders (WAD) grade I – II; • 5 women and 1 man; • Mean age 35.6 years; • Mean duration of symptoms 50.3 months 	WAD I-II according to QTF-WAD	Two educational session and leaflet on the neurophysiology of pain; One-on-one education session on neurophysiology of pain lasting 30 minutes; Physiotherapist delivered the education session; Content and pictures based on the <i>Explain Pain text</i> ; Physiology of the nervous system in general and of the pain system in particular; Using pictures, examples, and metaphors; Topics addressed during the educational sessions included the characteristics of acute versus chronic pain; the purpose of acute pain; how acute pain originates in the nervous system (nociceptors, ion gates, neurons, action potential, nociception, peripheral sensitization, synapses, synaptic gap, inhibitory/excitatory chemicals, spinal	None	<p>Primary outcome measures:</p> <ul style="list-style-type: none"> • Neck Disability Index (NDI) • Pressure Pain Threshold (PPT) (Fisher algometer) <p>Secondary outcomes:</p> <ul style="list-style-type: none"> • WAD symptom list • Pain Catastrophisation Scale (PCS) • Pain Coping 	<p>A-B-C design; period A = assessment prior to intervention (2-3 weeks); Period B = intervention = 1 week; Period C = post-intervention assessment = 3 weeks; Total time = 7 weeks;</p>

			<p>cord, descending/ascending pain pathways, brain role, pain memory, and pain perception); how pain becomes chronic (plasticity of the nervous system, modulation, modification, central sensitization, pain neuromatrix theory); and potential sustaining factors of central sensitization like emotions, stress, pain cognitions, and pain behavior; Educational session in line with the content of the Neurophysiology of Pain Test in such a way that after having received the education, patients should be able to answer all questions of the test correctly; Presented the educational information verbally (explanation by the therapist) and visually (summaries, pictures, and diagrams on computer and paper). Patients also received an information leaflet about the neurophysiology of pain and were asked to read it carefully at home. During the second session, the therapist answered and explained additional questions that arose after reading the information leaflet.</p>		<p>Inventory (PCI)</p> <ul style="list-style-type: none"> •Tampa Scale of Kinesiophobia (TSK) •Neck Extension Test •VAS •Brachial Plexus Provocation Test (BPPT) 	
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* EG = Experimental group; ** CG = Control group

5.3.2.7 Professionals performing NE

NE in the reviewed studies was performed by physiotherapists. Only 1 study failed to clearly identify the professional qualifications of the educator.²¹²

5.3.2.8 Duration and frequency of NE

The duration and frequency of the NE sessions were quite varied. Educational sessions lasted as long as 4 hours,⁷⁷ while more recent studies reported sessions lasting 30 minutes.^{203,212} Educational sessions were also varied between single educational sessions^{77,79,202,212,252,253} and multiple sessions.^{77,81,203} The most common frequency between multiple educational sessions was one week apart.^{77,81,203} Considering studies varied between single educational interventions and multiple interventions, total education time was also determined. On the high end, one study spent 8 hours on NE,⁸¹ while the 2 studies with the least amount of total time only spent 30 - 60 minutes on NE.^{203,212} The remainder of the studies averaged between 2.5 and 4 hours total education time.

5.3.2.9 Educational format

The format in which the NE was delivered was primarily by means of one-on-one verbal communication^{77,79,81,202,203,212} Only 2 studies utilized group sessions.^{77,253}

5.3.2.10 Educational tools

Details of the specific educational tools used during NE sessions are found in Table 5.4. In summary, NE sessions are accompanied by:

- Prepared pictures^{79,202,203,212,252}
- Examples^{202,203,212}
- Metaphors²⁰³
- Hand drawings^{79,252,253}
- Workbook with reading/question-answer assignments^{81,202}
- Neurophysiology Pain Questionnaire²⁰³

5.3.2.11 Adjunct treatment to the NE

Several different research designs are included in this review. In all the studies, patients received various forms of other therapeutic interventions at various stages of the studies for various reasons. NE was thus preceded, combined with, or followed by, various therapeutic activities. The therapeutic activities that accompanied NE included:

- Manual therapy, including spinal mobilization and manipulation⁸¹
- Soft tissue treatment/massage⁸¹
- Neural tissue mobilization⁸¹
- Spinal stabilization exercises^{77,81,252}
- Home exercises⁸¹
- Circuit training²⁵²
- Aerobic exercise²⁵²
- None (NE only)^{79,202,203,212,253}

5.3.2.12 Use of control groups

Several different comparisons were made to groups receiving NE. Control interventions varied in the studies, and included NE sessions compared to:

- On-going medical care⁸¹
- Not attending physiotherapy⁸¹
- Health care professional knowledge of pain²⁵³
- Group session of NE⁷⁷
- Anatomy and physiology of the lumbar spine^{79,202,252}
- Back Book²⁵²
- Exercise and NE combination²⁵²
- Pacing and self-management program²¹²
- None²⁰³

5.3.3 Outcome measures

There was great variability in outcome measurements across the studies in terms of the number and type of outcome measures used and the number of occasions they were used. (Table 5.4) Researchers and clinicians utilizing NE were interested in determining if NE affected issues related to pain, disability, psychological issues associated with pain, and movement. A review of the outcome measures used in the studies revealed that most of the outcome measures fit into 1 of 4 categories:

- Outcomes directly measuring issues related to pain
 - Pain ratings (Numeric Pain Rating Scale (NPRS) and Visual Analogue Scale (VAS))^{77,81,203,252}
 - Pain knowledge (Neurophysiology of pain test)^{212,253}
 - Pressure pain thresholds (PPT)^{203,212}

- Self-report symptoms (WAD symptom list)²⁰³
- Outcomes related to function and disability
 - Roland Morris Disability Questionnaire (RMDQ)^{77,81,202,252}
 - Neck Disability Index (NDI)²⁰³
- Outcomes related to psycho-social issues
 - Tampa Scale of Kinesiophobia (TSK)^{203,212,252}
 - Pain Catastrophization Scale (PCS)^{79,202,203,212}
 - Pain Coping Inventory (PCI)^{203,212}
 - Survey of Pain Attitudes (SOPA(R))^{79,202}
 - Pain Self-Efficacy Questionnaire (PSEQ)²⁵²
- Movement
 - Neurodynamic tests: Straight leg raise (SLR) and Brachial Plexus Provocation Test (BPPT)^{79,202,203}
 - Trunk forward flexion and neck extension^{79,202,203}
 - Abdominal draw in maneuver (ADIM)²⁰²
- Endurance: Sit-to-stand; fifty-foot walk test; 5 minute walk test and step count²⁵²

Measurement periods were variable, ranging from immediate effect of NE^{79,203,212,253} to 1 year follow-up,^{77,81} but several studies also reported intermediate effects of NE.

5.3.4 Effectiveness of NE

Data gained from the RCTs could not be pooled because of the heterogeneity of the outcome measures and comparison groups. Results are thus reported in narrative form and summarized in Table 5.5.

Table 5.5: Efficacy of neuroscience education (NE) on pain, disability, anxiety and stress for musculoskeletal conditions

Outcome	Moseley 2003a	Moseley 2002	Ryan, et. al 2010	Van Oostervij, et. al 2011	Meeus, et. al 2010	Moseley 2003b	Moseley et al 2004b	Moseley 2004a
Decrease pain ratings	+	+	+	+				
Increase knowledge of pain					+	+		
Increase pain tolerance				+	N			
Alter self-report whiplash symptoms				N				
Improve function and disability	+	+	N	+			+	
Decrease fear of re-injury			N	+	N			
Decreased pain catastrophization				N	+		+	+
Develop strategies to cope with pain				+	N			
Develop healthy attitudes regarding pain			N				+	+
Improve physical movement and performance			N	+			+	+

 = positive (experimental group obtained a significantly greater improvement than the control group)
 = neutral (there were no statistically significant differences between the group)

5.3.4.1 NE addressing pain

Six of the 8 studies in this review examined the effectiveness of NE addressing issues associated with pain.^{77,81,203,212,252,253} Methodological quality of the 6 studies addressing pain ranged from 11 (good) to 15 (excellent), with a mean score of 13/16.

- A NE session for patients with CLBP by itself produces a more favorable immediate effect on decreasing pain ratings (out of 100) (39.3 ± 26.2 to 8.4 ± 7.5) than a program combining NE and an exercise program (28.1 ± 20.4 to 23.9 ± 23.3) ($p < 0.025$), but loses its superior efficacy at 3 month follow-up.²⁵²
- NE for patients with CLBP, decreased pain in both short term (1 month) and long term (1 year) interventions ($p < 0.01$), compared to patients receiving ongoing medical care without physiotherapy.⁸¹ Mean improvement of the NE session was 1.5 points on the NPRS.
- NE sessions for patients with CLBP delivered as single 1-on-1 sessions or as group sessions decreased pain significantly ($p < 0.05$), yet individual 1-on-1 educational sessions were associated with a more favorable outcome, compared to the group educational sessions ($p = 0.004$).⁷⁷ Average reduction in pain was 3.1 (1.8 – 4.2) for the individual education group versus 2.7 (1.6 – 3.9) in the group education session.
- Following a NE session, patients with chronic WAD had a significant reduction in pain (VAS) during a neck extension test without fixation ($p = 0.04$) and with fixation ($p = 0.04$).²⁰³ Perceived pain on the VAS was decreased 43.5% for the test without fixation and 59.2% with fixation.
- In patients with CFS, a 30-minute NE session is able to increase their knowledge of pain, compared to a program focused on pacing and self-management ($p < 0.001$).²¹²
- A single NE session will increase the knowledge of pain in patients with CLBP.²⁵³
- NE did not improve PPT in patients with CFS,²¹² while PPT was significantly increased (decreased sensitivity of the nervous system) in patients with chronic WAD (trapezius $p = 0.03$ and calf $p = 0.04$).²⁰³
- Of all the self-report WAD symptoms on the WAD symptoms list (photophobia, neck mobility and sweating), NE showed only a significant effect on decreasing photophobia ($p = 0.04$).²⁰³

5.3.4.2 NE addressing function and disability

Five of the 8 studies in this review examined the effectiveness of NE addressing issues associated with function and disability.^{77,81,202,203,252} Methodological quality of the 5 studies addressing pain ranged from 11 (good) to 15 (excellent), with a mean score of 12.6/16.

- NE sessions for patients with CLBP delivered as single 1-on-1 sessions or as group sessions decrease disability (RMDQ) significantly ($p < 0.05$; average 5.5 points), yet individual 1-on-1 educational sessions were associated with a more favorable outcome, compared to the group educational sessions ($p = 0.004$).⁷⁷ The change in RMDQ in this

study was clinically meaningful and comparable to studies showing manipulation (3 RMDQ points)²⁵⁷ and exercise (2.9 RMDQ points)²⁵⁸ effects on changing disability.

- NE session for patients with CLBP alters disability as measured by RMDQ ($p=0.02$), but due to effect size (< 2 points on the RMDQ), was clinically insignificant.
- NE for patients with CLBP, decreased perceived disability in both short term (1 month) and long term (1 year) ($p<0.01$), compared to patients receiving ongoing medical care without physiotherapy.⁸¹ The mean improvement on the RMDQ was 3.9 points for the experimental group, which is clinically significant.⁸¹
- NE reduced perceived disability in patients with CLBP, but failed to reach significance ($p=0.127$). The immediate effect leveled off at 3-month follow-up.
- In measuring perceived disability from whiplash, Van Oostervijk et al.²⁰³ showed that NE was able to decrease perceived disability ($p=0.046$), which was reduced from 28.26% to 22.72%, which is comparable to disability decrease by Moseley.⁸¹

5.3.4.3 Outcome related to psycho-social issues

- Tampa Scale of Kinesiophobia (TSK). Three studies used the TSK as an outcome measure to assess fear of (re)injury due to movement.^{203,212,252}
 - A single NE session for patients with chronic WAD decreased fear of (re)injury ($p=0.03$).²⁰³
 - A NE program alone compared to a NE and exercise program failed to show any significant difference in pain related fear as measured by the TSK ($p>0.05$).²⁵²
 - In a study on patients with CFS, a NE session failed to show a significant difference in fear of (re)injury compared to a pacing and self-management program ($p>0.05$).²¹²
- Pain Catastrophisation Scale (PCS). Four studies used the PCS as an outcome measure to assess pain catastrophisation.^{79,202,203,212}
 - Meeus et. al.²¹² evaluated the effect of NE compared to pacing and self-management for patients with CFS and found that NE changed one of the PCS factors (ruminating) by a statistically significant difference compared to the control group ($p<0.05$).
 - A single NE session for patients with chronic WAD showed no effect on pain catastrophisation ($p>0.05$).²⁰³
 - A RCT of patients with CLBP comparing NE to a back education program showed a statistical significant effect in decreasing pain catastrophisation ($P<0.001$).²⁰²

- NE has been shown to decreased pain catastrophisation ($p < 0.001$), which was correlated to increased SLR and forward bending.⁷⁹
- Pain Coping Inventory (PCI). Two studies used the PCI as an outcome measure to assess cognitive and behavioral pain-coping strategies.^{203,212}
 - In a study evaluating the effect of NE on patients with chronic WAD, NE changed passive coping strategies ($p = 0.03$), but not in the other PCI categories of retreating and worrying.
 - Meeus et. al.²¹² evaluated the effect of NE compared to pacing and self-management for patients with CFS and found that NE failed to produce a significant change in PCI ($p > 0.05$).²¹²
- Pain Attitudes (SOPA(R)). Two studies used the SOPA(R) as an outcome measure to assess attitudes and beliefs regarding pain.^{79,202}
 - In a RCT comparing NE to back education, the NE session provided a significant change in patient attitudes and beliefs regarding pain, compared to the back education group ($p < 0.001$). Patients who received NE were less likely to seek care from others when they experienced pain; more likely to believe that they could control their pain; more likely to believe pain is affected by emotional distress; and less likely to believe pain is due to tissue injury.²⁰²
 - The study by Moseley⁷⁹ showed that a NE session altered 2 SOPA(R) factors significantly ($p < 0.05$) – harm and disability, which in turn was associated with increased physical performance.
- Pain Self Efficacy Questionnaire (PSEQ). Only 1 study used the PSEQ as an outcome measure to determine an individual's beliefs regarding their ability to carry out activities and function despite their pain.²⁵²
 - In a study comparing NE to a NS and exercise session, no statistically significant changes were found between the groups ($p > 0.05$).²⁵²

5.3.4.4 NE addressing physical movement

Four of the 8 studies in this review examined the effectiveness of NE addressing issues associated with physical movement.^{79,202,203,252} Methodological quality of the 4 studies addressing physical movement ranged from 12 (good) to 15 (excellent), with a mean score of 13.5/16.

- Neurodynamic tests: NE compared to back education causes an immediate increase in straight leg raise (SLR) ROM ($p < 0.01$)^{79,202} including taking into consideration measurement error,²⁵⁹ and decreased pain perception during a brachial plexus provocation test (BPPT) in patients with chronic WAD.²⁰³
- Spine movements: NE compared to back education causes an immediate increase in trunk forward flexion in patients with CLBP ($p < 0.01$),^{79,202} and decreased pain perception during neck extension movements in patients with chronic WAD.²⁰³
- Motor control: NE compared to back education resulted in no statistical difference between the groups ($p > 0.05$).²⁰²
- Physical performance: NE compared to a NE and exercise program did not show a statistically significant difference ($p > 0.05$).²⁵²

5.4 Discussion

Utilization of NE is increasing.^{77,79,82,202,260,261} This is the first systematic review of NE for pain, disability, anxiety, and stress in patients with MSK pain. Although this review comprised a rather heterogeneous sample of studies utilizing NE, the results indicate compelling evidence for the use of NE in decreasing pain ratings, increasing physical performance, decreasing perceived disability, and decreasing catastrophisation in patients suffering from MSK pain.

NE focuses on a detailed description of the biology and physiology of the nervous system and brain's processing of pain and nociceptive input.^{202,203} This approach is in direct contrast to prevailing biomedical models, which focus on tissues and tissue injury.^{114,196,197} Orthopedic-based professions such as orthopedic surgeons and physiotherapists commonly use anatomy and pathoanatomy based models to explain pain to their patients.^{114,196-198} Not only have these models shown limited efficacy in decreasing pain and disability, but they may increase fear in patients, which in turn, may increase their pain.^{199,200}

Although NE features an anatomical component (anatomy of the nervous system), it de-emphasizes tissue injury (i.e., disc or joint),^{81,202} rather using the anatomy to describe pathways to process nociceptive input.^{202,203} A key message that NE tries to impart to the patient is the clear difference between 'nociception' and 'pain.' Patients are taught that the nervous system has the ability to increase or decrease its sensitivity (neuroplasticity) to help them cope with persistent pain.^{202,203} Considering that other educational models use similar education delivery methods as NE, it could be argued that the content of NE may be the key element in its efficacy compared to the more traditional models of explaining pain to patients.^{67,79,81,82,202}

The results indicate that 1-on-1 education was used the most^{79,202,203,212,252} and is superior with respect to outcomes, when compared to group sessions.²⁵³ Considering the individualistic and complex processing of pain, it should not be surprising that 1-on-1 educational sessions produced superior results.^{67,253} Various brain pathways process nociception and these pathways are influenced by personal experiences, thoughts, feelings, and emotions' thus creating an individual neural-signature of the event.^{67,75}

Although this review failed to identify the optimal duration and frequency of NE sessions, it is noteworthy that the 3 most recently published studies used considerably less education delivery time.^{203,212,252} This reduction in time could be due to an increased proficiency in applying NE and also a potential means to develop a NE session that could be clinically useful,²¹² potentially alleviating issues of time constraints in clinical practice.²⁶²⁻²⁶⁴ This trend may not only allow clinicians to provide NE in as little as 30-45 minutes, but be able to combine it with other physical treatments. The combination of NE and exercise^{81,252,260} is in line with best-evidence guidelines managing patients with chronic pain.²⁶⁵⁻²⁶⁷ Physiotherapists provided all the NE in this review.^{77,79,81,202,203,212} Physiotherapists' knowledge of neurophysiology and movement-based approach may indicate a unique role for physiotherapists in managing patients with chronic pain.

Educational sessions were also accompanied by various teaching tools, including hand drawn images, prepared pictures and workbooks.^{79,202,203,212,252} The use of booklets concurs with patient education studies highlighting booklets as valuable tools in aiding information retention compared to verbal communication only.^{57,163,268} In 2 of the NE studies, patients were also asked to complete daily tasks.^{81,202} Patient tasks would likely aid in the development of much needed deep learning processes, since the patient is active compared to a more passive education endeavor.²⁶⁹⁻²⁷³

Although various definitions for pain are provided in the scientific literature,^{67,75} patients often see pain as a measure of the health of their tissues.^{199,200} Pain is complex and recent authors have highlighted the fact that pain could possibly be a better measure of potential threat of tissue damage, rather than true tissue health.^{67,82,232,233} The larger the threat, the more pain is perceived.⁸² Patients' pain perception due to tissue health is yet another example of an anatomy and pathoanatomy model driving pain. Considering that NE purposefully de-emphasizes tissue injury, focuses on the processing of nociception, and aims to increase the patient's awareness that nociception and pain are not correlated, it could be seen as a

possible mechanism to decrease the threat, thus dampening the pain perception in the patient.^{82,266}

Several studies have shown that patients with higher pain ratings have increased disability.²⁷⁴⁻²⁷⁷ Since patients view pain as an indicator of tissue health and the potential that activity may further damage their tissue and thus increase pain, decreased physical movements may be seen as a logical protective mechanism.²³³ The results from this study would indicate that decreased pain perception and a greater understanding of the non-mechanical factors that may increase or decrease nerve sensitivity (i.e., failed treatment, fear, emotions, and different explanations of their pain) patients may be inclined to see themselves as less disabled and more inclined to increase their activity.²⁷⁴⁻²⁷⁷

Persistent pain has been shown to not only lead to significant physical changes in the brain,^{82,278,279} but also altered processing of pain and the activation of catastrophisation.^{280,281} With persistent pain, failed treatment, different explanations for their pain, etc., it is plausible that patients with chronic pain may view their condition as being far worse than it actually is and their future as bleak and thus have little hope.²⁸²⁻²⁸⁴ This irrational thought that patients have in believing their problems as being far worse than they actually are is known as catastrophisation, and it appears to enhance pain processing. This review included patients with more than two and a half years of chronic pain, which concurs with studies associating persistent pain with higher levels of catastrophisation.^{280,281,285} The de-emphasis of the faulty tissue model as portrayed by the NE could be seen as one reason for its ability to begin to alter pain catastrophisation.

Finally, we should consider a particular circumstance that is relevant to patients with MSK pain and how NE may facilitate therapeutic improvement. The nature of MSK pain is unique given its subjectivity, frequent lack of an "objective" radiographic correlate, and the many erroneous and often misleading things patients are told. These factors could trigger the development of maladaptive cognitions which, without adequate education during prior medical work-ups, reinforce fears of movement and the perception of serious tissue damage underpinning their pain (e.g., "you have a bulging disc"; "you have degenerative joint disease"; "your nerve is being pinched"). NE may have potential impact by countermanding any iatrogenically-induced maladaptive beliefs encouraged by treatment with physicians who practice pain management from the "tissue damage" perspective. These maladaptive beliefs are also often reinforced by misdirected and failed surgery or interventional procedures. Given the evidence for the importance of exercise in the management of MSK pain, these

fears become primary in understanding continued disability and may help to explain why NE may be particularly well suited to interventions for MSK disorders.

5.5 Limitations

This systematic review has limitations that need to be acknowledged. The review is limited by the number of studies as well as the need to use studies of lower levels of evidence to gain a better understanding of the effect of NE in MSK pain. The heterogeneous nature of studies in this review precluded true meta-analyses, which would have been helpful to determine the level of effectiveness NE. Based on the lack of consistent control groups in the articles reviewed, it is not possible to draw strong conclusions about the influence of the NE content versus individual attention and the acknowledgement that perceived pain may be real. This review contains mainly patients with CLBP and carry-over of the results to other MSK conditions is limited. Additional limitations include inclusion of English-only studies and patient populations, as well as excluding younger patients.

5.6 Conclusion

The results of this systematic review demonstrate compelling evidence for NE affecting passive^{79,202,203} and active physical movements.^{79,202,203} Furthermore, positive effects of NE on pain perception, disability, and catastrophization, may allow patients to apply this new view of their pain state by re-appraising their ability to move.²⁰² With the decreased threat of additional tissue injury, and a newly gained realization that pain may be due to neural sensitivity rather than tissue injury, patients may be able to actively move further and allow clinicians to passively move them further.

Chapter 6:

Development of a preoperative neuroscience educational program for patients with lumbar radiculopathy

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6.1 Introduction

It is estimated that between 10 – 40% of patients experience persistent pain and disability after lumbar discectomy for radiculopathy^{9,10,286} and postoperative rehabilitation has shown little effect on reducing this postoperative disability and pain.^{9,103} Additionally preoperative education in orthopedics, including lumbar surgery (LS), utilize anatomical and biomechanical models for addressing pain,^{59,66,79,250} which not only has shown limited efficacy,^{59,66,69,70,250} but may even increase patient fears, anxiety and stress, thus negatively impact their outcomes.^{66,72,73,287} LS patients are interested in knowing more about pain,⁵⁶ and non-LS studies aimed at educating patients more about their pain have shown promise in reducing pain and disability for non-surgical low back pain (LBP)^{81,202} as well as orthopedic surgery patients.¹⁸⁴ In this chapter the development of a preoperative neuroscience educational tool (PNET) for LS patients for radiculopathy is described, as it followed the results of the studies discussed in Chapters 3, 4 and 5. Chapters 3 highlighted the fact that pain education, not procedural or anatomical education, is able to have an immediate effect on postoperative pain,¹⁸⁴ while Chapter 4 underscored the importance of cognitions and beliefs regarding pain, including spine surgery patients.^{223,224} Chapter 5 provided an update into the efficacy, content and education delivery methods utilized in pain education for non-surgical musculoskeletal pain disorders, in order to facilitate the development of the PNET. The aim of this chapter is to incorporate the information gathered in chapters 3, 4 and 5 into a preoperative pain education program and booklet to trial in the main and final phase of this research study.

6.2 Methodology: Development of the booklet

The content of the neuroscience education (NE) sessions as found in the systematic review on NE²⁸⁸ was used to develop appropriate messages for patients booked for LS for radiculopathy. The educational messages are designed to be delivered as one-on-one educational sessions to

patients prior to LS along with the development of a patient booklet containing the same messages to provide patients with a written version of the content of the educational session. The booklet followed the general philosophy and style of the *Explain Pain* book,²⁵⁰ which has been used in studies examining NE for pain and disability.^{79,212,252,289} The main aim of the preoperative NE program was to help patients reconceptualize their back, hip and leg pain as an increase in nerve sensitivity, up-regulation of the peripheral and central nervous system and defocus attention from nociceptive input via the tissues from the affected areas. The NE message thus aims to reduce anxiety and uncertainty and thus promote positive expectations and beliefs. The structure of the developed NE program consists of six sections: 1) the decision to have back surgery; 2) the nervous system anatomy, physiology and pathways; 3) peripheral nerve sensitization; 4) environmental influences on nerve sensitivity; 5) down-regulation of the nervous system; and 6) recovery after LS. Several drafts of the text over a period of several months refined its content, clarity and readability. The booklet has been reviewed to be at 6th grade English⁵⁷ and the word count (4129) was well within the length of the *Your Back Operation* booklet used in the UK for a recent RCT (4622 words).¹⁸

The professional evaluation of the booklet included an expert panel consisting of spine surgeons, experts in NE, pain management physicians, orthopedic nurses, physiotherapists, psychologists and specialists in patient education. The expert panel was given a copy of the booklet along with a questionnaire and asked to send the completed questionnaire back to the researchers within 30 days. A reminder was sent to the expert panel one week prior to the deadline. The questionnaire had two parts: Part one contained 11 forced-choice questions on readability, style, information level, believability, length, content, and helpfulness (for example, 'I learned some new, helpful things', 'I knew most of it anyway', 'I didn't really find it helpful'). Part two contained open-ended questions about the most important messages they took from the booklet, anything they did not like or understand, if they had any concerns that were not covered, if they thought the booklet would change what they did after surgery, and their overall rating of the booklet on a scale from 1 to 10. The questionnaire was designed for and borrowed from a previous study (Appendix 6).⁵⁷ A second evaluation consisted of a convenience sample of patients who had recently undergone LS for radiculopathy. Patients at 2 orthopedic physiotherapy groups (Ortho Spine and Pain clinic in Iowa and RehabAuthority in Idaho) working closely with spine surgeons were approached, and written informed consent obtained. Each patient was given a copy of the draft text to read at their leisure, and asked to complete and return an evaluative questionnaire as described before. Thirdly, a convenience sample from the general population was asked to evaluate the booklet and complete the questionnaire described above. In the last group we excluded people who had undergone previous LS, experienced LBP at the time or were attending any treatment for LBP.

6.3 Results: Development of the program and booklet

Section 5.3.2.6 describes the content of NE which was used in the development of the preoperative NE program. The NE program was designed to de-emphasize anatomical and pathoanatomical reasons for pain from lumbar radiculopathy. Although the preoperative NE program described the anatomy of the nervous system, it was primarily done as a means to describe pathways of communication of nerve sensitivity. A neuroscience message focusing on peripheral neuropathic pain mechanism was developed, based on the understanding of the current mechanism associated with lumbar radiculopathy and to develop a program that could be administered in a clinically meaningful time period. The preoperative NE program was designed to include prepared pictures,^{79,212,252,289,290} examples^{212,289,290} and metaphors.²⁸⁹ The sensitivity of the nervous system metaphorically described as an alarm system²⁸⁹ accompanied with drawings of action potentials^{79,289} was used to describe peripheral sensitization,^{79,289,290} central sensitization^{79,289,290} and plasticity of the nervous system (Figure 6.1).^{289,290} The sensitization of the nervous system was further described in relation to various stressors associated with LS, including diagnosis, hospital procedures, having surgery, anesthesia and recovery.

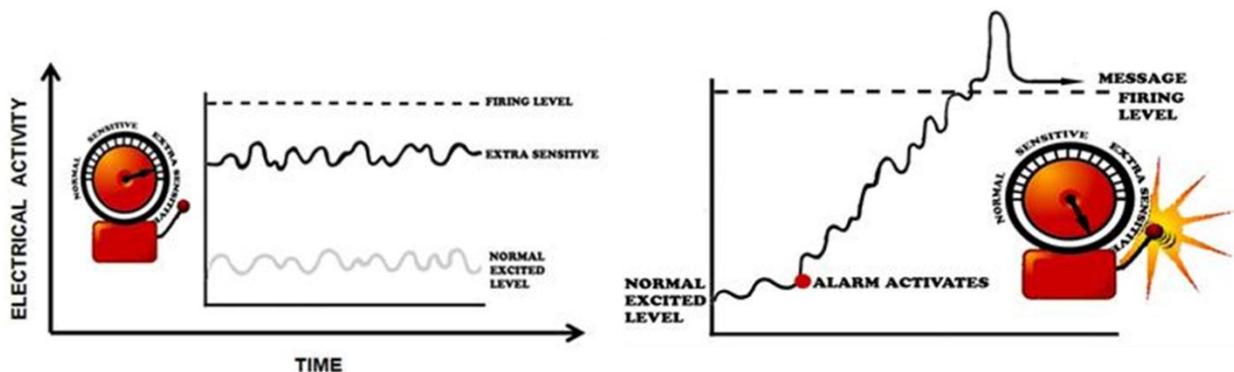


Figure 6.1: Example of the use of images in explaining peripheral nerve sensitization to patients in the preoperative neuroscience educational booklet.

The results from the expert panel and patient and the general population is found in Figure 6.2.

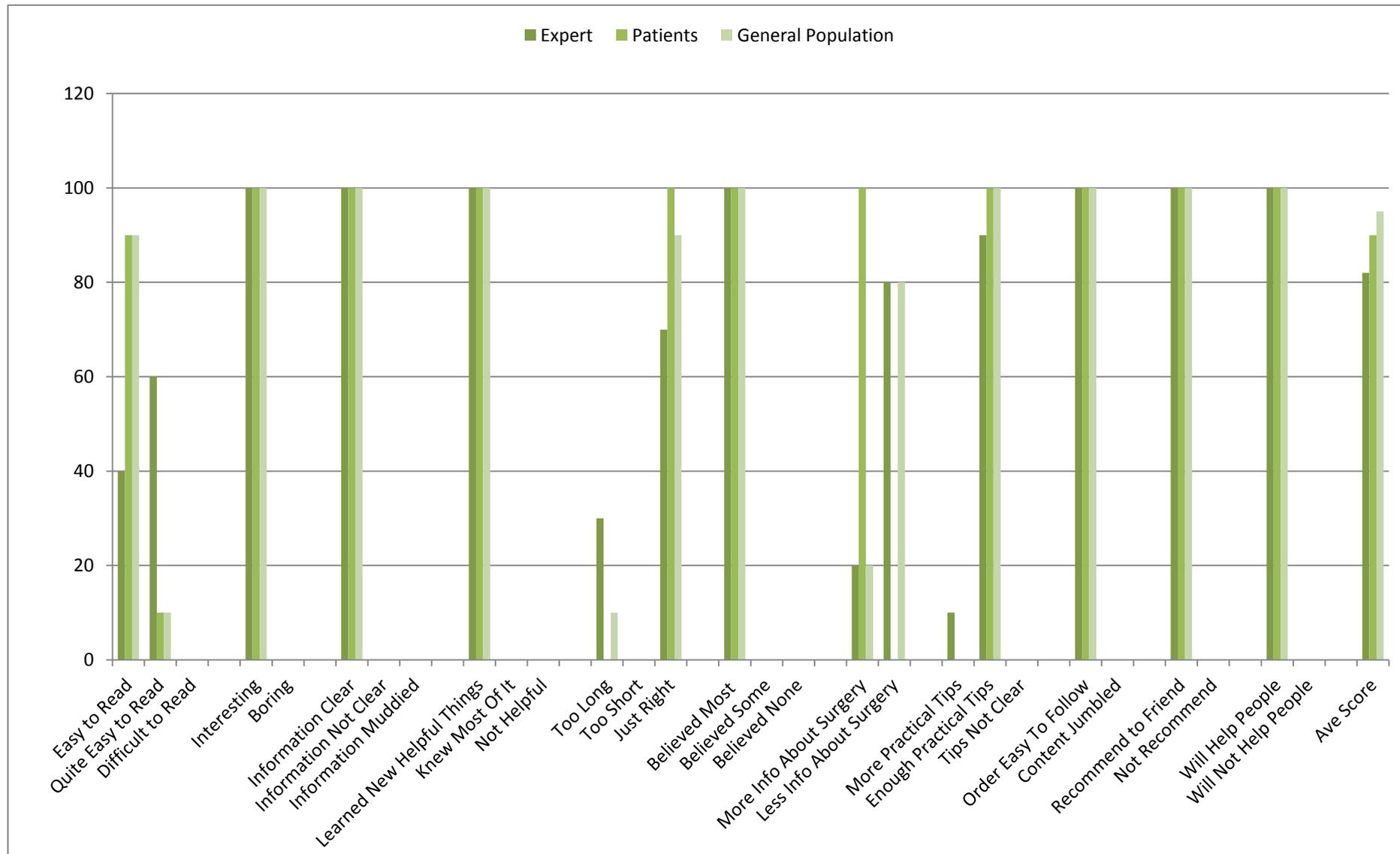


Figure 6.2: Results from the survey of the expert panel and patients and people from the general population.

All of the professional reviewers (n = 12) stated that they strongly supported the themes and messages of the booklet and recognized the need for such material. Although there were few and minor criticisms of the information provided, the overall comments were very positive. These comments and suggestions were discussed among the researchers and changes made to the text as appropriate. Importantly, all the spine surgeons welcomed the booklet and considered it would be useful in their practices. The overall rating of the booklet by the expert panel was 8.2 out of 10.

Evaluation of the booklet was returned by 5 patients and 5 people from the general population. Of the responders, all 5 patients and 5 people from the general population reported that they found the booklet easy to read, interesting, learned new things and thought the content was easy to follow. All stated that they felt the booklets were not too long, but just right, with an adequate number of images. They thought it would help patients and they'd recommend it to a family member. Although all patients and people from the general population indicated a need for more information about the operation, the booklet was designed to be an adjunct to the usual care provided by surgeons, who generally discuss the operation at length.²⁹¹ The narrative questions showed that patients and people from the general population understood the main aim of the booklet, i.e., the increased sensitization of the nervous system in radiculopathy and how nerves increase and decrease sensitivity. Patients and people from the general population further explained the greater understanding of movement and an active approach in rehabilitation following lumbar surgery (Table 6.1). The patients' average overall rating of the booklet was 9/10. The patients' responses were again discussed by the researchers, and appropriate changes made to the text.

Table 6.1: Themes captured from descriptions of the important messages from the preoperative neuroscience educational booklet by the patients and general population

Most important messages from the booklet?
<ul style="list-style-type: none"> • <i>Stress affecting nerve sensitivity</i> • <i>How much nerve sensitivity is dependent on blood flow</i> • <i>How to calm nerves down</i> • <i>Importance of movement after surgery</i> • <i>Be confident in your surgery decision and don't second-guess</i> • <i>Hospital experiences, anxiety and its effect on nerve sensitivity</i> • <i>Surgery may fix the problem, but the nerves take time to calm down</i>
Potential changes after surgery?
<ul style="list-style-type: none"> • <i>Decrease level of stress</i> • <i>Move more despite sensitivity</i>
Other comments about the booklet?
<ul style="list-style-type: none"> • <i>Wish my surgeon told me this before surgery</i> • <i>Good booklet with easy to understand information for all ages</i> • <i>Good explanation of nerve sensors</i>

6.4 Discussion

Utilization of NE is increasing.^{79,82,260,261,290,292} The systematic review used for the development of the preoperative neuroscience education program for lumbar surgery for radiculopathy is the first review of neuroscience education for pain, disability, anxiety and stress in musculoskeletal conditions.²⁹³ Although this review comprised a rather heterogenous sample of studies utilizing NE, the results from this review indicate strong evidence for the use of neuroscience education in decreasing pain ratings, increasing physical performance, decreasing perceived disability and decreasing catastrophization in patients suffering from chronic musculoskeletal pain.

NE focuses on a detailed description of the biology and physiology of the nervous system and brain's processing of pain and nociceptive input.^{289,290} This approach is in direct contrast to prevailing biomedical models focusing on tissues and tissue injury.^{114,196,197} A recent survey of US spine surgeons²⁹¹ showed that 97% of spine surgeons utilize anatomical spine models in their preoperative education, thus using an anatomy and pathoanatomy based model explaining pain to patients.^{114,196-198} Not only have these models shown limited efficacy in decreasing pain and disability, but may in fact have increased fear in patients, which in turn may increase their pain.^{199,200} Although NE features an anatomical component (anatomy of the nervous system), it de-emphasizes tissue injury (i.e., disc or joint),^{81,290} rather using the anatomy to describe pathways to process nociceptive input.^{289,290} A key message NE tries to impart to the patient is a

clear difference between nociception and pain. Patients are taught that the nervous system has the ability to increase or decrease its sensitivity (neuroplasticity via peripheral and/or central sensitivity) to help them cope with the injury, surgery and recovery.^{289,290} Considering that other educational models use similar education delivery methods as NE, it could be argued that the content of neuroscience education may be the key element as to its efficacy compared to more traditional models of explaining pain to patients.^{79,81,82,250,290}

Although various definitions for pain are provided in the scientific literature,^{250,294} patients often see pain as a measure of the health of their tissues.^{199,200} Pain is complex and recent authors have highlighted the fact that pain could possibly be a better measure of potential threat, rather than true tissue health.^{82,232,250,295} It is suggested that the larger a threat is perceived, the more pain is developed to protect against the threat.⁸² Patients' pain perception due to tissue health is yet another example of an anatomy and pathoanatomy model driving pain. Considering that NE purposefully de-emphasizes tissue injury but rather focuses on the processing of nociception and aim to increase patient's awareness that nociception and pain does not correlate, it could be seen as a possible mechanism to decrease the threat, thus dampening the pain perception in the patient.^{82,266} Several studies have shown that patients with higher pain ratings have increased disability.²⁷⁴⁻²⁷⁷ Since patients view pain as an indicator of tissue health and the potential that activity may further damage their tissue and thus increase pain, decreased physical movements may be seen as a logical protective mechanism.²⁹⁵ The results from the systematic review would indicate that decreased pain perception and a greater understanding of non-mechanical factors that may increase or decrease nerve sensitivity (i.e., failed treatment, fear, emotions and different explanations of their pain) patients may be inclined to see themselves as less disabled and more inclined to increase their activity.²⁷⁴⁻²⁷⁷ This result is the underlying premise of the preoperative NE program and accompanying booklet.

The development and use of booklets concurs with patient education studies highlighting booklets as valuable tools in aiding information retention compared to verbal communication only.^{57,268,296} Booklets are cost-effective, simple and a popular method of imparting healthcare information to patients.^{57,251,296,297} Booklets have also shown the ability to positively influence compliance,^{63,196,298} reduce anxiety⁴¹ and empower patients.^{63,299} The current booklet was developed according to established principles: an extensive review of the literature searching for best-evidence; careful synthesis into patient-centered messages; ensuring that text, messages and images were appropriately designed; as well as evaluation by an expert panel (representative of preoperative education, surgery and pain science), pre-operative back surgery patients, and a community sample. The format, presentation, and illustrations of the booklet were developed in close collaboration with a publisher of a more extensive NE book,

previously used in NE studies.³⁰⁰ This booklet is intended to be an adjunct to a preoperative NE program developed to be delivered in a one-on-one educational format by physiotherapists for patients prior to undergoing LS for radiculopathy to supplement verbal communication. It can, however, also be used as a template for the verbal one-on-one educational program, allowing for more consistency in the message delivered to patients.

Chapter 7: Analysis of Provocative Language of the Preoperative Neuroscience Educational Tool for Lumbar Surgery

7.1 Introduction

Pain scientists embracing the neuromatrix concept have redefined pain as a multiple system output, activated by the neuromatrix in response to what a patient perceives as a threatening situation.^{67,75,213} It is proposed that the larger the threat is perceived, the more pain is produced as a defender.^{67,213} Conversely, it is believed that if a perceived threat is decreased, less pain will be produced to defend. It is well established that various medical terminology and descriptions, although aimed at educating and thus assisting patients, may in fact increase fear and anxiety.^{199,200,301,302} In orthopedic spine literature terms such as *disc degeneration*, *wear and tear*, *disc space loss*, *crumbling* and *collapsing* are often used. These possibly provocative terminologies aimed at describing to patients their pain, may not be able to help patients, but may in fact induce more fear and anxiety.^{199,200,301,302} Additionally, it has also been shown that patients with persistent pain may in fact pay increased attention to words and descriptors of pain.³⁰³ The pain neuromatrix, originally described by Melzack in 1990³⁰⁴ and subsequently supported by imaging studies,^{82,305-307} may imply that terminology describing a patient's pain and the biomedical explanation for the pain via tissue injury description may in fact produce a heightened sensitivity to the CNS by inducing fear and anxiety.

In a recent randomized controlled trial (RCT), a very extensive spinal rehabilitation program (FASTER – Function After Spinal Treatment, Exercise and Rehabilitation), focusing on the delivery of an extensive educational program by itself (group 1) or added to a rehabilitation program (group 2), compared the added education to usual care (physician's usual protocol) (group 3) and rehabilitation-only (group 4).^{18,308} This comprehensive, 4-arm 308-patient study failed to show any benefit of adding the educational component in regards to function, pain and cost-effectiveness^{18,308}. In the discussion of the reasons why the study failed to show any difference, the authors eluded to possible heterogeneous nature of the surgeries (combining disc surgery and nerve root surgery), possible variations in the rehabilitation program or even optimal timing. The purpose of this chapter is the exploration of a possible additional reason why the FASTER program may have not changed postoperative pain or function, in lieu of the development of the Preoperative Neuroscience Educational Tool (PNET) (chapter 6). One key feature of the NE is a deliberate strategy to not use anatomical and pathoanatomical descriptions to explain pain^{250,288}, in direct contrast to a biomedical approach that may utilize provocative anatomical words and descriptions that may in fact increase fear and anxiety.

Considering the main aim of the research study and process of developing the PNET, the aim of this study was to compare the terminology used in the two booklets, both recently developed to provide preoperative education, namely, the PNET and the FASTER booklets.

7.2 Methodology

7.2.1 Educational Material

Two educational booklets, designed for decompressive LS for disc surgery and nerve root was used as comparison for this study. The first booklet, *Your Back Operation*³⁰⁹, associated with the recent comprehensive spinal surgery rehabilitation RCT (FASTER) has undergone extensive development and subsequent implementation^{17,18,57,308}. The second booklet (*Your Nerves are Having Back Surgery - PNET*),³¹⁰ based on a recent systematic review of neuroscience education for musculoskeletal conditions²⁸⁸, and developed for the final phase of the current study, was used in comparison.

7.2.2 Expert Panel

An expert panel was identified to evaluate the contents and statements of the two educational booklets. Considering the aim of the study was to examine the content of the booklets from a neuroscience perspective for LS, experts were identified who teach postgraduate neuroscience classes or practice a neuroscience approach to spinal pain, with at least 5 years of clinical experience and have at least attended 30 hours of training in NE. A total of 25 experts, representing 7 countries were identified for the study.

7.2.3 Examination of the booklets

The contents of the booklets were extracted and each booklet was typeset into a word processing document (Microsoft Word), Arial font size 12. All images and identifiable words or markings were removed. Each booklet was formatted into a separate Word document. Booklet A (*Your Back Operation*) comprised 4684 words in 14 pages and Booklet B (*PNET*) resulted in 3169 words in 17 pages. The booklets was accompanied with a demographic sheet of each reviewer, seeking information regarding age, gender, highest academic degree, publication in peer-reviewed journals, years of experience, allocation of clinical, teaching or administrative time, active involvement in research and their exposure to spinal surgery patients. To rule out potential bias, e-mails were sent to experts by an independent research assistant and collected by the same assistant.

Reviewers were e-mailed an invitation letter to participate in the study, the demographic sheet; booklet A and booklet B, and provided with the following description of their task:

“We are asking an expert panel to read through the booklets and highlight all words (not sentences, but single words) that may be deemed provocative. Provocative terms are defined (from a neuroscience perspective) as words that will likely increase threat to the brain and nervous system, rather than calming the nervous system down. An example may be the word pain. It could be argued that, based on the neuromatrix of processing threat, a word such as pain may “activate” the neuromatrix, rather and helping a patient ‘calming down.’ Research in the orthopedic domain have found that words such as “tear, rupture, herniated and deteriorated” are perceived as threatening by patients in spinal pain. The idea is to read the pages and as you encounter a word you deem provocative, to highlight it (highlighter or bold/color). Once done with both, you are asked to please e-mail it back to the research team. In the pilot, the average time it took to complete said task was 20 minutes. There is no right or wrong answers. We would greatly appreciate if you could send us your answers in 3 weeks.”

Two days prior to the completion of the data collection, a reminder e-mail was sent to the expert panel thanking them for their participation in the study and reminding them to complete the study if they have not done so by then.

7.2.4 Data Extraction and Analysis

Completed demographic information and highlighted words were entered into an Excel spreadsheet for analyses. This study was to a large degree a descriptive study, and the usual descriptive statistics such as means, total scores and descriptive analyses were used.

7.3 Results

7.3.1 Expert Panel

Seventeen experts completed the study with no missing data. All the experts were physiotherapists and represented seven different countries. See the demographic data of the expert panel below.

Table 7.1: Summary of the demographics of the expert panel

Description	Number
Female	3
Average age (years)	47
PhD or doctoral degree	10
Master's degree	5
Bachelor's degree	2
Average years of clinical experience (years)	22.18
Published in peer-reviewed journals	10
Estimated weekly time spent on clinical work (percentage)	55%
Estimated weekly time spent on teaching	41%
Actively involved in treating spinal surgery patients	15

7.3.2 Booklet Evaluation

Booklet A (*Your Back Operation*) resulted in nearly three times more provocative terms than Booklet B (*PNET*). Booklet A (*Your Back Operation*) resulted an average of 67.23 terms per expert review, while booklet B (*PNET*) resulted in an average of 22.64 provocative terms per expert review. The tabulation of the highest rated individual words per booklet can be found in Table 7.2.

Table 7.2 Tabulation of the provocative terms per booklet as expressed by the expert panel

Booklet A		Booklet B		
Rank	Word	#	Word	#
1	pain	203	surgery	91
2	sciatica	92	pain	85
3	operation	74	alarm	18
4	wound	72	stress	14
5	disc	48	dangers	11
6	surgery	32	anxious	7
7	painkillers	27	fear	4
8	bulge	26	back	3
9	pressure	24	nerves	3
10	damage	23	anesthesia	2
11	complications	22	blood	2
12	claudication	20	clots	2
13	surgeon	20	dry	2
14	prolapse	19	failed	2
15	disability	17	problem	2

7.4 Discussion

The booklet, *Your Back Operation*, contains three times more provocative terms associated with anxiety and fear, compared to a booklet utilizing the latest evidence for NE as deemed by an expert panel in clinical application of NE.

The study by McGregor et al.^{18,308} may have repercussions for physiotherapists and spine surgery patients. The FASTER study was comprehensive and published in a journal predominantly read and studied by spine surgeons. Considering the fact that the FASTER study failed to provide any meaningful changes in regards to function, back or leg pain and cost it would be easy for readers to extrapolate from this study that “postoperative rehabilitation” is ineffective. The findings from this expert review aims to interpret the results of the FASTER program from a neuroscience education perspective. The primary hypothesis of McGregor et al.^{18,308} was that the addition of an evidence-based booklet to a postoperative rehabilitation program will result in superior results and that the booklet itself would result in a meaningful change. Neither of these results was produced. The premise of the booklet was that well-designed and evidence-based information⁵⁷ would ease patient fears, increase knowledge and

thus result in improved function. The results of the current review, however, may indicate that the high proportion of potential provocative orthopedic terms such as *sciatica*, *operation*, *wound*, *disc* and *bulge* as well as symptomatic description of *pain* may have been a factor as to why the booklet produced similar results to the usual care and rehabilitation-only. It should be clear that terms such as *pain* and *surgery* (ranked high in both booklets) will inevitably be used to describe the experience to the patient, for example NE is in essence a neurobiological explanation of pain science^{252,288}, hence the regular use of the word *pain* in the text. Even with the omission of the words *pain* and *surgery*, the booklet *Your Back Operation* contained a much higher proportion of provocative terms (4.5 times more than PNET, compared to total score difference of 3 times).

Language is an input to an individual's pain construction in the pain neuromatrix.³⁰³ This information will further be modulated by the patient's memories, thoughts and emotions.^{67,303} Patient education should be redefined as the delivery of healthcare information to a patient's neuromatrix in an attempt to de-threaten the medical procedure or experience. The FASTER program, utilizing terminology associated with a biomedical model of tissue pathology may not have succeeded in decreasing threat. In contrast, therapeutic neuroscience education has been shown to produce changes in patients with spinal pain associated with de-threatening the pain experience²⁸⁸. NE has been shown to improve physical movement in the absence of physical treatments; catastrophization;^{79,202} function and disability^{77,81,202,203,252} and pain ratings.^{77,81,203,212,252,253}

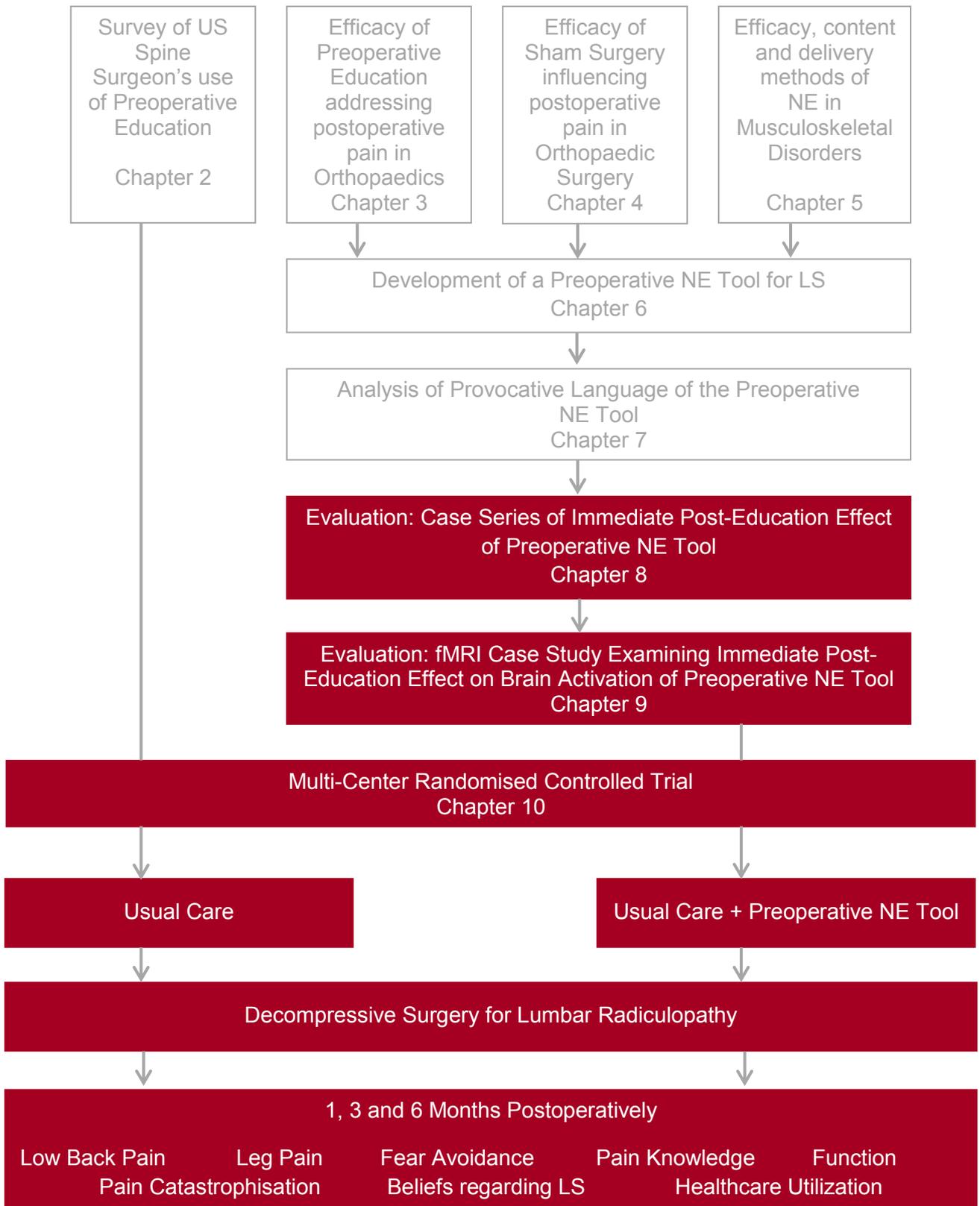
7.5 Conclusion

Educational strategies utilizing biomedical information have limited effect in reducing pain and disability in patients undergoing spinal surgery. On the other hand there is mounting evidence for the use of NE and its effect on the pain neuromatrix.

Phase 3

Measuring the efficacy of the newly developed preoperative neuroscience education tool for LS patients for lumbar radiculopathy

- **Chapter 8: Evaluation: Case Series of Immediate Post-Education Effect of Preoperative Neuroscience Educational Tool**
- **Chapter 9: Evaluation: Functional Magnetic Resonance Imaging Case Study Examining Immediate Post-Education Effect on Brain Activation of Preoperative Neuroscience Educational Tool**
- **Chapter 10: Multi-Center Randomised Controlled Trial of Preoperative Neuroscience Education compared to Usual Care for Lumbar Radiculopathy**



Chapter 8:

Evaluation: Case Series of Immediate Post-Education Effect of Preoperative Neuroscience Educational Tool

8.1 Introduction

The preoperative neuroscience educational tool (PNET) is grounded in previous neuroscience education (NE) studies which has shown changes in cognitions regarding pain and threat,^{292,311,312} as well as physical performance.^{79,81,312} This study sought to examine whether the developed PNET (as described in previous chapters), delivered in a preoperative educational session, would result in similar immediate changes of patients' symptoms, emotions, cognitions and physical movements associated with their lumbar surgery (LS). Additionally, the case series would allow the research team to trial the PNET and ensure its readiness for final randomized clinical trial (final and main phase of the research study)

8.2 Case Descriptions

8.2.1 Subject Description and Examination

This case series comprises data from 10 patients (7 female; average age 47.4 years) scheduled for non-instrumented decompressive LS for radiculopathy with an average duration of leg pain of 7.3 months (range 2-23), average leg pain of 4.1 out of 10 on a numeric rating scale (NRS) and average time to surgery of 9.5 days (range 2 – 28). Patient demographics can be found in Table 8.1. All patients presented with pain in the lower extremity (radiculopathy) with or without neurological symptoms such as numbness, pins and needles and weakness (Figure 8.1). Two patients (P1 and P10) had prior LS for radiculopathy (discectomy). All patients in the case series provided written consent prior to testing and treatment.

Table 8.1: Patient demographics prior to LS for radiculopathy

Patient	Age (years)	Gender	Duration of leg symptoms (months)	Leg pain rating (0-10 NRS)	Wait time till surgery (days)
1*	50	F	4	6	6
2	70	M	2	8	7
3	51	F	8	9	2
4	24	F	12	3	9
5	47	F	23	4	2
6	70	F	8	6	28
7	27	M	3.5	2	8
8	55	F	3	2	8
9	30	F	3	0	15
10*	50	M	6	1	10
Average	47.4		7.3	4.1	9.5

* Indicates patient had previous lumbar surgery for radiculopathy

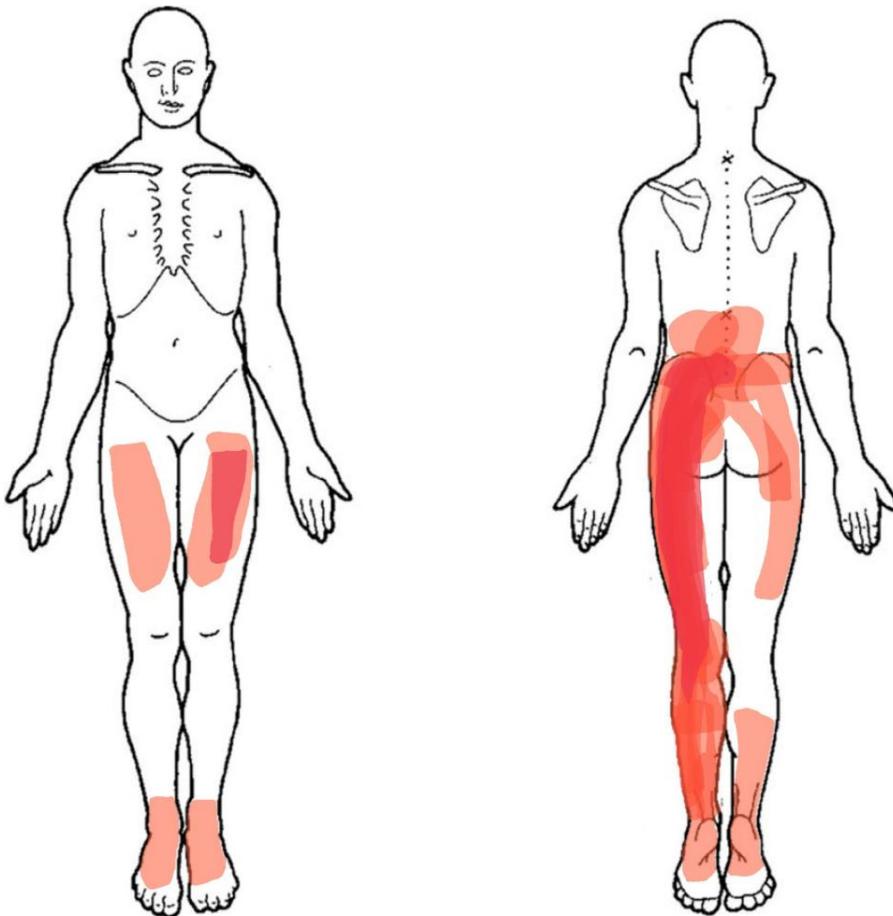


Figure 8.1 Cumulative presentation of leg pain in the case series patient population

8.2.2 Pre-education self-report measures

Prior to NE and after completion of the consent forms and demographic intake forms, patients were asked to complete self-report questionnaires related to function, fear avoidance, catastrophization and knowledge of pain:

- *Oswestry Disability Index (ODI)*: The ODI is a 10-item questionnaire that assesses different aspects of physical function. Each item is scored from 0 to 5, with higher values representing greater disability. The total score is multiplied by 2 and expressed as a percentage. The ODI has been shown to be a valid and reliable measure of disability related to low back pain (LBP).³¹³⁻³¹⁵ A change of 5 points (10%) has been proposed as the minimal important change.³¹⁶

- *Fear Avoidance Beliefs Questionnaire (FABQ)*: The FABQ is a 16-item questionnaire that was designed to quantify fear and avoidance beliefs in individuals with LBP. The FABQ has two subscales: 1) a 7-item scale to measure fear-avoidance beliefs about work and 2) a 4-item scale to measure fear avoidance beliefs about physical activity. Each item is scored from 0 to 6 with possible scores ranging between 0 and 24 and 0 and 42 for the physical activity and work subscales, respectively, with higher scores representing an increase in fear-avoidance beliefs. The FABQ has demonstrated acceptable levels of reliability and validity in previous LBP studies.^{72,317,318} Presence of avoidance behavior is associated with increased risk of prolonged disability and work loss. It is proposed that FABQ-W scores >34 and FABQ-PA >14 are associated with a higher likelihood of not returning to work.^{251,319}

- *Pain Catastrophization Scale (PCS)*: The PCS is a self-report questionnaire that assesses inappropriate coping strategies and catastrophic thinking about pain and injury. The PCS has been used in previous NE studies for chronic LBP^{79,80} and demonstrated strong construct validity, reliability and stability.³²⁰ The PCS utilizes a 13-item, 5-point Likert scale with higher scores indicating elevated levels of catastrophizing. Previous studies utilizing the PCS have shown a median score of 18 that of healthy individuals and in patients with pain the PCS is generally higher.³²⁰ The minimal detectable change for the PCS is reported to be 9.1.³²¹

- *Pain Knowledge Questionnaire*: Pain knowledge was measured by using a neurophysiology questionnaire (NPQ), since it deals with the content of the PNET for this case series. The NPQ is based on a current pain science text¹⁷⁶ and was used in a previous study measuring the neurophysiology knowledge of patients and healthcare personnel.³²² The NPQ is a 19-point questionnaire requesting 'true' or 'false' answers to statements, with the higher scores indicating more correct answers. The questionnaire used in this study is similar to the one used by Moseley³²² and adapted slightly to make it easier for patients to understand, e.g., "nociception" was replaced with "danger messages."

The results of the pre-education self-report measures are found in Table 8.2. The pre-education measures revealed patients with moderate disability (ODI > 40%),³¹³⁻³¹⁵ potential risk for not returning to work (FABQ-PA > 14),^{251,319} high levels of pain catastrophization (average PCS was 25.4)^{79,80} and limited knowledge of pain (NPQ).³²²

Table 8.2: Patient self-report psychometric measures prior to LS for radiculopathy

Patient	ODI %	FABQ – W	FABQ – PA	PCS	Pain Knowledge
1	44	0	23	27	13
2	44	10	10	21	15
3	48	31	17	47	12
4	48	23	22	22	13
5	18	12	18	11	12
6	48	10	15	24	12
7	36	38	23	28	12
8	74	0	24	47	15
9	26	19	22	23	10
10	22	15	13	4	15
Average	40.8	15.8	18.7	25.4	12.9

ODI = Oswestry Disability Index; FABQ-W = Fear Avoidance Beliefs Questionnaire – Work Subscale; FABQ-PA = Fear Avoidance Beliefs Questionnaire – Physical Activity Subscale; PCS = Pain Catastrophization Scale.

The 10 patients scheduled for LS for radiculopathy were also asked to rate, on a 10-point scale their level of agreement (strongly disagree [0] – strongly agree [10]) with 7 statements regarding LS (Table 8.3). In response to the beliefs regarding LS, patients were ambivalent on 4 of the 7 questions (*I am afraid of the upcoming surgery; I know what to expect after back surgery; back pain after surgery is expected; and, I can control the amount of postoperative pain*). Patients tended to agree that “*back surgery will ‘fix my pain’*”; and “*I feel prepared and ready for surgery.*” They tended to disagree that “*leg pain after surgery is to be expected*”.

Table 8.3 Patient self-report beliefs regarding LS and their radiculopathy

Patient	1	2	3	4	5	6	7	8	9	10	Average Score
I feel prepared and ready for surgery	10	10	1	6	2	8	7	8	3	7	6.2
I am afraid of the upcoming surgery	2	6	4	9	10	1	3	8	5	5	5.3
I know what to expect after back surgery	4	6	0	3	6	9	2	6	9	7	5.2
Back pain after surgery is to be expected	5	2	0	8	8	8	8	6	2	7	5.4
Leg pain after surgery is to be expected	5	2	0	7	7	2	7	0	0	4	3.4
I can control the amount of post-operative pain	5	8	3	8	6	8	3	2	5	7	5.5
Back surgery will 'fix my pain'	10	9	10	9	5	9	7	9	10	7	8.5

Scores are on a 10-point scale (strongly disagree [0] – strongly agree [10]) with each statement

8.2.3 Pre-education physical performance

Prior to the preoperative NE, 3 physical tests were performed: fingertip-to-floor test, measured from the longest finger on the dominant hand to the floor;^{79,80} passive straight leg raise (SLR), measured with an inclinometer placed on the tibial plateau 5cm distal to the inferior border of the patella on the most affected leg,^{79,80} and 3 pressure pain threshold (PPT) measures, using a pressure-pain algometer at the web space of the dominant hand, adjacent to the L3 spinous process on the most affected side, and the posterior knee of the affected leg.³²³⁻³²⁵ Given the high levels of fear and potential provocative nature of forward flexion with herniated discs, active forward flexion was only performed once. The SLR measurements followed a standard protocol described previously,^{79,80} as well as the PPT measurements.³²³⁻³²⁵ The SLR was repeated 3 times on the involved and uninvolved (or less involved leg) and average scores were determined. Physical measurement outcomes are shown in Table 8.4.

Table 8.4 Physical examination findings prior to preoperative education

Patient	Active forward trunk flexion (cm)	SLR (degrees)	PPT kg/cm ²
1	36.5	43	10.6
2	31.5	48	18.6
3	53	18	16.1
4	30	43	13.1
5	2	70	16.5
6	10.5	38	8.2
7	19.5	33	9.9
8	47	31	10.6
9	-30*	148*	23.2
10	10	78	13.1
Average	21	55	13.9

* Patient was a high-level professional dancer who could easily put her palms flat on the floor. A step was gradually increased until the patient had her longest finger, dominant hand just touch the floor. Step height (30 cm) was thus subtracted from a zero score (touching the floor).

8.2.4 Intervention: Preoperative Neuroscience Education

Each patient received a one-on-one NE session of 30 minutes pre-operatively. The NE session was performed by the primary researcher (AL), utilizing images from the PNET, drawings, metaphors and examples. The session also allowed ample time for questions to be answered.

8.3 Results

Post-intervention data was gathered immediately after NE, as well as 1, 3 and 6 months following LS. Two patients (patients 5 and 7) did not undergo LS (5 - medical complications; 7 - decided to opt out of LS) but they were followed along with the other cases out to 6 months. One, 3 and 6 month data was collected via mailed, pre-paid postage envelopes containing surveys.

8.3.1 Outcome Measures

8.3.1.1 Back Pain

Six out of 10 patients reported higher pain scores for their low back immediately after the NE; however, only one (patient 6) exceeded the minimally detectable change (MDC) of 2.1.³²⁶(Figure 8.2) At the 1-month follow up, 8 patients reported less pain than at baseline and immediately following NE, with 6 of them exceeding the MDC. At the 3 and 6 month follow ups, most patients had minimal to no LBP (< 2/10), including the two patients who did not receive LS.

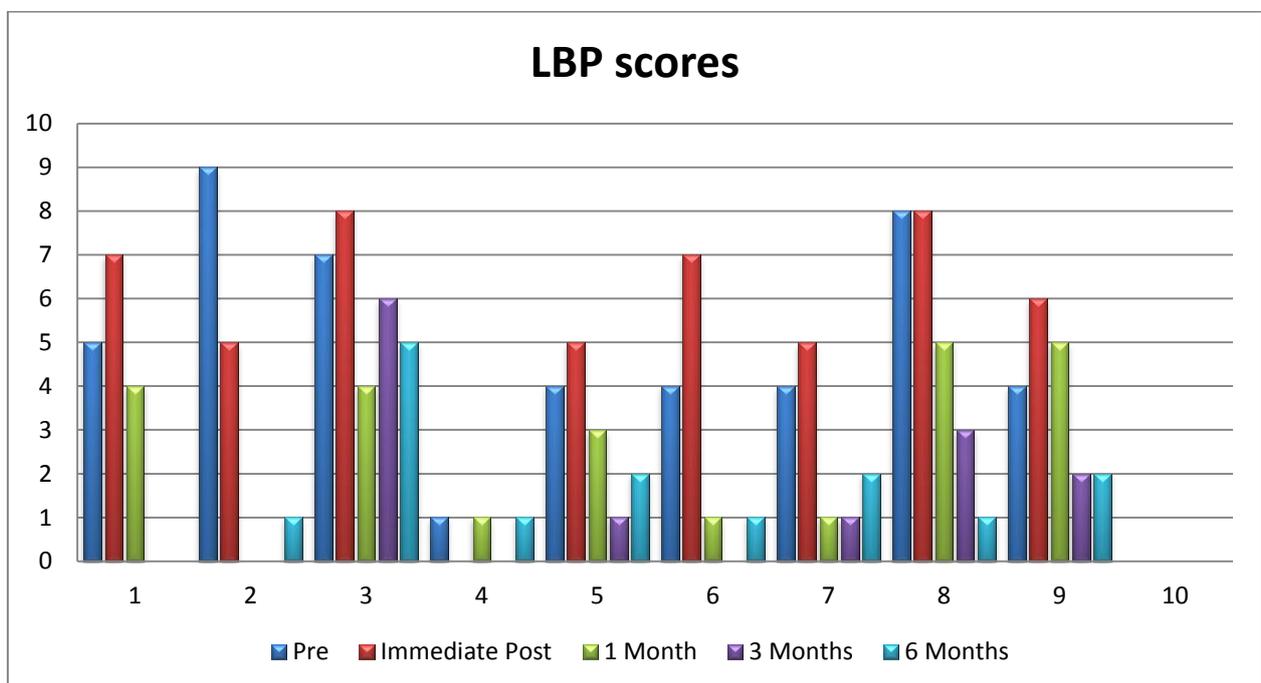


Figure 8.2: Low back pain (LBP) scores for all patients prior to neuroscience education (NE), immediately after and the 1, 3 and 6 month follow ups.

8.3.1.2 Leg Pain

Seven out of 10 patients reported higher pain scores for their leg (radiculopathy) immediately after the NE; however, none exceeded the MDC. (Figure 8.3) Most of the patients had no leg pain at the 1, 3 and 6 month follow ups.

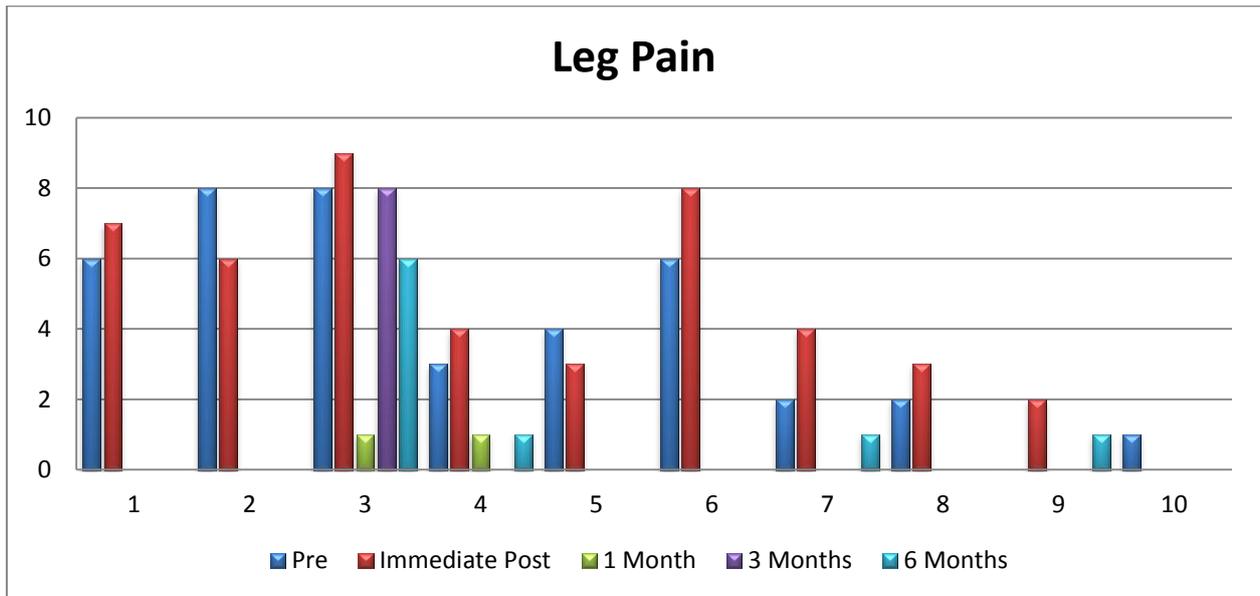


Figure 8.3 Leg pain scores for all patients prior to neuroscience education (NE), immediately after and the 1, 3 and 6 month follow ups.

8.3.1.3 PCS

All patients had lower PCS scores immediately following the NE, with 5 exceeding the MDC score of 9.1.³²¹ (Figure 8.4) Eight of the patients had PCS change scores exceeding the MDC by the 1, 3 and 6 month follow ups. Only patients 5 and 10, who started with low PCS scores (11 and 4 respectively) failed to show decreases in their scores beyond the MDC.

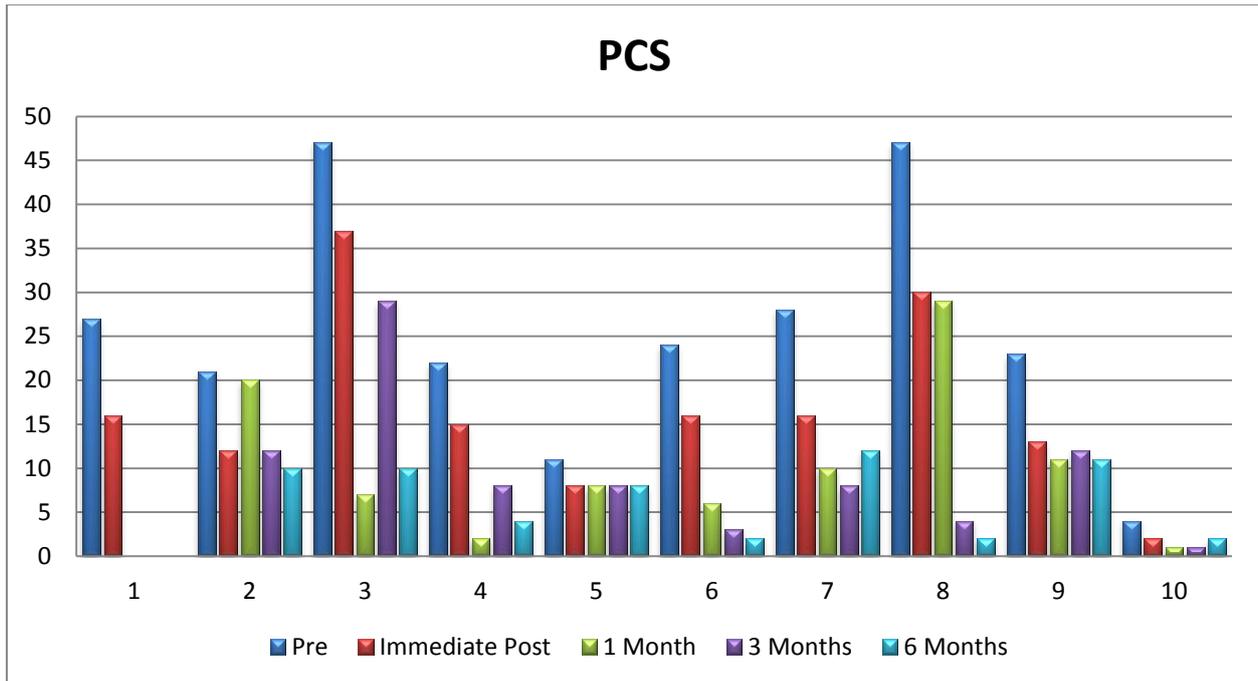


Figure 8.4 Pain Catastrophizing Scale (PCS) scores for all patients prior to neuroscience education (NE), immediately after and the 1, 3 and 6 month follow ups.

8.3.1.4 ODI

Seven of the patients reported decreased perceived disability beyond the minimal important change of 10%³¹⁶ at the 1-month follow up. (Figure 8.5) By the 6-month follow up, only 6 had achieved a 50% reduction in their ODI scores compared to baseline, representing a 60% success rate. It should be noted that of the 2 patients who did not undergo surgery, only one failed to achieve success (50% reduction in ODI) at the 6-month follow up.

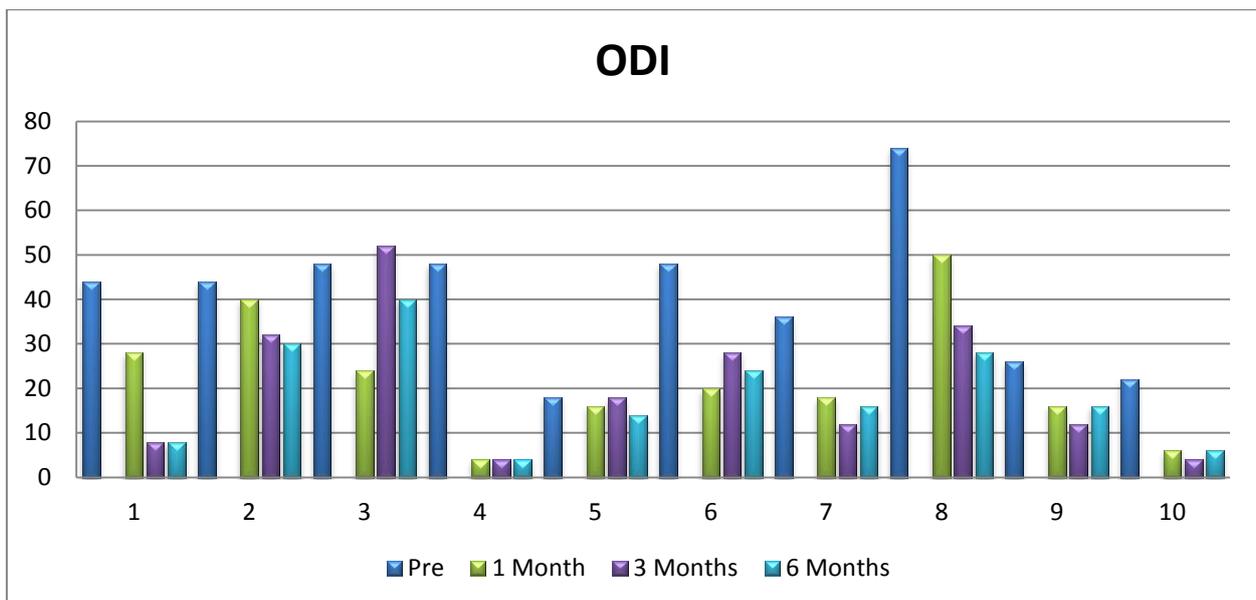


Figure 8.5 Oswestry Disability Index (ODI) scores for all patients prior to neuroscience education (NE), and at 1, 3 and 6 month follow ups.

8.3.1.5 Physical Measurements

Physical changes were only measured before and immediately after TNE (30 minutes later). Six of the patients demonstrated changes in fingertip-to-floor test beyond the MDC of 4.5 cm.³²⁷ (Figure 8.6) Six of the patients demonstrated changes in SLR beyond the MDC of 5.7°.³²⁷ (Figure 8.7) For the PPT measures, 6 patients had higher mean scores post-TNE. (Figure 8.8)

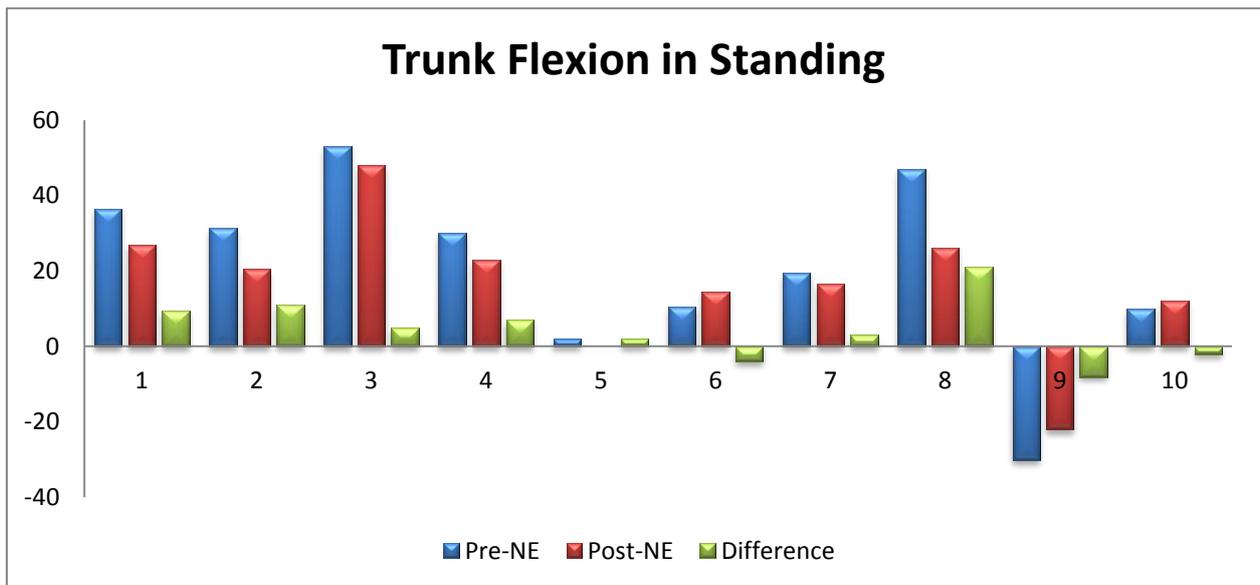


Figure 8.6 Fingertip-to-Floor Test measures for all patients prior to neuroscience education (NE), and immediately afterwards. Patient 9 was a professional dancer and contortionist who could easily put her palms flat on the floor. She was placed on a step where she had her longest finger, dominant hand just touch the floor. Step height (30 cm) was subtracted from a zero score (touching the floor).

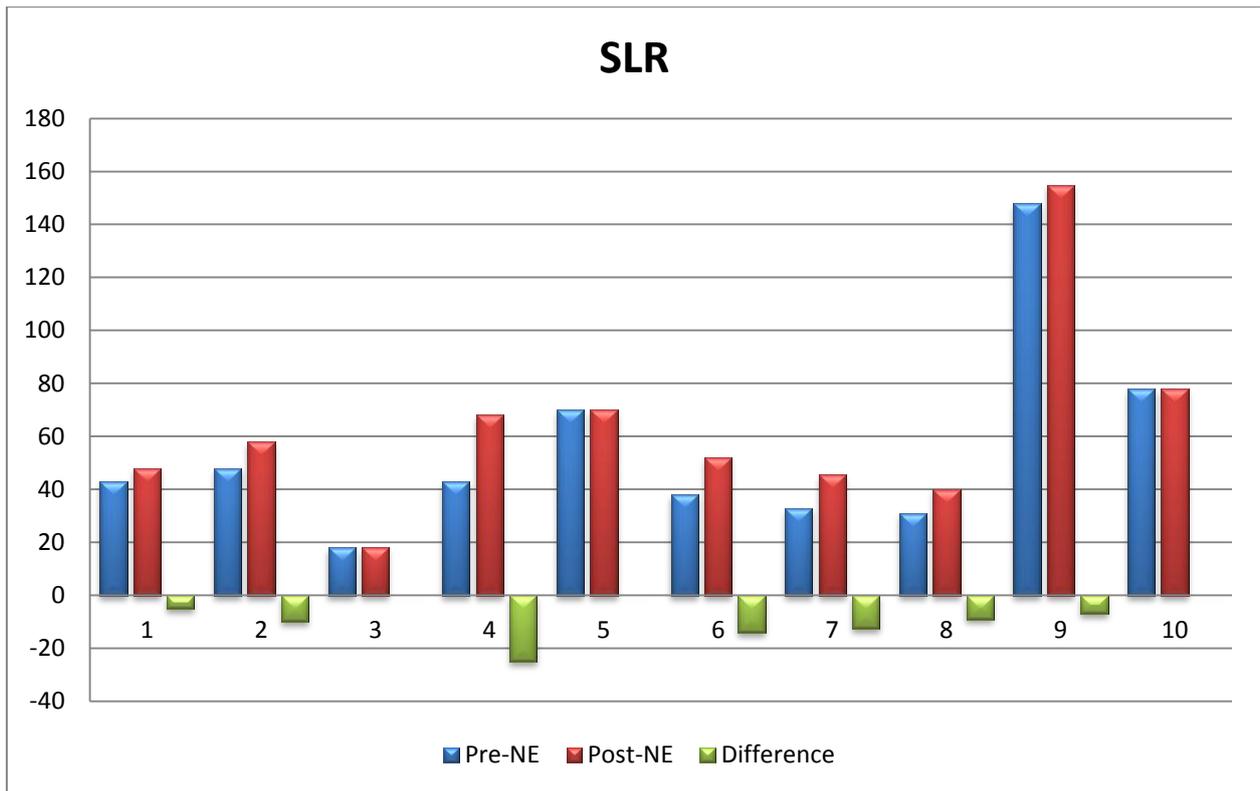


Figure 8.7 Straight leg raise (SLR) for all patients prior to neuroscience education (NE), and immediately afterwards.

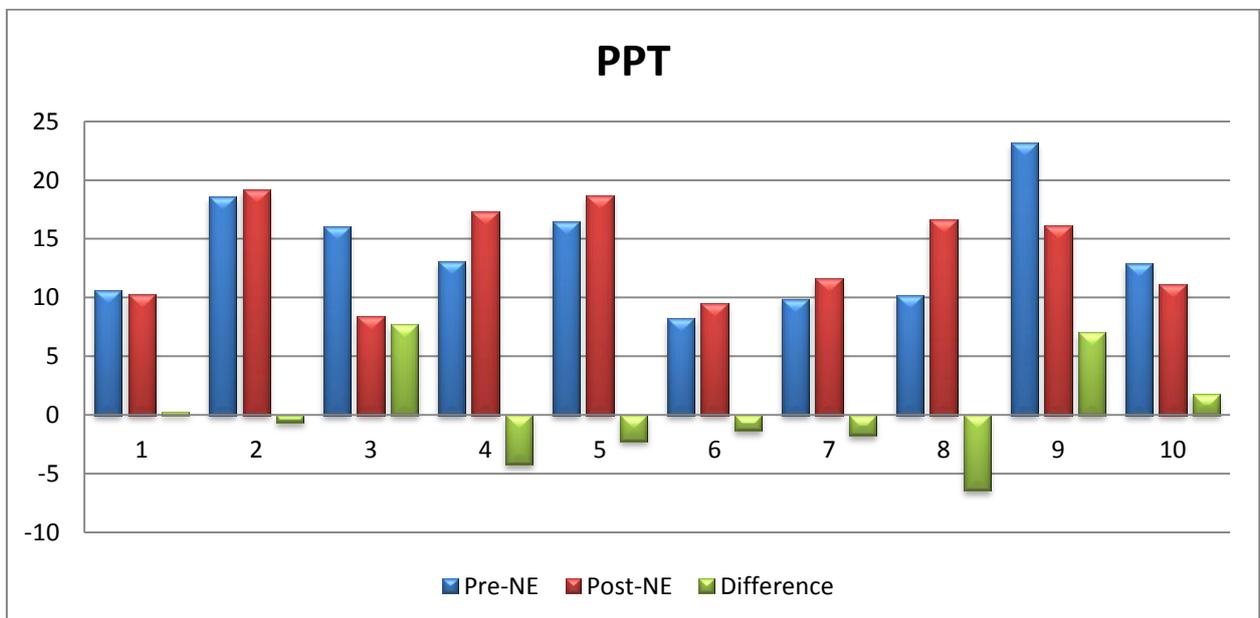


Figure 8.8 Pressure Pain Thresholds (PPT) for all patients prior to neuroscience education (NE), and immediately afterwards

8.3.1.6 Beliefs and cognitions about surgery

The immediate, post-TNE beliefs about lumbar surgery are presented in Figure 8.9. The results suggest positive shifts in patient beliefs about lumbar surgery, and the impact of the surgery on their expected symptoms and recovery.

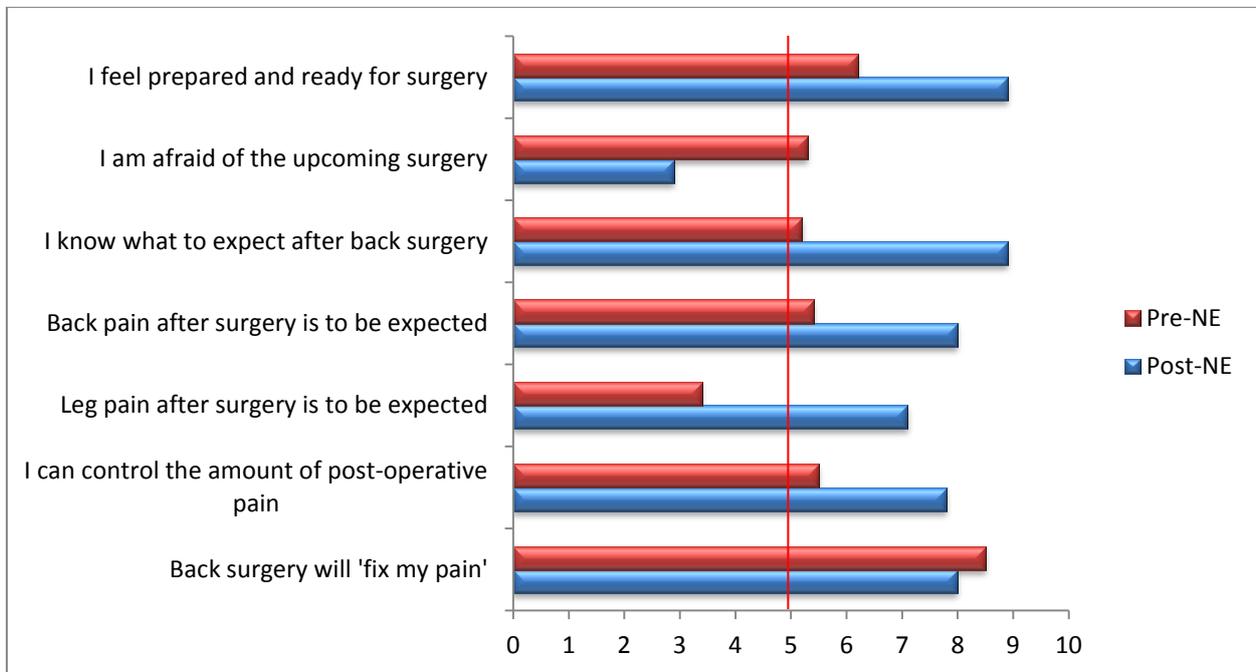


Figure 8.9 Patient self-report beliefs about lumbar surgery and their radiculopathy before and immediately after neuroscience education (NE). Scores below 5 indicate disagreement with the statements, whereas scores above 5 indicate agreement with the statements.

8.4 Discussion

This is the first study to measure the effects of preoperative NE on symptoms, emotions, cognitions and physical measurements associated with lumbar radiculopathy. The results of the case series show that immediately after NE, patients scheduled for LS for radiculopathy had detectable changes in pain catastrophizing, fingertip-to-floor test, passive SLR and positive shifts in their beliefs about LS.

Although care should be taken in the analysis of a case series of patients with no control subjects, results demonstrated immediate positive changes following the application of NE. The immediate changes in PCS and physical tests concur with previous studies using NE for chronic LBP (CLBP).^{79,80} At the core of NE for patients with lumbar radiculopathy is a message to help patients realize the pain they experience is more likely due to nerve sensitization and the effect of various perioperative influences rather than a more mechanistic and simple disc injury with resulting nerve irritation.

Disc herniation model descriptions have been associated with increased fear and anxiety,^{301,328,329} which has in turn been linked to limited movement and heightened increased irrational thoughts and coping strategies.^{80,330,331} Our results show that immediately after the NE, all patients had lower scores for PCS which could be interpreted as them changing their catastrophic thinking about their pain and injury. This reconceptualization is further demonstrated by the ability of the patients to willfully engage in further the fingertip-to-floor test, which has been shown to be very provocative in discogenic disorders and lumbar radiculopathy and also allow a clinician to move the involved lower extremity further.^{79,80} Both FABQ-W and FABQ-PA changed for the positive, though not clinically detectably, while the PCS resulted in an immediate lowering of 6.5 points, which is similar to the statistically significant changes produced by Moseley et al. performing NE in CLBP and measuring immediate post-education findings.⁸⁰ Considering the PCS assesses inappropriate coping strategies and catastrophic thinking about pain and injury it could be argued that NE aiming at re-conceptualizing pain cognitions are likely to have more of an immediate effect, whereas FABQ relates to physical tasks and work, which the newly acquired cognitions have not been able to be applied to. The one and three month data does show significant FABQ changes one and three months after surgery, which concurs with this possible explanation of the FABQ and PCS changes.

The largest effect however, occurred in patient beliefs regarding LS. Several studies have shown that beliefs and expected outcomes for LS are highly correlated with predicting outcome following LS.^{51,102,107,332} The sample of patients in this case series displayed numerous poor beliefs regarding LS beliefs prior to NE, associated with possible poor outcomes including

beliefs of LS “fixing” pain, expecting little to no pain after LS, uncertainty about the LS as well as unknown outcomes. Pain after LS is to be expected and expectations of no pain after LS are thus unrealistic.¹⁰⁷ In a study interviewing patients one month after LS for radiculopathy, Louw et al. showed that patients who experienced pain after LS expected to have some residual pain, and more than 50% indicated a true concern the pain would not go away, but rather increase.⁵⁶ Immediately following the NE, patients shifted their realistic expectations of back pain (*back pain after surgery is to be expected*), leg pain (*leg pain after surgery is to be expected*) and ability to control their own pain (*I can control the amount of post-operative pain*) by > 50%, thus preparing them for potential pain after surgery. One and three month post-operative data indicated some patients were still experiencing pain, which coincided with persistent decreased psychometric measures of fear avoidance and pain catastrophizing.

The reconceptualization of pain and the pain experience is a key point. To date there have been several preoperative education studies used in orthopedic extremity surgery^{12-14,63} and spine surgery,^{47,49,188} mainly preparing patients for their surgery by explaining procedural information. Several RCT's and systematic reviews, however, have shown little to no effect in postoperative outcomes.^{20,21,23,24} The studies did show patients felt more prepared for the impending surgery, which concurs with the findings of this case series where patients feel more prepared for surgery (*I feel prepared and ready for surgery; I know what to expect after surgery; and I am afraid of the upcoming surgery*), but no post-operative changes in range of motion, pain, length of hospital stay or function. The one and three month postoperative data from this case series show a dramatic decrease in pain ratings and function. This addition of pain education to preoperative education concurs with the study by McDonald, where total joint arthroplasty patients were provided with pain science education and showed immediate postoperative pain reduction effects.¹⁸⁴

Another very important potential implication of this case series is the delivery of pre-emptive NE. To date NE has been applied to various orthopedic and musculoskeletal patients, mainly CLBP.²⁸⁸ One weakness of a case series design is the lack of control patients. This case series, however, showed that patients who received NE prior to LS had significant changes in LBP, leg pain, pain catastrophization, fear of work, fear of physical activity and function one month after LS and these positive changes remain intact 2 months later (3 months after surgery). Given the fact that between 10 to 40% of patients following LS for radiculopathy experience persistent pain, loss of movement and disability,¹⁴ and postoperative rehabilitation has shown little effect in changing postoperative disability and pain^{9,12,18,308} NE may provide a unique role for physiotherapy and LS patients. Furthermore, NE may provide an additional lessening of pain and disability following LS for radiculopathy, with benefits for all stakeholders in the patient's outcome.

8.5 Limitations

There are several limitations to the level of evidence from case series. Case series by design do not utilize a comparison group and the true effect of NE compared to other interventions or no interventions is not known. The case series was specific to adults undergoing a selective surgical procedure for specific conditions. The possible effect of NE on other kinds of LS (i.e., fusions); younger patients; patients with other symptoms and indications for surgery are unknown.

8.6 Conclusions

In this case series, 10 patients scheduled for LS for radiculopathy underwent a preoperative NE program, resulting in immediate, 1 and 3 months postoperative clinically meaningful changes in pain, psychometric measures of pain catastrophizing and fear avoidance, function, physical movement and beliefs regarding LS. Although this case series does not suggest superior results to usual or no care, the intervention may be clinically effective in leading to preoperative and possible postoperative changes in lumbar radiculopathy patients undergoing surgery.

Chapter 9:

Evaluation: Functional Magnetic Resonance Imaging Case Study Examining the Immediate Post-Education Effect on Brain Activation after Application of the Preoperative Neuroscience Educational Tool

9.1 Introduction

It is well established that the surgical environment is associated with increased stress and anxiety,^{120,172,333} and several studies have shown that increased anxiety in the preoperative period is associated with increased postoperative pain.^{33,38,120-122,172} Additionally, several studies have shown that pain is a critical issue with orthopedic surgery.¹⁶⁵⁻¹⁶⁹ Preoperative education is a strategy designed to decrease postoperative pain, complications and disability.^{20,21} To date, only a handful of studies have been conducted on the outcome of preoperative education for lumbar surgery (LS), and those that focus on procedural information and informed consent have demonstrated limited benefit for post-surgical outcomes.^{23,47,49,188,189} This may be because most of the education programs used in orthopedic patient populations have utilized anatomical and biomechanical models for addressing pain,^{59,66,79,250} which not only show limited efficacy,^{59,66,69,70,250} but may even increase patient fears, anxiety and stress, thus negatively impacting outcomes.^{66,71-73}

In lieu of the high levels of fear and anxiety prior to LS, the limited effect of biomedical and procedural education prior to surgery and the evidence for NE, a preoperative neuroscience educational tool (PNET) was developed for pre-operative education of lumbar radiculopathy patients (described in Chapters 3 – 7). The PNET has demonstrated immediate post-education positive effects on fear, catastrophization, attitudes and beliefs regarding LS as well as physical movement including straight leg raise (SLR) and active trunk forward flexion in a series of 10 case studies (Chapter 8).³³⁴ Considering the immediate positive changes to range of motion (ROM), psychometric measures of pain, as well as attitudes and beliefs regarding LS in the absence of a physical intervention (manual therapy or exercise) it is postulated that the immediate changes may in fact be due to a change in the construction of a patient's pain neuromatrix. The purpose of this single-case study was therefore to determine if there were changes in brain activation, which may be associated with the changes in self-reported beliefs and attitudes regarding LS, psychometric measurements and ROM, in a patient, scheduled for LS for lumbar radiculopathy, by undergoing a functional MRI (fMRI) scan before and immediately after the application of the PNET.

9.2 Case Description

Prior to examination and treatment the patient provided written consent to be part of the study. The patient was a well-nourished, healthy 30 year-old female high-level professional dancer who provided consent for the study, including undergoing fMRI while performing a painful task. The patient had a 4-year history of chronic recurrent LBP. The patient could not recall a specific injury or accident, and related her symptoms to her work as a professional dancer and the repetitive strain on her back. Her symptoms had been treated conservatively with physiotherapy (manual therapy, exercise and modalities), medication and modified or decreased activity. The patient had undergone magnetic resonance imaging (MRI) studies of her lumbar spine on 3 separate occasions with each revealing an L5/S1 disc bulge. The most recent scan (3 months previously) demonstrated a marked herniated L5/S1 disc; central and left towards the nerve root (Figure 9.1).



Figure 9.1 Recent MRI of the lumbar spine indicating L5/S1 herniated disc

Clinically, the patient presented in no visible distress, demonstrated normal gait and no visible abnormalities with functional tasks such as sitting, transfers to and from sit to stand, taking her shoes off and putting on a gown needed for the fMRI procedure. On the day of the study, the patient reported vague, constant, non-variable LBP across the back (left more than right), spanning the L2-L5 spinal levels, and radiating pain into both buttocks and upper thighs (Figure 9.2). The patient denied any neurological symptoms, including sensory symptoms or muscle weakness. Her neurosurgeon, who attended the session, reported decreased motor power of great toe extension on the left foot, with manual muscle testing.

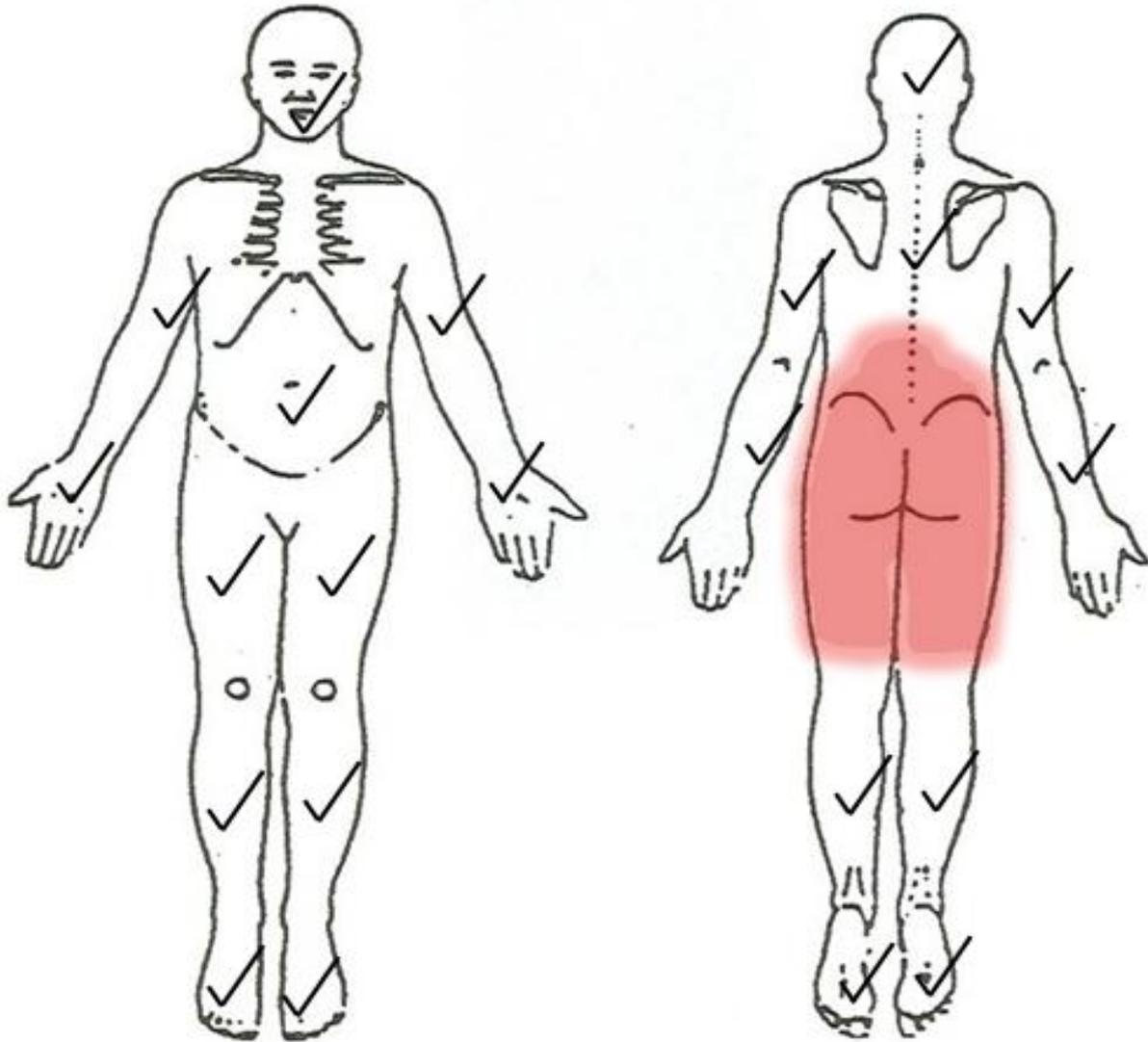


Figure 9.2 Patient's body chart indicating pain distribution. Check marks indicate pain-free areas

9.2.1 Baseline Measures:

Intake forms included a demographics questionnaire, fear avoidance beliefs questionnaire (FABQ),³³⁵ pain catastrophization scale (PCS),^{56,59} Oswestry disability index (ODI),^{313,314} visual analogue scale (VAS) for LBP and leg pain,^{77,81,82,326} pain neurophysiology knowledge questionnaire³¹¹ and a series of Likert-scale questions on her beliefs and attitudes regarding lumbar surgery as it relates to her LBP and leg pain.⁵⁶ (Table 9.1)

Table 9.1 Intake information prior to Preoperative NE

Measure	Score
Low back pain rating (VAS)	4
Leg pain rating (VAS)	0
Disability (ODI)	26%
Fear of work (FABQ work sub-scale)	19
Fear of physical activity (FABQ physical activity sub-scale)	22
Neurophysiology pain knowledge	10/19
Pain catastrophization (PCS)	23
I feel prepared and ready for surgery (strongly agree [0] – strongly disagree [10])	7
I am afraid of the upcoming surgery (strongly agree [0] – strongly disagree [10])	5
I know what to expect after back surgery (strongly agree [0] – strongly disagree [10])	1
Back pain after surgery is to be expected (strongly agree [0] – strongly disagree [10])	8
Leg pain after surgery is to be expected (strongly agree [0] – strongly disagree [10])	10
I can control the amount of post-op pain (strongly agree [0] – strongly disagree [10])	5
Back surgery will fix my pain (strongly agree [0] – strongly disagree [10])	0
Lumbar flexion	10cm
SLR	148°
Pressure pain thresholds (average of 3 measurements) (kg/cm ²)	23.23

Abbreviations: VAS – Visual Analogue Scale; ODI – Oswestry Disability Index; FABQ – Fear Avoidance Beliefs Questionnaire; PCS – Pain Catastrophizing Scale; SLR – Straight Leg Raise

Her intake data portrayed a patient presenting with moderate LBP, no leg pain, high fear levels associated with physical activity and work, a high level of pain catastrophization, limited knowledge of pain and various beliefs regarding the pending LS.

The physical examination consisted of 3 tests (active trunk flexion, SLR and PPT) described in section 8.2.3. Given the patient's significant flexibility as a dancer, she stood on a stool (30 cm off the floor) to ensure she could potentially reach the end-limit of her active trunk flexion. The resulting forward flexion produced a high degree of flexion allowing fingertips to easily touch the floor, but not the palms of the hands. It was decided to modify this test and measure the

distance (patient on the stool) from the distal crease of the dominant hand to the floor (Figure 9.3). The SLR was repeated twice on the involved (left) and less involved (right) leg and average scores were determined (figure 9.4). Data from the physical tests can be found in Table 9.1.



Figure 9.3 Forward flexion in standing test was performed with the patient standing on a 30 cm stool. Measurement (cm) was taken from the distal crease of the dominant wrist to the floor.

Figure 9.4 Passive straight leg raise (SLR) was measured using a bubble inclinometer placed on the tibial plateau 5 cm distal to the inferior border of the patella. In this case, the patient was extremely flexible.

The patient's surgery date had not been set at the time of the case study, but was imminent. The patient, apart from psychometric measures, verbalized a concern and general anxiety about undergoing LS. The neurosurgeon indicated surgery was likely the preferred option due to the long history; persistent pain; high-level of performance of the patient; visibly worsening disc pathology on the latest MRI; and weakness in the right big toe extensors (L5 Myotome).

9.3 Functional Magnetic Resonance Imaging (fMRI)

An imaging protocol used in a previous fMRI study examining brain activity with a Phillips fMRI scanner before and after NE was used for this case study.⁸² The patient was placed supine with pillows under her knees and her head in a headrest to ensure no movement of the head during the scan. The patient was draped with a blanket. While in the scanner, the patient was listening to music. During this time, the scanner developed a neutral, anatomical image of the brain (Figure 9.5). The brain activity during this phase (5 minutes) would be considered the normal, resting brain activity during a pleasant, neutral experience such as listening to music or

watching a movie. The anatomical (resting level) scan would be used as a “canvas” to “paint” brain activity during the experimental pain task.

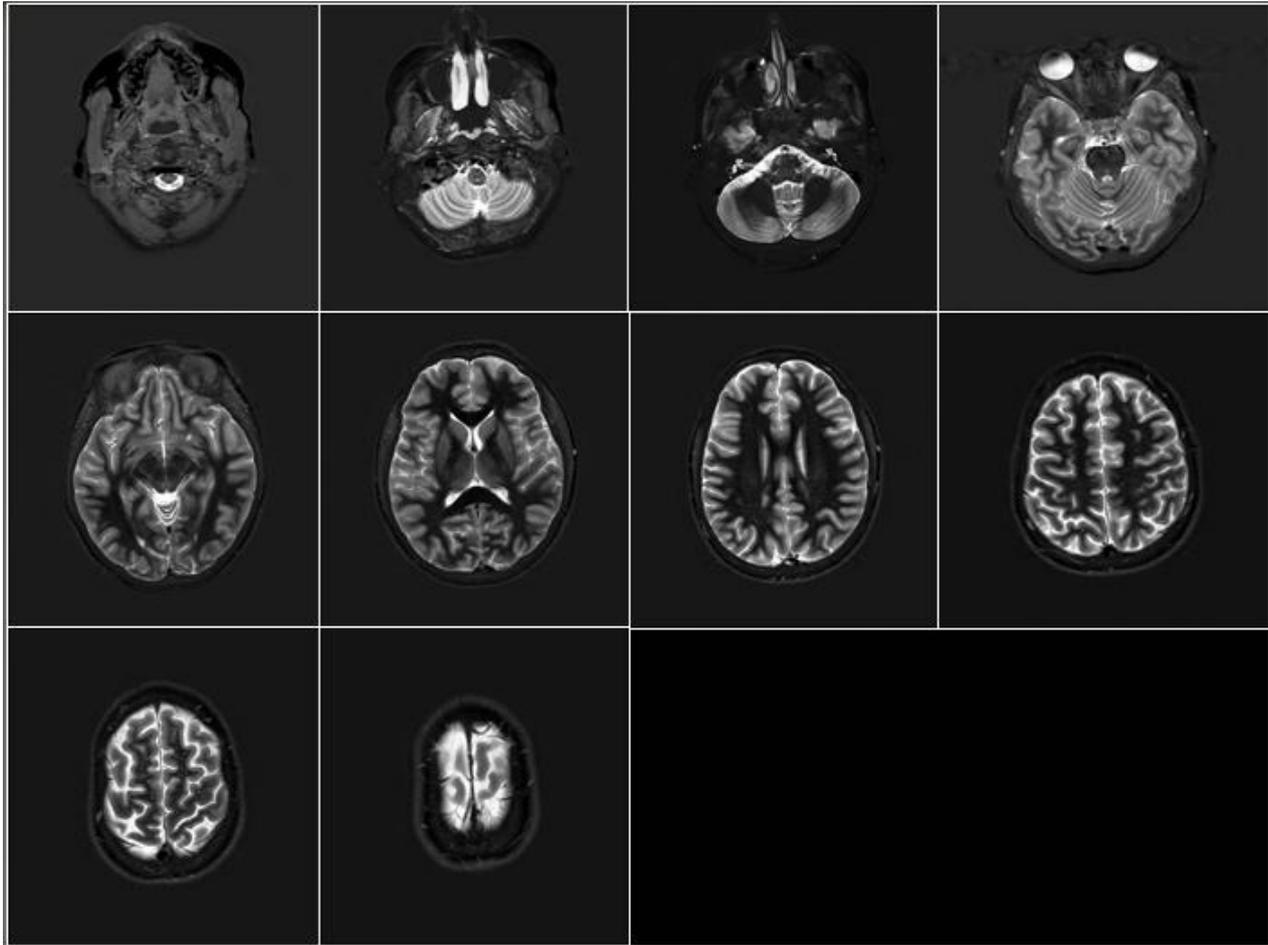


Figure 9.5 Anatomical fMRI of the brain in this patient without performance of the painful activity (quiet resting state)

Prior to scanning, it was determined that the patient could reproduce her LBP by arching her lumbar spine (extension in supine) and the pain would remain until she released the lumbar extension and resumed a neutral position. After the 5-minute anatomical scan, the patient was instructed to perform 5 sets of 30 seconds of lumbar extension (painful task) followed by 30 seconds of relaxing (non-painful tasks), thus alternating (for 5 minutes) painful and non-painful tasks. The scanner was able to produce a real-time acquisition of brain activity during the task. The patient was cued to perform the tasks with a visual cue on a screen. Observation of the patient during the extension task revealed 100% compliance with the lumbar extension task of the 5 x 30 second pain task of spinal extension and 5 x 30 seconds non-painful relaxation in-between. The fMRI thus yielded images of brain activation during a painful task for a patient scheduled for LS for radiculopathy (Figure 9.6). Statistical comparisons between the activity of the brain during the “on” (painful task) condition and the “off” (rest; non-painful task) condition were made using statistical parametric software.⁸²

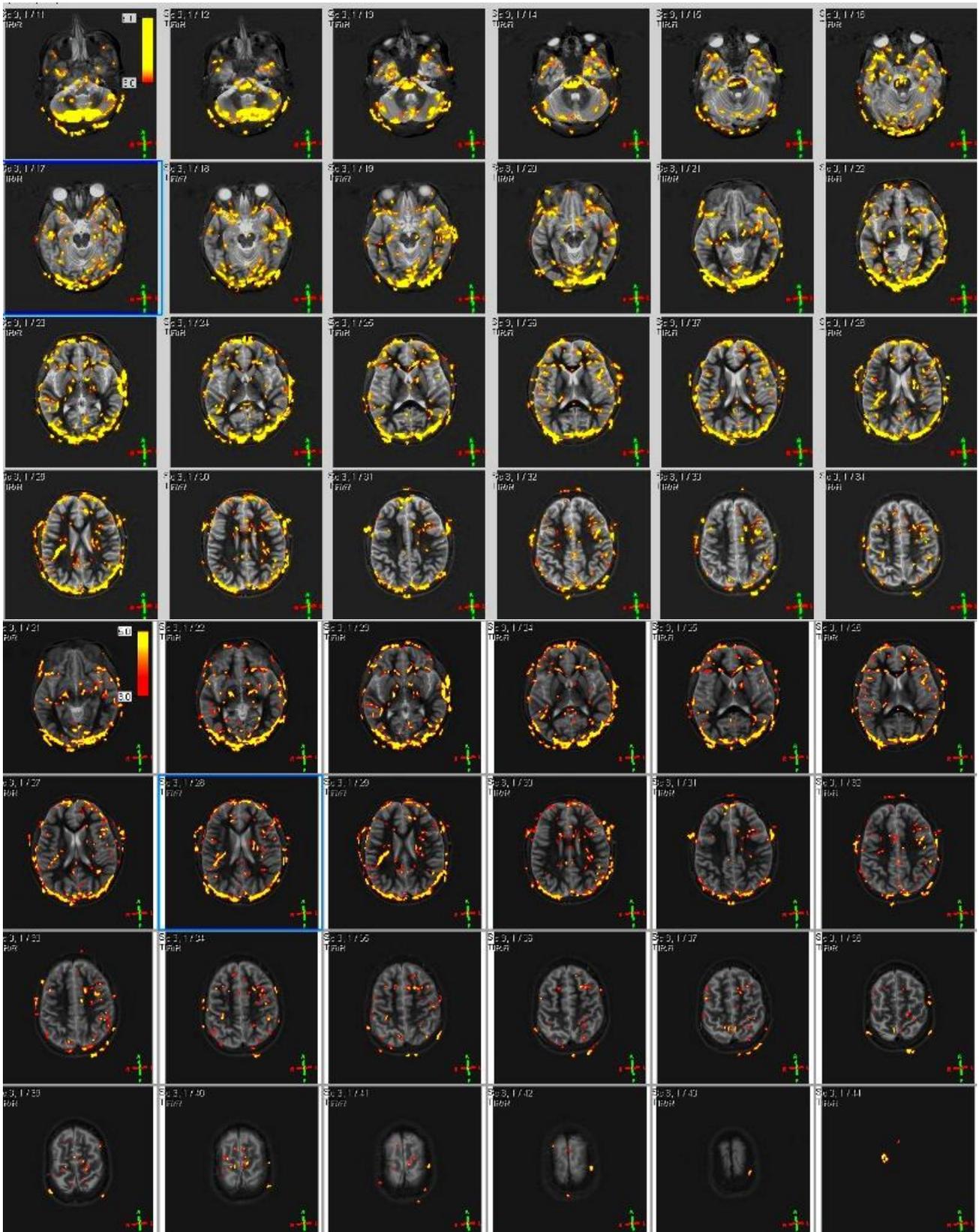


Figure 9.6 Pre-NE fMRI scan of brain activation during the painful lumbar extension task

9.4 Clinical interpretation of the demonstrated brain activity

The psychometric data, physical measurements and subjective examination portrayed a clinical picture of a high-level professional dancer presenting with persistent LBP, intermittent leg pain, worsening neurological deficit, with high levels of fear associated with her physical tasks and work as a dancer. Furthermore, she held certain beliefs about LS and recovery, and displayed a limited knowledge about pain. Physically, she presented with high level of physical movement and high pressure pain tolerance. Despite this, she appeared to be afraid of both the impending LS, as well as the uncertainty of the outcomes. Given her high level of dance performance and the fact that she, post-operatively, would need to physically and emotionally perform at a high level, it could be argued that her anxiety and fear was heightened, as she faced the possibility of not being able to return to her regular high-level activities.^{336,337} This was underscored by her heightened FABQ and PCS scores. In regards to LS, she demonstrated a lack of preparedness. It is interesting to note that she had very strong beliefs that after LS she was expected to have little, if any, LBP or leg pain. This is contrary to literature pertaining to decompressive surgery outcomes, as well being a potential predictor of persistent pain after surgery.¹⁰² Several studies have correlated unrealistic expectations with poor outcomes after LS.^{102,332,338,339} The heightened fear and anxiety prior to surgery concurs with several studies implicating a hypervigilance of the nervous system prior to surgery.^{120,172,333}

Considering this single-case fMRI study was based on a similar study by Moseley⁸² and the patient had several comparable signs and symptoms to his patient case study (years of LBP, leg pain, high fear, failed treatment, pain medication, etc.) similar widespread brain activation was expected.⁸² In the Moseley study, widespread brain activity occurred in areas known to be frequently activated in the pain neuromatrix.^{75,82,250} The fMRI scan in this case study indicated 3 very specific brain activities which were deemed important to the interpretation of the scans: significant activation in the cerebellum; activation of the periaqueductal gray (PAG) area and very little cortical activation, especially the motor cortex.

9.5 Intervention: Preoperative NE

After completion of the baseline fMRI, the patient was escorted to a private room to undergo a one-on-one 30-minute verbal session of the developed PNET with the primary researcher. Her neurosurgeon was also present in the room, but out of the visual field of the patient. The educational session included questions and answers, open ended-questions for the patient to answer, drawings and descriptions of action potentials and nerve sensitivity. The patient was visibly intrigued by the program, alert and engaged.

9.6 Outcomes

After completion of the PNET, the patient was asked to complete the same intake forms she completed at the start of the session. Additionally, the same physical measurements were repeated and recorded. (Table 9.2) The most noticeable immediate positive changes in psychometric measures following the session included a 10% decrease the ODI and a 10 point decrease in the PCS along with several positive changes in beliefs and attitudes regarding the impending LS. Physically, the patient demonstrated increased SLR by 7 degrees and forward flexion by 8 cm (stool height was adjusted accordingly to accommodate measurement). Several measures showed little or no change, including: fear avoidance (total score, FABQ-W and FABQ PA) and pain knowledge. In some categories, a negative effect occurred, including slight increased pain ratings and decreased PPT measurements.

Table 9.2 Measurements pre- and post-NE

Measure	Pre Ed	Post Ed	Changes
Low back pain rating (VAS)	4	6	↑ 2
Leg pain rating (VAS)	0	2	↑ 2
Disability (ODI)	26%	16%	10%
Fear of work (FABQ work sub-scale)	19	18	↓ 1
Fear of physical activity (FABQ physical activity sub-scale)	22	22	No change
Neurophysiology pain knowledge	10/19	12/19	↑ 2
Pain catastrophization (PCS)	23	13	↓ 10
I feel prepared and ready for surgery (strongly agree [0] – strongly disagree [10])	7	5	↓ 2
I am afraid of the upcoming surgery (strongly agree [0] – strongly disagree [10])	5	8	↑ 3
I know what to expect after back surgery (strongly agree [0] – strongly disagree [10])	1	0	↓ 1
Back pain after surgery is to be expected (strongly agree [0] – strongly disagree [10])	8	4	↓ 4
Leg pain after surgery is to be expected (strongly agree [0] – strongly disagree [10])	10	9	↓ 1
I can control the amount of post-op pain (strongly agree [0] – strongly disagree [10])	5	5	No change
Back surgery will fix my pain (strongly agree [0] – strongly disagree [10])	0	1	↑ 1
Lumbar flexion*	10cm	2cm	↑ 8 cm
SLR	148	155	↑ 7 degrees
Pressure pain thresholds	23.23	16.17	↓ 7.06

* Lumbar flexion was assessed with the patient standing on a 30 cm stool.

The same fMRI protocol was repeated after the delivery of the PNET. The patient once again completed 100% of her painful tasks (lumbar extension) in the 5 x 30 second blocks interspersed with rest periods. After the fMRI, she appeared to be in less discomfort and reported that there was less discomfort than after the baseline fMRI scan. The brain activity from the post-NE scan

is seen in Figure 9.7. The post-education scan revealed 3 marked differences compared to the baseline scan, including; deactivation of the periaqueductal grey area (PAG) and cerebellum, and increased activation in the motor cortex (Table 9.3).

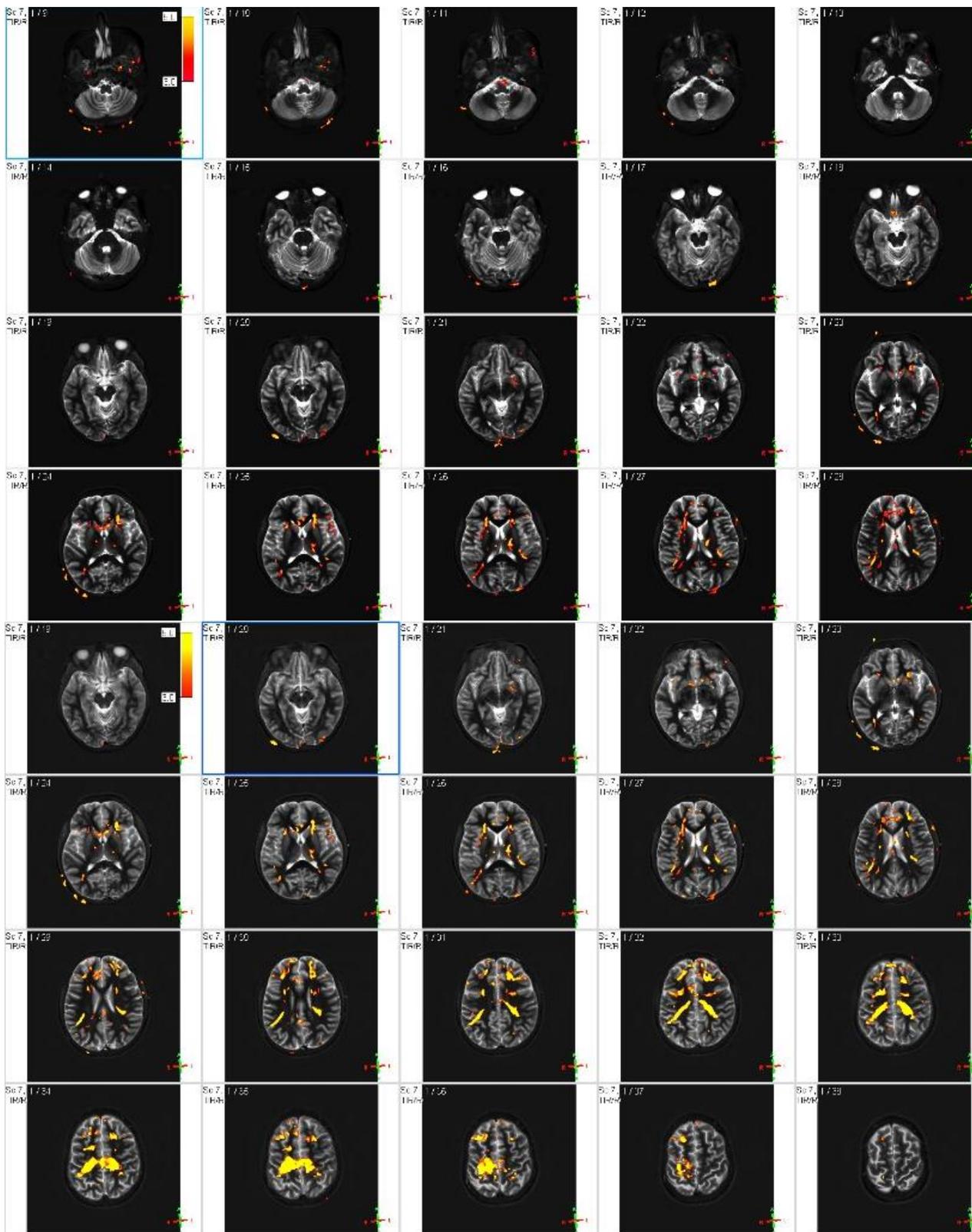
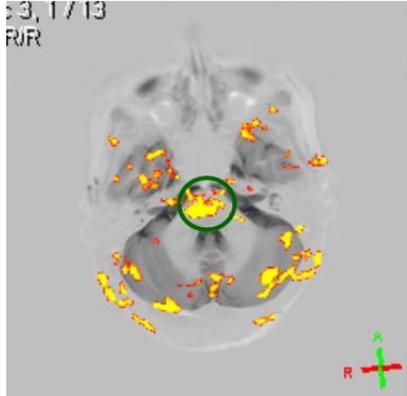
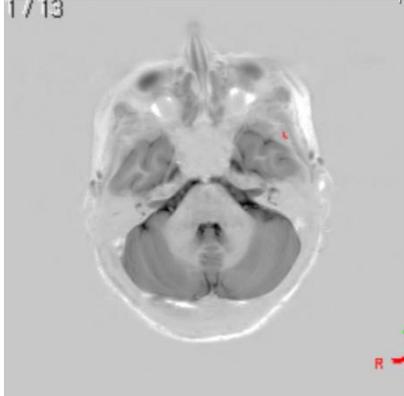
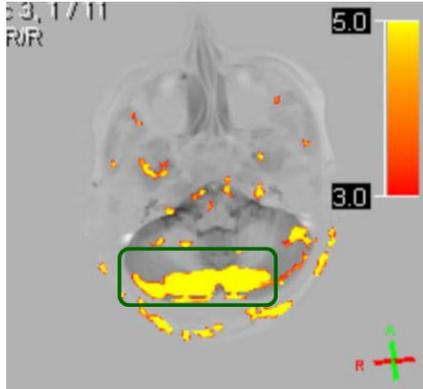
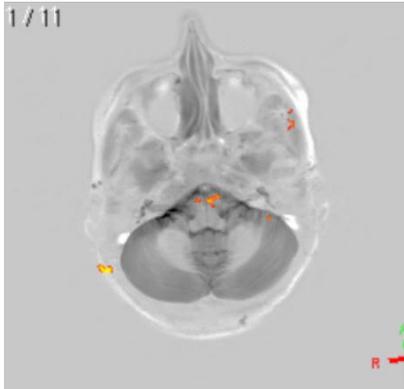
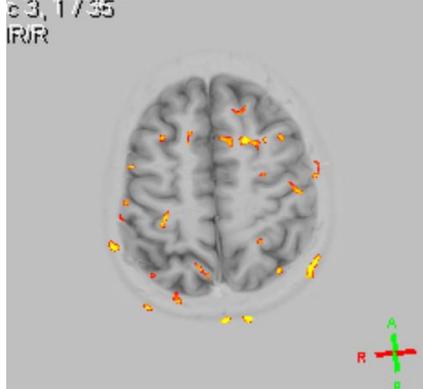
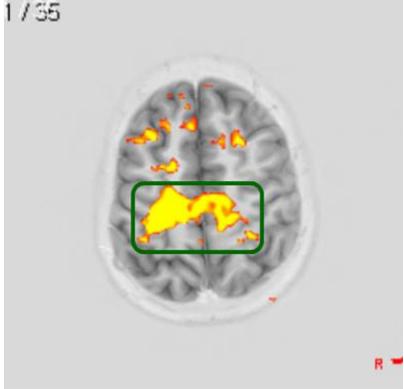


Figure 9.7 Post-NE fMRI scan of brain activation during the painful lumbar extension task

Table 9.3 Comparison slices of brain activation before and after preoperative NE. Green circles and blocks indicate areas described in column 1 and main area of activation.

Description	Pre-education scan	Post-education scan
Decreased activation of the Periaqueductal Grey matter (PAG)		
Decreased activation of the cerebellum		
Increased activation of the motor cortex		

9.7 Discussion

To our knowledge this is the first study where the effect of NE on brain activation is demonstrated on a patient scheduled for LS for radiculopathy. The preoperative NE program resulted in positive changes in several psychometric measurements, the patient's beliefs and attitudes regarding the impending LS, physical movements and changes in brain activity.

The results from this single case study concur with various studies utilizing NE.^{77,79,81,202,288} Although the patient reported slightly higher pain levels following the education session (increase by 2 points for both low back and leg pain scores), NE often produces no significant immediate changes in pain ratings.^{202,288,340} Clinical experience often shows a slight increase in pain after a NE program. This slight, immediate increase in pain can likely be either due to the increased awareness and discussion of pain, which has been shown to increase pain ratings.³⁰³ Furthermore, it could be argued for patients seeking a true cognitive change, a deep learning process needs to occur.^{270,271,273} Deep learning implies the reception of the information, processing of the information and applying the information to their specific condition, i.e., facing spinal surgery.³⁰³ Deep learning is an emotional process addressing beliefs, fears, hopes and goals, which may in fact produce a greater awareness of the pain experience, which may manifest by a slight increase pain perception, before the perceived pain decreases.^{270,271,273} If pain, according to the modern definitions of pain, is an output as a defender of perceived threat, it may underscore the notion of a defense mechanism, in place for 4 years in this patient, not readily shutting down all pain.^{75,213,250}

In contrast to perceived pain, the patient had improved movement, comparable to several other studies examining the immediate effect of NE on physical tasks.^{79,202,288,340} Even though the patient did not participate in functional tasks prior to re-measuring her disability, her perceived disability was lower on the ODI, comparable to other NE studies.^{202,252,288} We consider this as the essence of NE; the ability to function and move better *despite* pain. Pain is essentially 'reconceptualized'.^{202,213} Pain is often seen as an indication of injury or disease.^{301,302} NE provides the patient another paradigm to explain their pain, i.e., nervous system sensitivity and the nervous system's processing of nociceptive input.²⁸⁸ This allows for a reappraisal of threat, and in lieu of the decreased threat, movements increase, function improves and various psychological perspectives change.

Even though the patient had several positive changes, expressed fear was not changed. Several NE studies have clearly shown that scores in psychometric tests aimed at evaluating fear and fear-related measures, were reduced after NE, but not in this case.²⁸⁸ Catastrophization, though, was markedly changed in this patient, similar to the study by

Moseley et al.²⁰² Catastrophization is the process whereby a patient has irrational thoughts, believing a situation is far worse than it actually is. It is postulated that, given the high demands of such a professional dancer, fear may have remained high, since the patient had little margin for error.^{336,337,341} LS for radiculopathy is typically performed on middle-aged patients, of which few likely have such demanding physical tasks where a recovery of less than 100% may be disastrous.^{9,16} This interpretation is further enhanced by the fact that the patient reported less fear of the surgery after the educational session, which may indeed indicate greater fear associated with recovery.^{336,337,341}

The patient demonstrated a marked shift in beliefs and expectations regarding LS with an average of almost 3 points on a 10 point Likert scale. From unsure/ambivalent thoughts regarding being prepared for LS, the patient reported feeling more prepared and a decreased self-reported fear of LS. The biggest change regarding LS occurred in relation to her expectations of the outcomes. Prior to the educational session, the patient demonstrated a high degree of expecting pain to be abolished (back and leg) immediately after LS. The patients' starting score (untrained) in neurophysiology pain knowledge³¹¹ (52%) was high in comparison to the study by Moseley (29%), and improved after the PNET to 63%, comparable to the Moseley study (61%).³¹¹ The increased knowledge of the neurophysiology of pain may have likely provided the patient with a greater understanding that pain after surgery is expected. This is important, as several studies have correlated unrealistic expectations with poor LS outcomes.^{102,332,338}

The fMRI results need to be carefully analyzed, as fMRI, although increasingly utilized in pain studies, still have many unanswered questions.³⁴² Even if we consider all the potential pitfalls in our understanding of fMRI, this case study revealed notably different brain activations during a painful task in the same patient, before and after a preoperative NE program. Although the fMRI study by Moseley did not include performance of a painful task, it was decided to have the patient perform a painful task (lumbar extension) as a means to activate the pain neuromatrix. It was deemed acceptable to include a painful task in the study, given the patient's relative low levels of pain, her long history of regularly performing while in pain, and her willingness to perform the painful task.

The three main brain area changes in the scans are intriguing. The PAG is the grey matter located around the cerebral aqueduct within the tegmentum of the midbrain.³⁴³ It plays a role in the descending modulation of pain and in defensive behavior.^{344,345} The ascending nociceptive fibers from the injured spinal level (L5/S1) send information to the PAG via the spinomesencephalic tract. Stimulation of the PAG activates encephalins, serotonin and

neurotransmitters aimed at modulating the incoming nociception.²⁰⁴ With the high activation of the PAG initially (pre-education scan) it could be argued that the painful task of lumbar extension provided a nociceptive (A- δ and C-fiber) barrage to the brain. This may have been further enhanced by the patient's high levels of fear. In the post-education scan, the patient was provided with a different paradigm for her pain, de-emphasizing tissues as the "source of pain", which may have deactivated the PAG's immediate protective function. The fact that the patient performed a physical task would imply the activation of the motor cortex of the brain.³⁴⁶ In the pre-education scan, no cortical activation is observed, but rather a significant activation of the cerebellum, more specifically the vermis and lateral lobes of the cerebellum. This activation is consistent with coordinated trunk activity. The vermis plays a significant role in various aspects related to movement potentially important to our high-level dancer including locomotion, coordination, strength, limb movements, planning and initiation and time of movements.³⁴³ Given the fact that the patient was supine (no locomotion) and a high level dancer, it could be postulated that the vermis activation may be related to the position she assumed (spinal extension), possibly even due to the fact she experienced pain in that posture. It is also important to realize that during a pain experience, such as this, the lower centers of the brain, including cerebellum activate prior to cortical activation, thus allowing lower centers of the brain to deal with immediate danger including basic protection, motor and autonomic dysfunction. The higher cortical areas, including motor cortex, follow dealing more with motor planning, feelings and thoughts.^{250,346} This lower-level activation could thus be interpreted as an immediate defense from the nociceptive input. After the NE, the threat was changed, thus disengaging lower-level protection, including the PAG and cerebellum, thus allowing higher cortical activation in the motor cortex, which may be associated with a restored, normal expected motor activation.^{250,346} This possible change in cortical activation during the painful task could thus be correlated with the improved physical tasks of forward flexion and SLR in the absence of physical treatment.

9.8 Limitations

Several limitations apply to this study. The results from any single case study have limitations to its application to a broader, general population. The fact that the patient was a high-level dancer further complicates its application to other patient populations. The patient may not truly be regarded as a preoperative patient, since a specific day or date had not been set for LS. The PNET was designed specifically for decompressive LS, and thus its effect for other types of LS such as fusion or disc replacement is unknown. The results from the fMRI are clouded in various discussions about the exact meanings of fMRI, and is based on the current knowledge and understanding of the interpretation of such imaging tests.

9.9 Conclusion

This case is of interest because it describes the first-ever use of an fMRI evaluation of a pre-operative NE program specifically developed for LS. Additionally, this program is the first of its kind as a pre-emptive program aiming to decrease potential pain and disability after LS. The message of this case study is powerful for the physiotherapist treating spinal pain patients, by confirming the importance of education in leading to immediate changes in cognitions, ROM and beliefs regarding a patient's perception of injury, treatment and potential recovery.

Chapter 10: Multi-Centre Randomized Controlled Trial of Preoperative Neuroscience Education compared to Usual Care for Patients with Lumbar Radiculopathy

10.1 Introduction

It is estimated that 10-40% of patients following lumbar surgery (LS) still experience persistent pain and disability.⁹⁻¹¹ Postoperative rehabilitation has shown little benefit in reducing the postoperative pain and disability^{12,18,19} and surgeons do not readily send patients to rehabilitation following LS,^{17,347} indicating many postoperative LS patients possibly suffering pain and disability. Recent research on the effect of neuroscience education (NE) in a chronic LBP (CLBP) population, have shown an ability to alter pain and disability.^{77,78,81,288}

Considering the proposed positive effects of NE and the persistent pain and disability many patients experience following LS, the current research study set out to develop a preoperative NE program for patients undergoing LS for radiculopathy (Chapters 3 – 7) and to determine if such a program would result in superior outcomes compared to usual care. Given the preliminary positive results of the case series and single-case functional magnetic resonance imaging (fMRI) study (Chapters 8 & 9), the final phase of the research study set out to examine the efficacy of the preoperative NE program in a multi-center randomized controlled trial (RCT), to determine if preoperative NE provide superior outcomes compared to usual care for patients undergoing LS for radiculopathy?

10.2 Materials and Methods

10.2.1 Type of study

A multi-center RCT was used to answer the research question.

10.2.2 Patient population

Patients with lumbar radiculopathy who were scheduled for LS were invited to participate in the RCT if they met the following inclusion criteria and had none of the exclusion criteria (Table 10.1)

Table 10.1 Inclusion and exclusion criteria for the RCT

Inclusion criteria	Exclusion criteria
<ul style="list-style-type: none"> • Scheduled for LS for radiculopathy • Scheduled LS is a decompressive surgical procedure • Willingness to comply with the predetermined follow-up³⁴⁸ • Able and willing to complete postoperative questionnaires at designated time-intervals 	<ul style="list-style-type: none"> • Not proficient in reading or comprehending the English language^{77,189,202} • Under the age of 18 and over the age of 65¹⁸⁹ • Scheduled for LS involving instrumentation, e.g., spinal fusion or arthroplasty • Worsening neurological deficit^{77,102,202} • Participated in a formal back school or multi-disciplinary pain management program²⁰² • Undergoing LS for a condition other than lumbar radiculopathy^{51,348} • Accompanying chronic pain-related conditions such as fibromyalgia or chronic fatigue syndrome • Symptoms of cord compression¹⁰²

10.2.3 Subject recruitment

Subjects for the RCT were recruited from several sites in the United States (US). The sites were based on the availability of trained physiotherapists to deliver the preoperative NE program and these therapists having access to a spine surgeon in their geographical region, who was willing to participate in the RCT (Appendix 7 - surgeon invitation letter). In all, seven sites were developed with a primary physiotherapist trained in the preoperative NE program and a surgeon willing to participate in the study (Figure 10.1).



Figure 10.1 Locations of data collection sites for the randomized controlled trial

The primary role of the spine surgeon during consultation was to determine if a patient may benefit from LS. By means of informed consent, if the patient and surgeon agreed that decompressive surgery was indicated for lumbar radiculopathy, the patient consulted with the surgeon's assistant/nurse to set up the date for the surgery and received administrative and procedural information on the procedures associated with the impending surgery, such as preoperative blood work, intake of food and liquids the night before surgery, etc. An example of such preoperative procedural instructions is found in Appendix 8

Patients who met the inclusion criteria were informed of the surgeon's loyalty to the study and were subsequently asked if they wish to participate in the study and provided with an informed consent sheet (Appendix 9). Patients were informed that this was a RCT, examining two preoperative education programs, of which they will be randomly assigned to receive one or the other.

10.2.4 Randomization and Blinding

Concealed randomization was performed using computer-generated random numbers.^{98,172,173} Upon agreement to participate, patients were given an envelope which

randomly assign them to either the control group (usual care [UCG]) or the experimental group (usual care and NE [EG]). Therapists providing the preoperative NE was thus aware of the patient's assignment to the EG. The envelopes contained the exact same information, except that patients in the EG were asked to schedule a one-time educational session with a physiotherapist to deliver their preoperative educational session. Patients were asked to ensure the session be completed in the week before the operation, which were within the parameters of what is known about optimal timing for the delivery of preoperative education.^{21,43,349} The envelope additionally contained a demographics sheet (Appendix 10), the surgeon's procedural information sheet (Appendix 8) and a referral from the surgeon to attend a one-time physiotherapy educational session (EG group only) (Appendix 11). Patients in the EG were advised that this is the surgeon's usual practice and needed to call the physiotherapy clinic to schedule the appointment. Since the envelopes contain no distinctive markings, the physician's assistant/nurse were blinded to which patients get assigned to the UCG and the EG. All intake forms (preoperative, 1 month, 3 months and 6 months) were completed by the patients with no input from the therapists, physician, physician staff or researchers, placed in a pre-paid sealed envelope and mailed to the primary researcher (AL).

10.2.5 Usual care protocol

Patients in the control group received what constitutes "usual care" regarding preoperative education from their respected surgeons. To ensure all the surgeons involved in the RCT provided relative similar UC, each surgeon (n = 7) was personally asked to complete the SSEQ survey (Chapter 2; Appendix 1) to determine if their treatment followed the UC established in SSEQ study,³⁴⁷ to allow for comparison in the RCT. Two researchers (AL and ID) independently reviewed the surgeon's responses to the SSEQ to ensure their preoperative education to be in line with the findings of the SSEQ.

10.2.6 Experimental protocol

Chapters 3 to 7 describe in detail the development of the experimental protocol. The EG patients undergoing LS received usual care as described in section 10.2.5, as well as the addition of the preoperative NE program. The NE was provided by the designated physiotherapists for the RCT in a one-on-one verbal format, with the addition of pictures, examples, metaphors and the use of drawings if needed. Patients were encouraged to ask questions. To ensure a standardized program, a systematic checklist was developed.^{161,186,350-352} The educational sessions averaged 30 minutes. Patients were additionally provided with a preoperative NE booklet summarizing the educational content of the preoperative NE session,

including pictures, examples and metaphors.³⁵³ Patients were requested to read the booklet at least one time before LS and one time after LS.

10.2.7 Clinicians providing the preoperative NE

To obtain the necessary number of patients for the RCT (section 10.2.8), it was decided to recruit clinicians familiar with NE and currently utilizing NE in clinical practice who had access to spine surgeons and willing to participate in the RCT. To date, NE has been performed by physiotherapists²⁸⁸ and it was decided to target physiotherapists with a knowledge of the current understanding of NE. To ensure a level of proficiency, competency parameters were set to be part of the study (Table 10.2)

Table 10.2 Competency measures of the clinicians providing NE for LS

Competency	Reason
Minimum 5 years of clinical practice	Less experienced clinicians have shown limited knowledge of pain and report more struggles treating patients in pain ^{56,354}
Minimum score of 90% on the Pain Neurophysiology Questionnaire (PNQ) ²⁵³	The PNQ is specifically designed to measure a person's knowledge of pain based on the current neuroscience view of pain. After a 3-hour training session, healthcare providers scored 78% on the PNQ ²⁵³ and it was decided to ensure the highest possible proficiency to teach NE, the physiotherapists in this RCT should score > 90% on the NPQ
Currently utilize NE in clinical practice.	Allows for practical, clinical experience in performing NE
Must have attended at least 15 hours of postgraduate continuing education on NE	It has been shown that a pain education program of similar duration change physiotherapist attitudes and beliefs regarding pain ³⁵⁴
Minimum score of 90% on the preoperative NE tool questionnaire (Appendix12)	Therapist had to demonstrate a knowledge of the material of the preoperative NE tool as well as the intent of each section

The database of a seminar company teaching postgraduate NE classes for physiotherapists in the US were obtained. An invitation was sent out via electronic mail to the physiotherapists to recruit interested parties meeting the criteria in Table 10.2 and working closely with a spine surgeon. Following screening of the demographic information relevant to the criteria in Table

10.2, scoring of the therapists NPQ knowledge and establishing the extent of the therapists relationship with their spine surgeon, seven therapists were included in the RCT to gather data (Figure 10.1). The characteristics of the physiotherapists who delivered the NE for the RCT can be found in Table 10.3.

Table 10.3 Characteristics of the physiotherapists who performed the NE in the RCT

Characteristic	Physiotherapy group (n = 7)
Age (years)	41.14
Gender	1 Female; 6 Males
Years of clinical experience (years)	18
NPQ score	97.72%
Actively using NE in clinical practice	7 x yes
Spinal surgery NE questionnaire	98.86%
Have attended at least 15-hours of postgraduate training in NE	7 x yes

To ensure consistency in delivering the preoperative PNET intervention for the RCT, therapists underwent either a one-on-one verbal, in-person training session with the primary researcher (AL) or via a phone conversation. The education involved a discussion of the aims of the study, systematic review and discussion of each section of the program, including utilization of the pictures, examples, metaphors and drawings. Upon completion, the seven therapists were asked to complete a true/false questionnaire mimicking the NPQ specific to the preoperative NE program (Appendix 12).

10.2.8 Sample size

A sample size necessary for a randomized controlled trial was calculated based on the primary outcome measures for pain and function.

10.2.8.1 Sample size based on pain scores

Based on an interaction effect for a 2 (experimental condition: education and usual care) X 3 (time: pre, 1 month post, 3 months post), and using 80% power and a degree of freedom of 2, the sample size was estimated from preliminary data (12 subjects; 9 education and 3 usual

care). Using an interaction effect index of .160 (calculated from the preliminary data), the estimated sample size needed to see an interaction would be 81 to 144 subjects (70% power: 65 to 115). However, with one additional measurement point (i.e., 6 months post) in the analysis, the sample size estimate would be 69 to 123 subjects (70% power: 56 to 99).

10.2.8.2 Sample size based on Oswestry scores

Based on an interaction effect for a 2 (experimental condition: education and usual care) X 3 (time: pre, 1 month post, 3 months post), and using 80% power and a degree of freedom of 2, the sample size was estimated from preliminary data (12 subjects; 9 education and 3 usual care). Using an interaction effect index of .169 (calculated from the preliminary data), the estimated sample size needed to see an interaction would be 81 to 144 subjects (70% power: 65 to 115). However, with one additional measurement point (i.e., 6 months post) in the analysis, the sample size estimate would be 69 to 123 subjects (70% power: 56 to 99).

10.2.9 Outcome measures

The primary outcomes measured in this RCT were back/leg pain and function. Secondary outcome measures were fear, pain catastrophization, knowledge of pain, beliefs regarding surgery and healthcare utilization. Postoperative outcome measures were measured at 1, 3 and 6 months (Figure 10.2). The outcome measure time-frames were chosen based on past postoperative LS studies.^{14,18,104,308}

10.2.9.1 Low back and leg pain

LBP and leg pain were measured with the use of a numeric rating scale (NRS), as has been used in various RCTs for NE and spinal pain.^{77,81,82,326} A change of 2.1 has been proposed as the minimal detectable change (MDC).³²⁶

10.2.9.2 Function

Functional limitation was measured utilizing the Oswestry Disability Index (ODI). The ODI is a 10-item questionnaire that assesses different aspects of physical function. Each item is scored from 0 to 5, with higher values representing greater disability. The total score is multiplied by 2 and expressed as a percentage. The ODI has been shown to be a valid and reliable measure of

functional limitation related to low back pain (LBP).³¹³⁻³¹⁵ A change of 5 points (10%) has been proposed as the MDC.³¹⁶

10.2.9.3 Fear

Fear of work and physical activity was measured with the Fear Avoidance Beliefs Questionnaire (FABQ). The FABQ is a 16-item questionnaire that was designed to quantify fear and avoidance beliefs in individuals with LBP. The FABQ has two subscales: 1) a 7-item scale to measure fear-avoidance beliefs about work and 2) a 4-item scale to measure fear avoidance beliefs about physical activity. Each item is scored from 0 to 6 with possible scores ranging between 0 and 24 and 0 and 42 for the physical activity and work subscales, respectively, with higher scores representing an increase in fear-avoidance beliefs. The FABQ has demonstrated acceptable levels of reliability and validity in previous LBP studies.^{72,317,318} Presence of avoidance behavior is associated with increased risk of prolonged disability and work loss. It is proposed that FABQ-W scores >34 and FABQ-PA >14 are associated with a higher likelihood of not returning to work.^{251,319}

10.2.9.4 Pain catastrophization

Pain catastrophization was measured by means of the pain catastrophization scale (PCS): The PCS is a self-report questionnaire that assesses inappropriate coping strategies and catastrophic thinking about pain and injury. The PCS has been used in previous NE studies for chronic LBP^{79,80} and demonstrated strong construct validity, reliability and stability.³²⁰ The PCS utilizes a 13-item, 5-point Likert scale with higher scores indicating elevated levels of catastrophizing. Previous studies utilizing the PCS have shown a median score of 18 that of healthy individuals and in patients with pain the PCS is generally higher.³²⁰ The MDC for the PCS is reported to be 9.1.³²¹

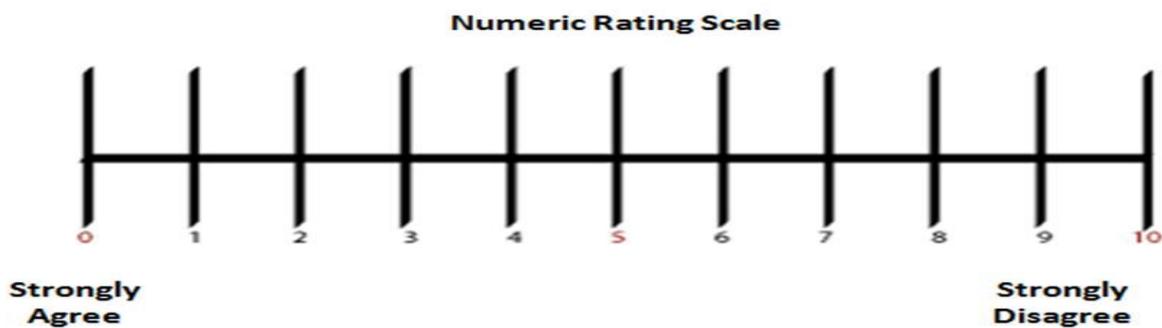
10.2.9.5 Knowledge of pain

Pain knowledge was measured by using a neurophysiology questionnaire (NPQ), since it deals with the content of the NE used in the trial. The NPQ is based on a current pain science text¹⁷⁶ and was used in a previous study measuring the neurophysiology knowledge of patients and healthcare personnel.³²² The NPQ is a 19-point questionnaire requesting 'true' or 'false' answers to statements, with the higher scores indicating more correct answers.

10.2.9.6 Beliefs regarding surgery

Patients were asked to indicate by means of a numeric scale (1 to 10) how much they agree with a statement regarding the spinal surgery/education experience. Patients were asked to read each statement carefully and rate each one by placing an X on the line based on how strongly they agree or disagree with the statement. Statements have been identified based on previous studies evaluating patient satisfaction with LS:^{58,102,332}

- *I am glad I underwent surgery for my leg pain.*
- *I was fully prepared (physically, emotionally, psychologically) for the surgery.*
- *The preoperative education I received prepared me well for the surgery.*
- *Knowing what I know now, I would do this again given the same choices.*
- *The surgery met my expectations.*



10.2.9.7 Healthcare utilization.

Patients were asked to indicate if they had any of the following medical tests specifically related to their LS: X-ray, magnetic resonance imaging (MRI), computerized tomography (CT scan), bone scan, nerve conduction test, myelogram or to specifically list any other medical tests. Additionally, patients were asked to identify (from the provided list) healthcare providers they have consulted after surgery specifically due to their LS. The list included spine surgeon, family doctor, physiotherapist, other specialist physicians, chiropractor, massage therapist, acupuncturist, psychologist, psychiatrist or to specific any other professionals. In both cases (medical tests and healthcare providers) patients were asked to indicate how many times they have had the tests or consults. Examples were provided to aid patients. Data was gathered to determine the total number of visits for each medical test and visits per healthcare provider to compare the EG to the UCG. For each test and healthcare provider visit a financial cost was calculated based on the average cost for such tests and visits in the US (www.newchoicehealth.com)

10.2.10 Layout of the study

Sections 10.2.1 to 10.2.9 describes the specific details of the layout of the RCT. Figure 10.2 provides a graphic illustration of the procedure of the RCT comparing preoperative NE to UC following LS for radiculopathy

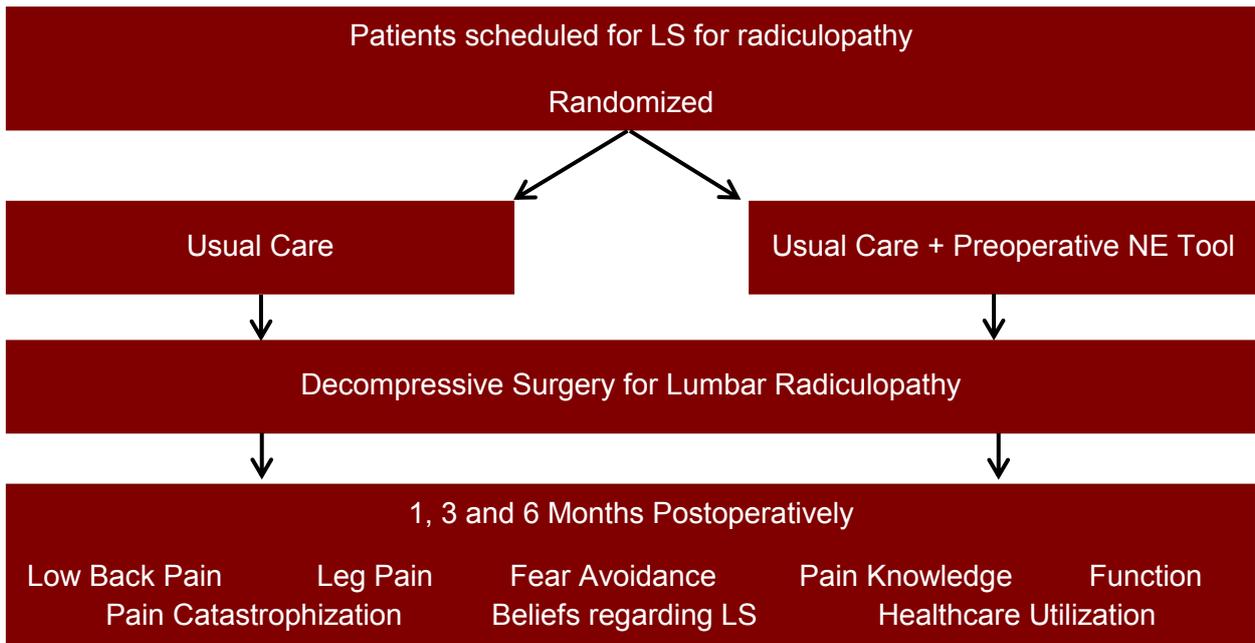


Figure 10.2: Layout of the randomized controlled trial

10.2.11 Data collection

Postoperative outcome data was collected via mailed packets containing the outcomes measures described in section 10.2.9. Packets contained informed consent (preoperative packets), the questionnaires, a pre-paid addressed return envelope and instructions regarding the follow up. All packets were sent out and returned to an independent research assistant. None of the outcomes were viewed or handled by the surgeons, their staff, therapist who provided the NE or the researchers. Patients who did not return their assigned postoperative packets in the allotted time frames were sent reminders via mail (postcard), electronic mail or phone calls. Two elderly patient's data was collected by the research assistant over the phone with the patients to help the patients with their questionnaires. All completed questionnaires and personal data of the patients were kept in secure files under lock and key with access only by the research assistant and the primary researcher (AL). Personal data (name, mailing address, phone number and e-mail) was collected on the

demographic sheets prior to the study to allow for postoperative follow-up. Data was extracted by the research assistant and entered in an Excel Spread sheet (Microsoft Corporation 2012) for data analysis. All data was checked for accuracy by the primary researcher (AL) prior to data analysis.

10.2.12 Funding and subject remuneration

Subjects were provided a \$20 (US) gift card to a restaurant at each interval of completion of the packets (preoperatively, 1, 3 and 6 months). The gift cards were provided as a means to thank patients for taking the time to complete the questionnaires at each interval and to provide a potential incentive to ensure patients return their packets in a timely manner. Upon return of a packet, a patient was sent the gift card by mail including a thank you letter, reminder of the study and the importance of completing the trial. The funding for the study was partly covered by two grants (Iowa Physical Therapy Association and The International Spine and Pain Institute).

10.2.13 Data analysis

In order to ascertain the differences between the EG and CG, 8 ANOVAs (2 [group: treatment and control] X 4 [time: pre, 1 month, 3 month, 6 month]), on 6 different outcome measures (LBP, leg pain, Oswestry, catastrophizing, FABQ, NE knowledge) were conducted using a per protocol analysis (PPA) and an intent-to-treat (ITT) analysis wherein missing value imputation was conducted using the last-observation-carried-forward method. The results of the PPA were the main focus of the results and were to be reported in detail; the ITT analyses were to be reported in detail only if they differ from the PPA. If interactions were observed then simple main effects using an appropriate Bonferroni were used to determine significance. If no interaction was observed then main effects were analyzed. If violations of sphericity were observed, then the Greenhouse-Geisser or Huynh-Feldt correction were utilized. To compare the differences between the groups on their preoperative opinions (prepared, afraid, overall expectation, back expectation, leg expectation, control pain, and surgery fix) independent-samples t-tests were conducted. Six different ANOVAs (2 ([group: treatment and control] X 3 [time: 1 month, 3 month, 6 month]) were conducted, both PPA and ITT, on the following postoperative opinions: *glad, feeling prepared, pre-op went well, do again, met expectations*). Interactions were broken down as previously outlined. Total medical costs were compared between the groups by using t-tests. All analyses were conducted using SPSS version 19.0 (SPSS, 233 S. Wacker Drive, 11th Floor, Chicago, IL 60606). The significance threshold was set at $\alpha=0.05$. The following were

analyzed as candidates to enter the analyses as covariates: age, gender, education, income, and duration of symptoms. None of them met the threshold for inclusion in the analysis as covariates (correlational coefficients greater than 0.70).

10.3 Results

10.3.1 Patients

Sixty seven patients were recruited for the RCT. Six patients were lost to follow up (Figure 10.3). The characteristics of the patients are found in the Table 10.4. The results from this RCT reports on 61 patients in Figure 10.3

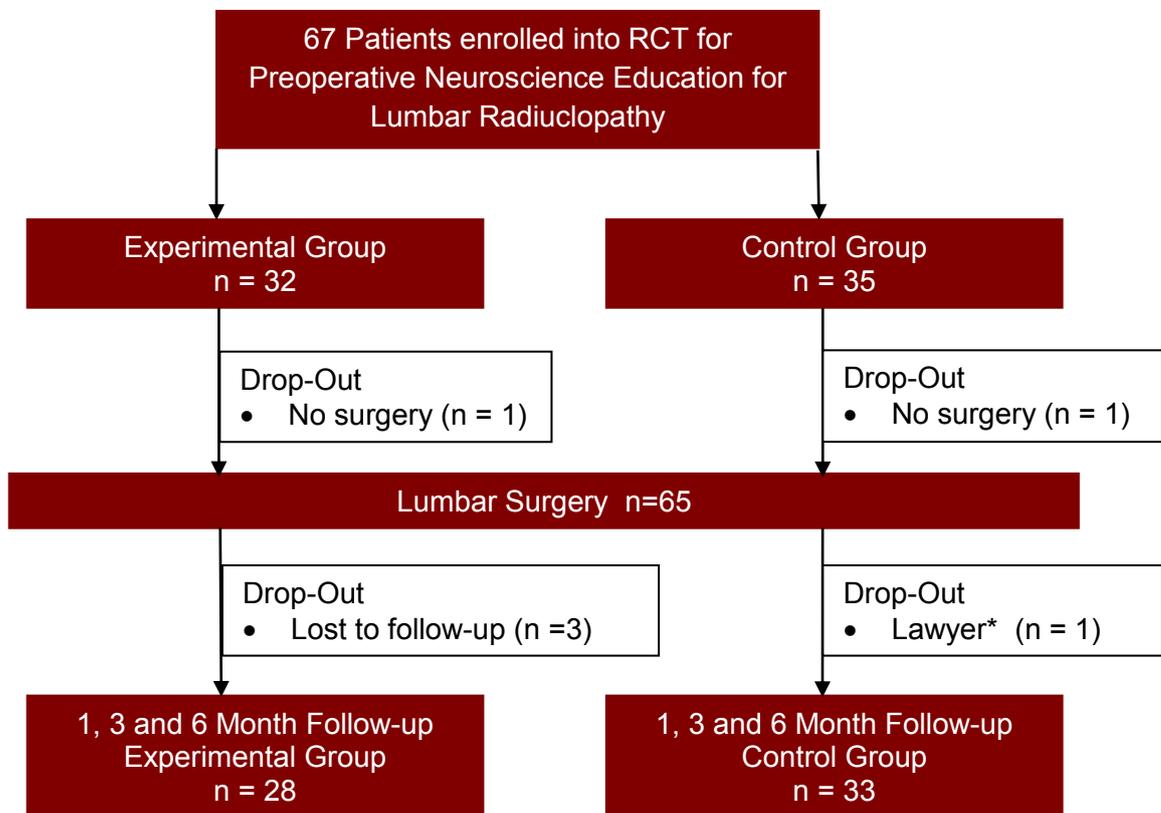


Figure 10.3 Schematic layout of the actual patient follow-up in the RCT (*Patient undergoing litigation and lawyer requested patient to withdraw from study)

Table 10.4 Characteristics of the patients in the RCT

Characteristic	EG (n = 32)	CG (n = 35)	Difference
Age (years) (mean)	49.59	49.6471	0.987
Gender (female)	17 (53%)	19 (54%)	-----
Duration of symptoms (days)	91.41	92.29	0.978
Low Back Pain (mean)	4.57	5.12	0.592
Leg Pain (mean)	5.25	6.06	0.123
Pain Catastrophization	24.54	27.24	0.458
Fear Avoidance – Work Subscale	17.79	17.076	0.708
Fear Avoidance – Physical Activity	17.54	17.70	0.965
Oswestry	44.21	46.67	0.17
Pain Knowledge	12.64	11.21	0.01*

* statistically significant

10.3.2 Low back pain

There was no significant difference between the treatment group and the control over time on LBP, $F(3,177)=0.492$, $p=0.671$, $\eta_p^2=0.008$ (power=0.144). The main effects of group approached significance favoring the EG ($p=0.077$). The main effect for time was significant ($p<.001$) suggesting that both groups improved over time regardless of the intervention. Both EG (2.07) and CG(2.09) reached minimal detectable change (MDC) for LBP (2.1). The results of the ITT analysis were consistent in these findings (Tables 10.5 and 10.6; Figure 10.4). The EG did have a larger immediate post-op LBP drop, compared to EG.

Table 10.5 Descriptive statistics for LBP comparing EG versus CG

	Experimental condition	Mean	Std. Deviation	N
LBP preoperatively	Experimental	4.57	3.036	28
	Control	5.12	2.631	33
	Total	4.87	2.814	61
LBP1 month	Experimental	2.20	2.196	28
	Control	3.39	2.371	33
	Total	2.84	2.351	61
LBP3 months	Experimental	2.04	2.219	28
	Control	3.18	2.506	33
	Total	2.66	2.428	61
LBP6 months	Experimental	2.50	2.632	28
	Control	3.03	2.698	33
	Total	2.79	2.659	61

Table 10.6 Main effect showing changes in LBP over time

Time	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	4.846	.363	4.120	5.572
2	2.795	.295	2.206	3.384
3	2.609	.306	1.997	3.220
4	2.765	.343	2.079	3.451

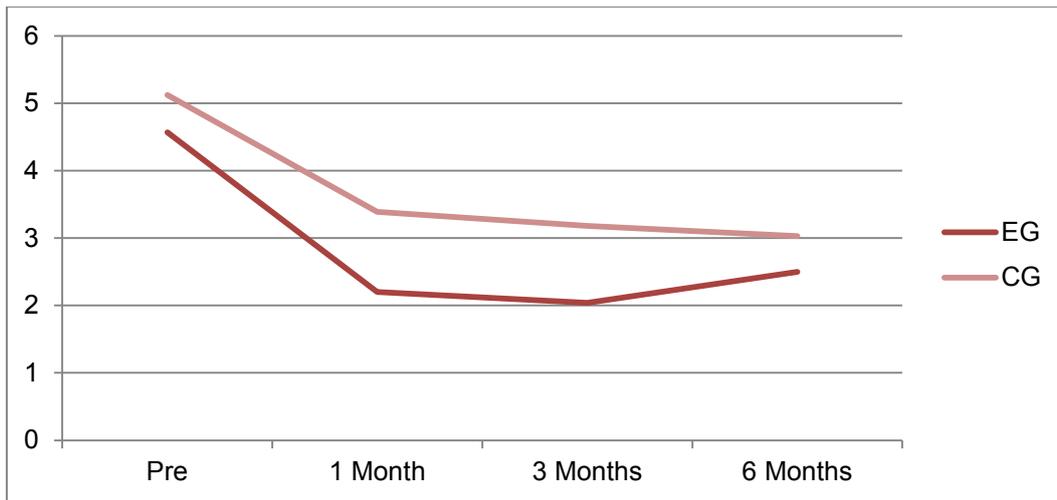


Figure 10.4 Comparison of LBP at timed intervals comparing EG versus CG

10.3.3 Leg pain

There was no significant difference between the treatment group and the control over time on leg pain, $F(3,177)=0.656$, $p=0.571$, $\eta_p^2=0.011$ (power=0.181). The main effects of group approached significance favoring the EG ($p=0.074$); however, the main effect for time was significant ($p<.001$) suggesting that leg pain decreased over time regardless of experimental group. The results of the ITT analysis were mostly consistent these findings; however, the group main effect was significantly different between the groups ($p=0.039$) suggesting that the control condition had more leg pain than the treatment group regardless of time (Tables 10.7 and 10.8; Figure 10.5). The EG did have an immediate postop (1-month) decrease in leg pain, compared to the CG.

Table 10.7 Descriptive statistics for leg pain comparing EG and the CG

	Experimental condition	Mean	Std. Deviation	N
Legpain preoperatively	Experimental	5.25	2.648	28
	Control	6.06	2.150	33
	Total	5.69	2.405	61
Legpain1 month	Experimental	1.37	2.012	28
	Control	2.91	2.614	33
	Total	2.20	2.462	61
Legpain3 months	Experimental	1.89	2.793	28
	Control	2.82	3.046	33
	Total	2.39	2.945	61
Legpain6 months	Experimental	2.36	3.046	28
	Control	2.79	3.333	33
	Total	2.59	3.185	61

Table 10.8 Main effect showing changes in leg pain over time

Time	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	5.655	.307	5.041	6.270
2	2.142	.303	1.536	2.748
3	2.356	.377	1.602	3.110
4	2.573	.412	1.749	3.396

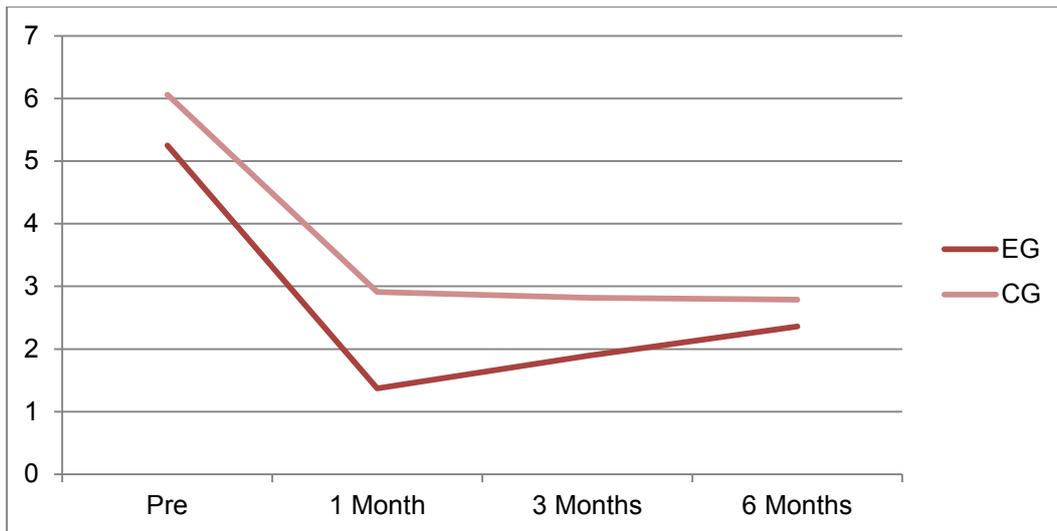


Figure 10.5 Differences in leg pain at timed intervals between EG and CG

10.3.4 Low back disability

There was no significant interaction between the treatment group and the control over time on low back disability (Oswestry scores), $F(3,177)=0.654$, $p=0.542$, $\eta_p^2=0.011$ (power=0.166). The main effects of group was not significant ($p=0.296$); however, the main effect for time was significant ($p<.001$) suggesting that low back disability decreased over time regardless of intervention. The results of the ITT analysis paralleled these findings (Tables 10.9 and 10.10; Figure 10.6)

Table 10.9 Descriptive statistics pertaining to Oswestry disability between the EG and CG

	Experimental condition	Mean	Std. Deviation	N
Oswestrypreoperatively	Experimental	44.21	15.514	28
	Control	46.67	13.808	33
	Total	45.54	14.544	61
Oswestry 1 month	Experimental	32.43	17.043	28
	Control	35.58	19.594	33
	Total	34.13	18.384	61
Oswestry 3 months	Experimental	21.29	18.509	28
	Control	29.15	19.307	33
	Total	25.54	19.199	61
Oswestry 6 months	Experimental	23.50	20.761	28
	Control	24.48	19.912	33
	Total	24.03	20.141	61

Table 10.10 Main effect showing changes in Oswestry disability over time

Time	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	45.440	1.877	41.684	49.197
2	34.002	2.373	29.254	38.750
3	25.219	2.434	20.348	30.089
4	23.992	2.609	18.773	29.212

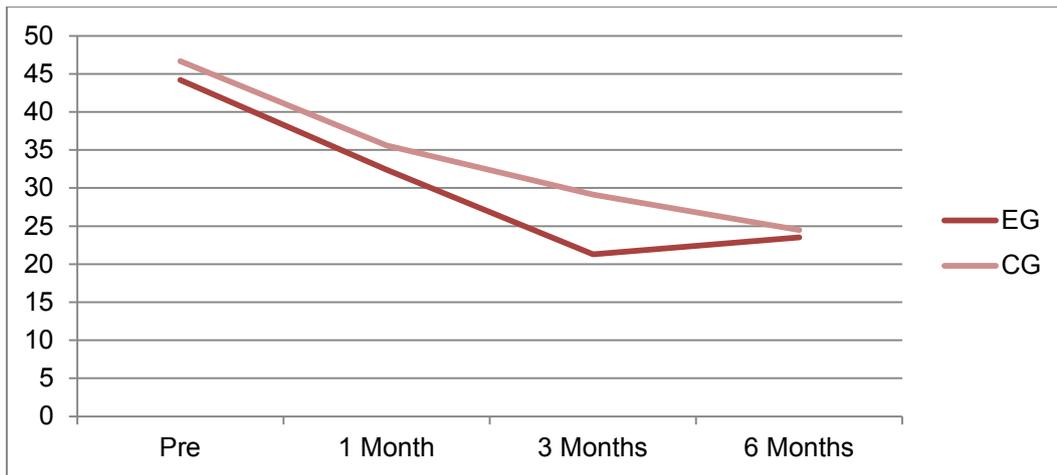


Figure 10.6 Changes in Oswestry in the postoperative period between the EG and CG

10.3.5 Pain Catastrophizing

There was no significant interaction between the treatment group and the control over time on catastrophizing, $F(3,177)=0.762$, $p=0.517$, $\eta_p^2=0.013$ (power=0.211). The main effects of group was not significant ($p=0.357$); however, the main effect for time was significant ($p<.001$) suggesting that catastrophizing decreased over time regardless of treatment allocation. There were no differences with the ITT analysis (Tables 10.11 and 10.12; Figure 10.7). The CG matched the EG after one month, but then increased, compared to the overall downward trend of the EG.

Table 10.11 Descriptive analysis of pain catastrophization between the EG and CG

	Experimental condition	Mean	Std. Deviation	N
Pain catastrophization preoperatively	Experimental	24.54	13.398	28
	Control	27.24	11.830	33
	Total	26.00	12.541	61
Pain catastrophization 1 month	Experimental	12.18	12.927	28
	Control	11.73	10.474	33
	Total	11.93	11.566	61
Pain catastrophization 3 months	Experimental	9.00	11.408	28
	Control	13.48	13.175	33
	Total	11.43	12.499	61
Pain catastrophization 6 months	Experimental	9.86	12.852	28
	Control	12.18	12.616	33
	Total	11.11	12.672	61

Table 10.12 Main effect showing changes in pain catastrophization over time

Time	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	25.889	1.615	22.657	29.121
2	11.953	1.498	8.955	14.951
3	11.242	1.593	8.055	14.429
4	11.019	1.635	7.749	14.290

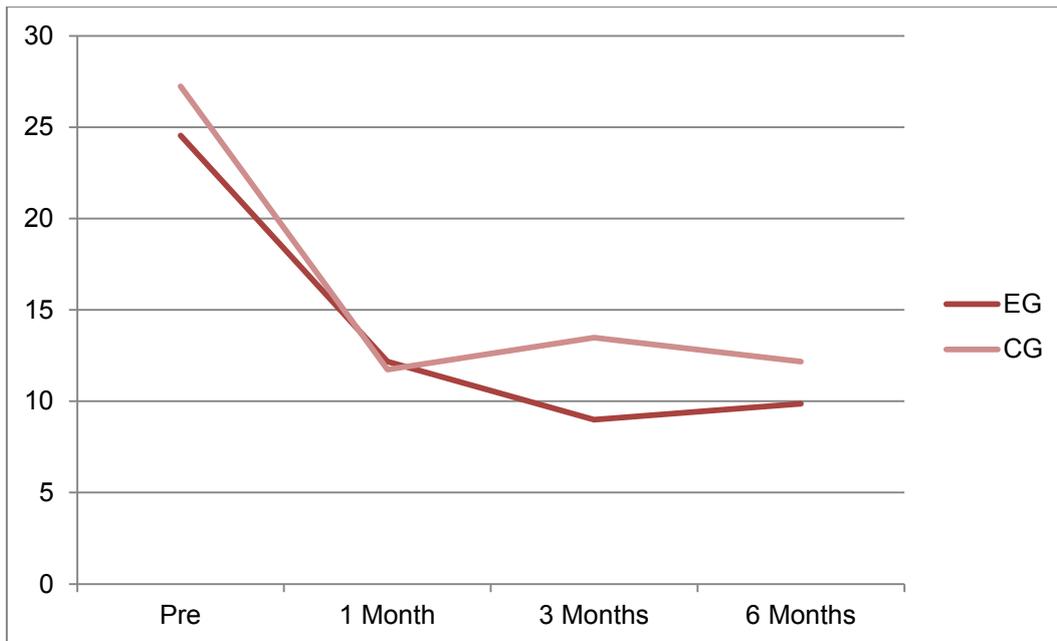


Figure 10.7 Comparison of pain catastrophization between the EG and CG

10.3.6 Fear avoidance beliefs

There was no significant interaction between the treatment group and the control over time on fear avoidance beliefs (FABQ work subscale), $F(3,177)=1.655$, $p=0.179$, $\eta_p^2=0.027$ (power=0.429). The main effects of group was not significant ($p=0.859$); however, the main effect for time was significant ($p=0.001$) suggesting that FABQ work subscale scores decreased over time regardless of the treatment allocation. There were no differences with the ITT analysis (Tables 10.13 and 10.14; Figure 10.8) Both EG and CG decreased FABQ-W at 1-month, but between 1-3 months, the CG elevated in FABQ=W, compared to the continuous trend of the EG.

Table 10.13 Descriptive statistics pertaining to FABQ-W for the EG and CG

	Experimental condition	Mean	Std. Deviation	N
FABQW preoperatively	Experimental	17.79	11.698	28
	Control	17.06	12.747	33
	Total	17.39	12.181	61
FABQW 1 month	Experimental	14.39	10.475	28
	Control	12.61	11.672	33
	Total	13.43	11.084	61
FABQW 3 months	Experimental	10.82	9.603	28
	Control	15.21	13.543	33
	Total	13.20	12.008	61
FABQW 6 months	Experimental	11.54	10.236	28
	Control	11.36	12.617	33
	Total	11.44	11.491	61

Table 10.14 Main effect showing changes in FABQ-W over time

Time	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	17.423	1.577	14.267	20.579
2	13.499	1.431	10.636	16.363
3	13.017	1.529	9.957	16.077
4	11.450	1.489	8.471	14.429

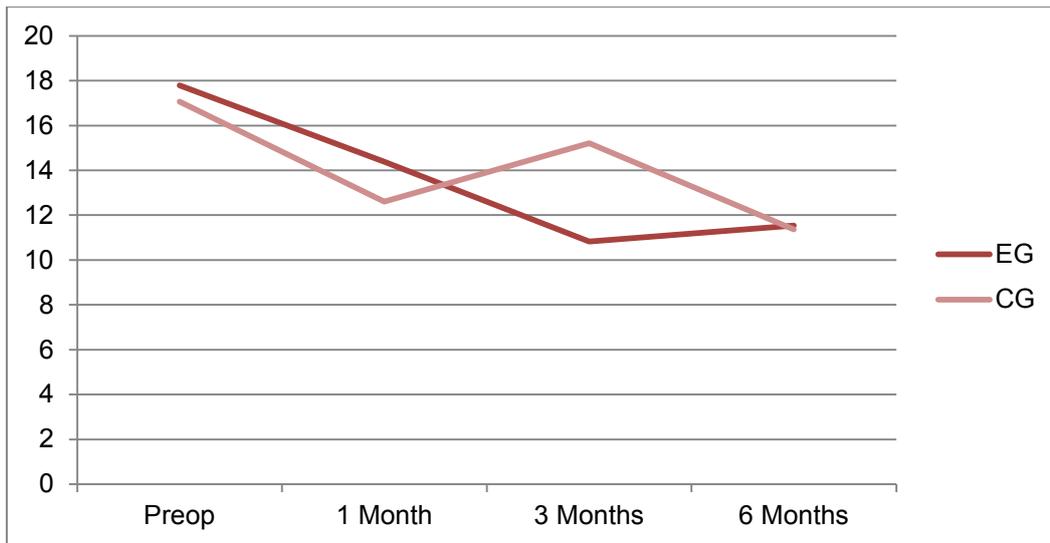


Figure 10.8 Differences in FABQ-W between the EG and CG

The results for the FABQ PA subscale were no different. There was no significant interaction, $F(3,177)=0.865$, $p=0.460$, $\eta_p^2=0.014$ (power=0.236). The main effects of group was not significant ($p=0.800$); however, the main effect of time was significant ($p<0.001$) suggesting that FABQ PA subscale scores decreased over time regardless of treatment approach. Again, there were no differences with the ITT analysis (Tables 10.15 and 10.67; Figure 10.9) Between 3-6 months post-op the EF trended upward, compared to the CG.

Table 10.15 Descriptive statistics regarding FABQ-PA between the EG and CG

	Experimental condition	Mean	Std. Deviation	N
FABQ-PA preoperatively	Experimental	17.54	5.267	28
	Control	17.70	5.053	33
	Total	17.62	5.109	61
FABQ-PA 1 month	Experimental	15.54	6.552	28
	Control	15.42	5.646	33
	Total	15.48	6.027	61
FABQPA 3 months	Experimental	12.61	7.455	28
	Control	14.61	5.612	33
	Total	13.69	6.544	61
FABQPA 6 months	Experimental	14.18	6.025	28
	Control	13.21	7.136	33
	Total	13.66	6.613	61

Table 10.16 Main effect showing changes in FABQ-PA over time

Time	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	17.616	.662	16.292	18.941
2	15.480	.781	13.918	17.042
3	13.607	.838	11.930	15.283
4	13.695	.854	11.986	15.405

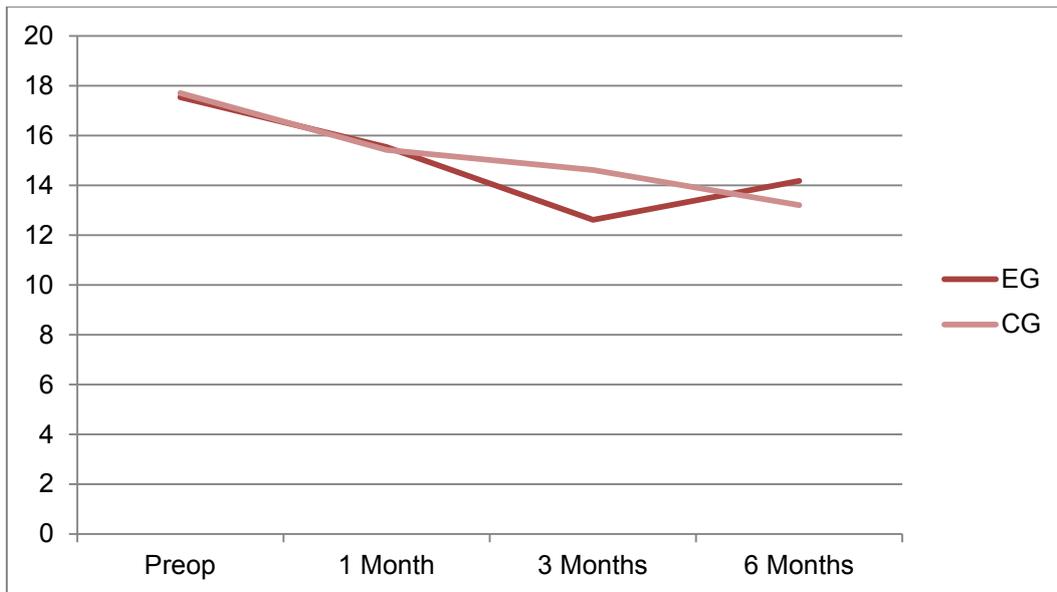


Figure 10.9 Differences over time in FABQ-PA between the EG and CG

10.3.7 Pain knowledge

There was no significant interaction between the treatment group and the control over time on pain knowledge, $F(3,177)=0.850$, $p=0.468$, $\eta_p^2=0.014$ (power=0.233). The main effects of time was not significant ($p=0.244$) suggesting that the groups pain knowledge did not change over time; however, the main effect of group was significant ($p=0.016$) suggesting that pain knowledge scores were higher in the treatment group regardless of time. Pain knowledge scores in the ITT analysis were not different than the PPA (Tables 10.17 and 10.18; Figure 10.10).

Table 10.17 Descriptive statistics regarding pain knowledge between the EG and CG

	Experimental condition	Mean	Std. Deviation	N
Pain Knowledge preoperatively	Experimental	12.64	1.909	28
	Control	11.21	2.497	33
	Total	11.87	2.341	61
Pain Knowledge 1 month	Experimental	12.96	2.755	28
	Control	11.15	3.456	33
	Total	11.98	3.258	61
Pain Knowledge 3 months	Experimental	12.32	2.342	28
	Control	11.67	3.388	33
	Total	11.97	2.949	61
Pain Knowledge 6 months	Experimental	13.04	2.168	28
	Control	11.85	2.138	33
	Total	12.39	2.216	61

Table 10.18 Main effect showing changes in pain knowledge over time

Experimental condition	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Experimental	12.741	.375	11.990	13.492
Control	11.470	.346	10.778	12.162

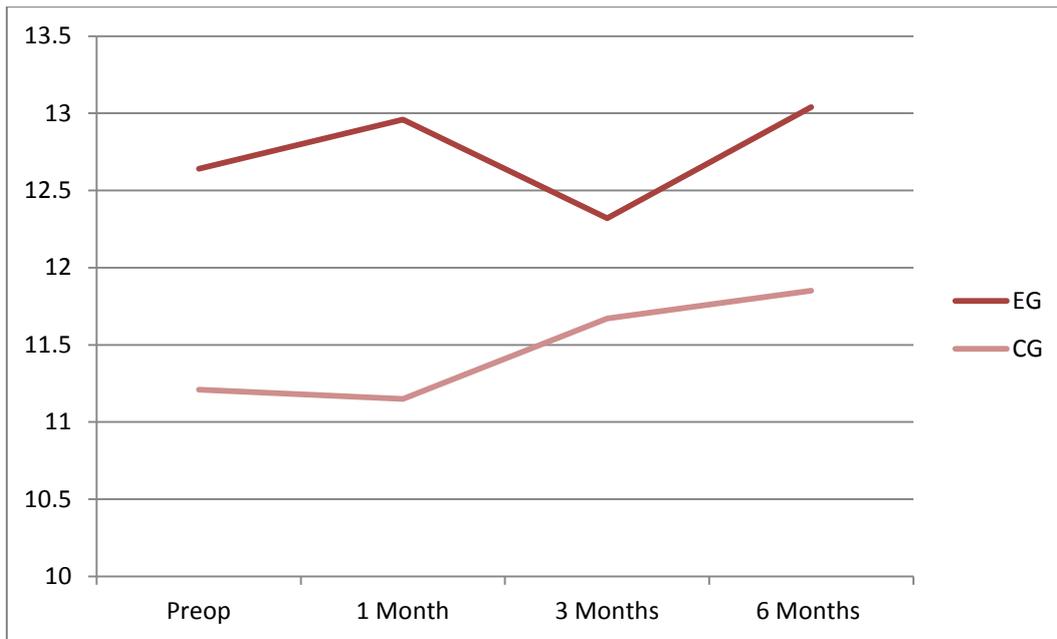


Figure 10.10 Differences in pain knowledge between the EG and CG

In order to more specifically analyze the questions within the NPQ that were specifically addressed in the education piece, correct responses from 9 relevant questions (#2, #7, #8, #10, #13, #15, #17, #18, #19) were totaled. There was no significant interaction between the treatment group and the control over time on pain knowledge for these 9 questions, $F(3,177)=1.157$, $p=0.325$, $\eta^2=0.019$ (power=0.286). The main effects of time was not significant ($p=0.579$) suggesting that the groups pain knowledge for these 9 questions did not change over time; however, the main effect of group was significant ($p=0.025$) suggesting that pain knowledge scores for these 9 questions were higher in the treatment group regardless of time. Pain knowledge scores for these 9 questions in the ITT analysis were not different than the PPA (Tables 10.19 and 10.20; Figure 10.11)

Table 10.19 Descriptive statistics for specific 9 preoperative NE questions for the EG and CG

	Experimental condition	Mean	Std. Deviation	N
Preoperatively 9 questions	Experimental	7.3571	1.39348	28
	Control	6.7273	1.66344	33
	Total	7.0164	1.56516	61
1 month 9 questions	Experimental	7.7500	1.60150	28
	Control	6.4848	2.38644	33
	Total	7.0656	2.14374	61
3 months 9 questions	Experimental	7.5714	1.42539	28
	Control	6.5758	2.64611	33
	Total	7.0328	2.21335	61
6 month 9 questions	Experimental	7.5714	1.06904	28
	Control	7.0909	1.44403	33
	Total	7.3115	1.29796	61

Table 10.20 Main effect showing changes over time for specific 9 preoperative NE questions

Experimental condition	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Experimental	7.563	.269	7.025	8.100
Control	6.720	.247	6.225	7.215

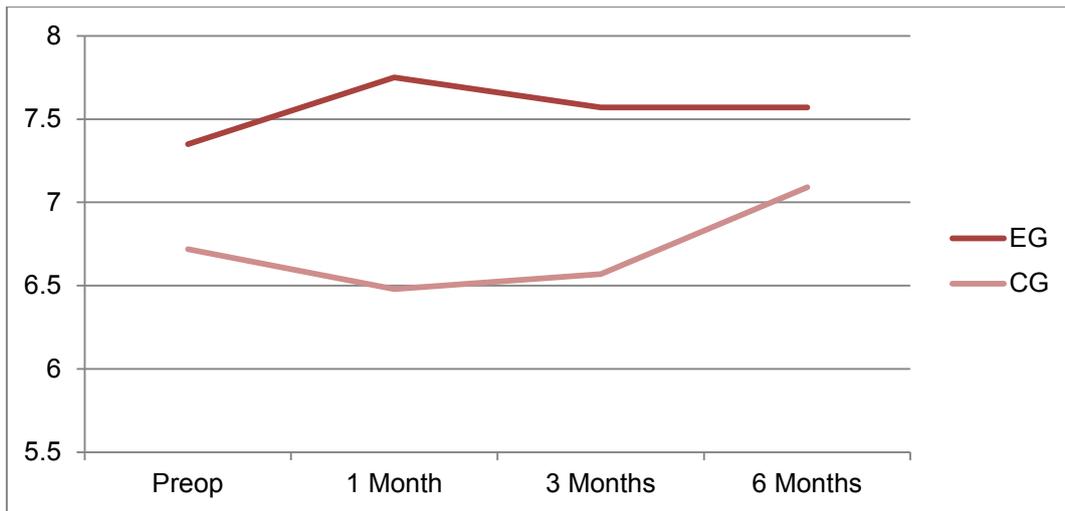


Figure 10.11 Comparison regarding 9-specific NPQ questions for the EG and CG

10.3.8 Preoperative attitudes and beliefs regarding LS

Before surgery there were no differences between the treatment and control groups ($p > 0.120$) on the questions aiming to measure their attitudes and beliefs regarding LS (Table 10.21).

Table 10.21 Group statistics for the preoperative attitudes and beliefs of the EG and CG

Topic	Experimental condition	N	Mean	Std. Deviation	Std. Error Mean
I feel prepared for the surgery	Experimental	32	2.97	2.978	.526
	Control	35	1.94	2.248	.380
I am afraid of the surgery	Experimental	32	5.16	3.070	.543
	Control	35	5.71	2.793	.472
I have realistic expectations regarding surgery	Experimental	32	4.50	2.907	.514
	Control	35	4.40	2.637	.446
Back pain is to be expected after surgery	Experimental	32	3.44	2.816	.498
	Control	35	3.63	2.961	.501
Leg pain is to be expected after surgery	Experimental	32	5.22	2.992	.529
	Control	35	6.29	2.782	.470
I can control the pain I experience after surgery	Experimental	32	4.00	2.383	.421
	Control	35	4.29	2.094	.354
Surgery will fix my pain	Experimental	32	2.88	2.587	.457
	Control	35	3.37	2.414	.408

10.3.9 Postoperative attitudes and beliefs regarding LS

10.3.9.1 I am glad I undergone surgery for my leg pain

There was no significant interaction between the two groups on being glad about having had the LS, $F(2,118)=0.36$, $p=0.715$, $\eta^2=0.006$ (power=0.103). The main effects of group was not significant ($p=0.240$); however, the main effect of time was significant ($p=0.009$) suggesting that over time both groups were more glad about having had the LS. Again, there were no differences with the ITT analysis (Tables 10.22 and 10.23; Figure 10.12)

Table 10.22 Descriptive statistics between EG and CG for being glad they had undergone LS

	Experimental condition	Mean	Std. Deviation	N
Glad I underwent surgery 1 month	Experimental	1.04	2.186	28
	Control	1.71	2.719	33
	Total	1.40	2.491	61
Glad I underwent surgery 3 months	Experimental	.93	2.610	28
	Control	1.45	2.017	33
	Total	1.21	2.303	61
Glad I underwent surgery 6 months	Experimental	1.61	3.348	28
	Control	2.64	3.656	33
	Total	2.16	3.527	61

Table 10.23 Main effect showing changes over time for being glad to having undergone LS

Time	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	1.374	.320	.734	2.014
2	1.192	.296	.598	1.785
3	2.122	.452	1.217	3.026

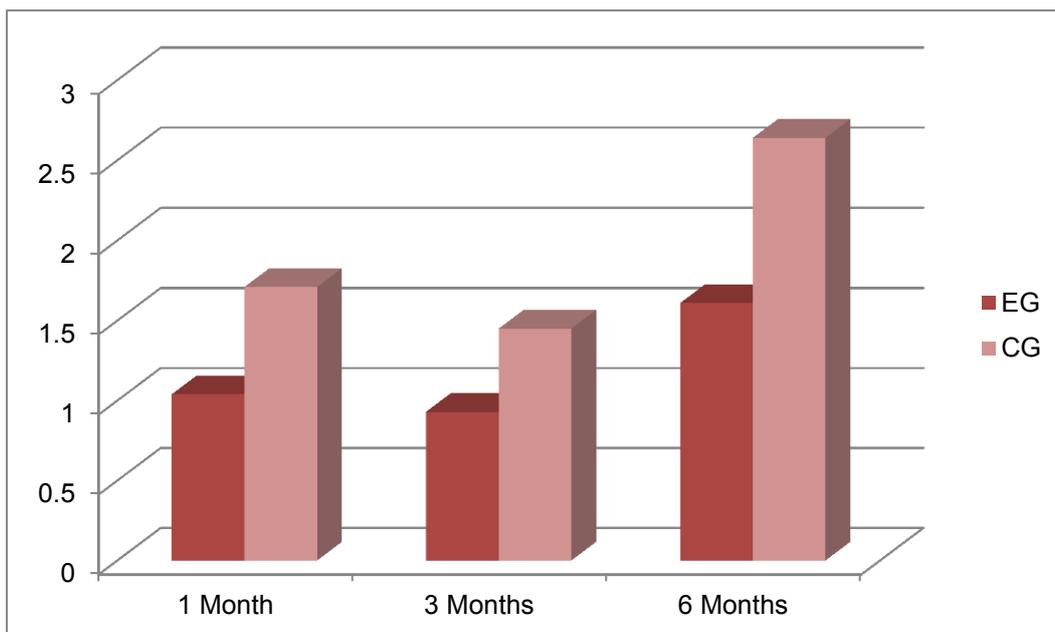


Figure 10.12 Differences between the EG and CG regarding being glad they underwent LS

10.3.9.2 I was fully prepared (physically, emotionally, psychologically) for the surgery

There was no significant interaction between the two groups on feeling fully prepared for the surgery, $F(2,118)=1.709$, $p=0.189$, $\eta^2=0.028$ (power=0.335). The main effects of group was significant ($p=0.001$) which means that the experimental group felt more prepared (physically, emotionally, psychologically) than the control group regardless of time point; however, the main effect of time was not significant ($p=0.054$) suggesting that over time their sense of feeling prepared did not change. There were no differences with the ITT analysis (Table 10.24 and 10.25; Figure 10.13)

Table 10.24 Descriptive statistics regarding being fully prepared for LS between the EG and CG

	Experimental condition	Mean	Std. Deviation	N
Fully prepared 1 month	Experimental	.73	1.601	28
	Control	2.35	2.313	33
	Total	1.61	2.160	61
Fully prepared 3 months	Experimental	1.11	2.149	28
	Control	2.61	2.872	33
	Total	1.92	2.654	61
Fully prepared 6 months	Experimental	1.04	2.252	28
	Control	3.58	3.123	33
	Total	2.41	3.019	61

Table 10.25 Main effect showing changes over time for being fully prepared to undergo LS

Experimental condition	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Experimental	.958	.386	.186	1.730
Control	2.843	.355	2.132	3.555

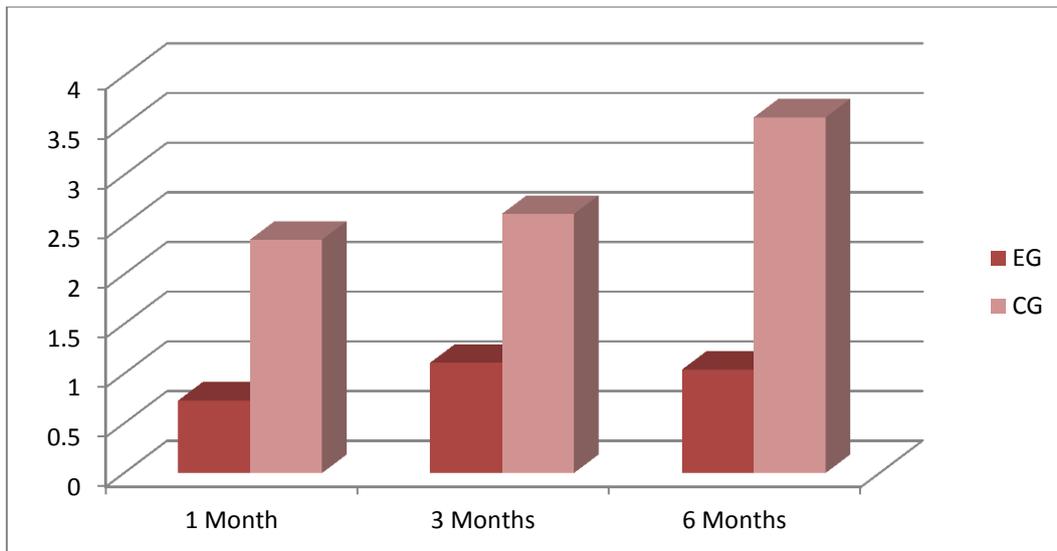


Figure 10.13 Differences between EG and CG regarding being fully prepared for LS

10.3.9.3 The preoperative education I received prepared me well for the surgery.

There was no significant interaction between the two groups on feeling that the preoperative education prepared the patients, $F(2,118)=0.592$, $p=0.533$, $\eta^2=0.010$ (power=0.140). The main effects of group was significant ($p<0.001$) which means that the experimental group rated their preoperative preparation better than the control group; however, the main effect of time was not significant ($p=0.447$) suggesting that overall their opinion did not change over time. There were no differences with the ITT analysis (Tables 10.26 and 10.27; Figure 10.14)

Table 10.26 Descriptive analysis of the EG and CG regarding preoperative education preparing the patients well for LS

	Experimental condition	Mean	Std. Deviation	N
Preoperative education prepared well 1 month	Experimental	.68	1.307	28
	Control	3.08	2.722	33
	Total	1.98	2.484	61
Preoperative education prepared well 3 months	Experimental	.87	1.476	28
	Control	2.73	2.649	33
	Total	1.88	2.364	61
Preoperative education prepared well 6 months	Experimental	.93	1.489	28
	Control	3.42	2.926	33
	Total	2.28	2.672	61

Table 10.27 Main effect showing changes over time for preoperative education preparing patients well for LS

Experimental condition	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Experimental	.827	.330	.168	1.487
Control	3.076	.304	2.468	3.683

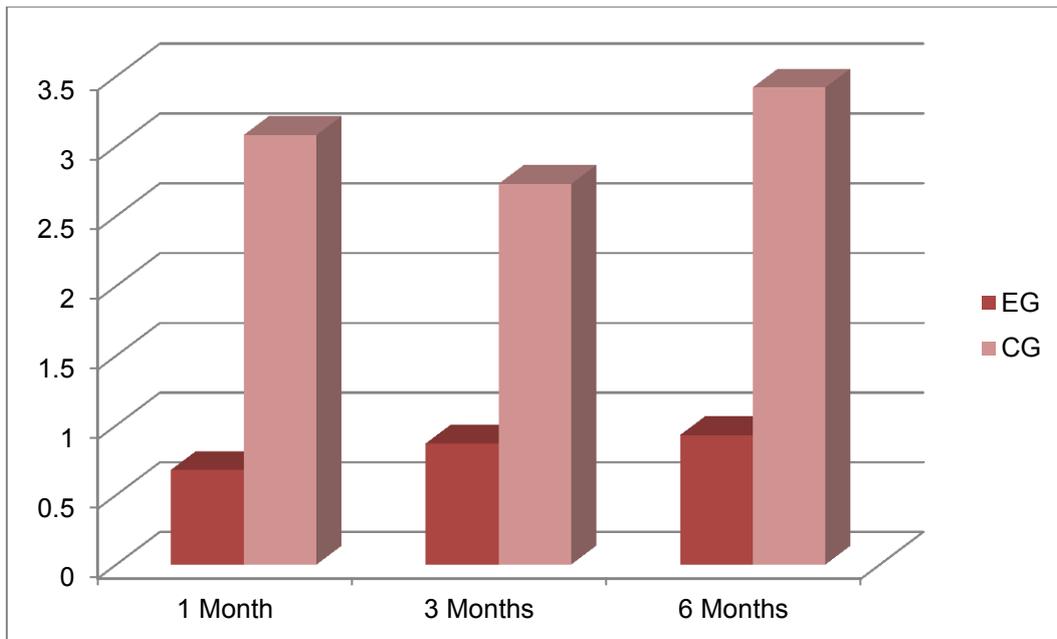


Figure 10.14 Differences between EG and CG regarding preoperative education preparing patients well for LS

10.3.9.4 Knowing what I know now, I would do this again given the same choices.

There was no significant interaction between the two groups on whether they would have the surgery again, $F(2,118)=0.237$, $p=0.777$, $\eta^2=0.004$ (power=0.086). The main effects of group was not significant ($p=0.412$); however, the main effect of time was significant ($p=0.012$) suggesting that over time all subjects were more likely to agree to have the surgery again. There were no differences with the ITT analysis (Tables 10.28 and 10.29; Figure 10.15)

Table 10.28 Descriptive analysis of the EG and CG regarding willingness to repeat LS

	Experimental condition	Mean	Std. Deviation	N
Do it again 1 month	Experimental	1.23	2.693	28
	Control	1.71	2.881	33
	Total	1.49	2.783	61
Do it again 3 months	Experimental	1.21	2.923	28
	Control	1.64	2.356	33
	Total	1.44	2.617	61
Do it again 6 months	Experimental	1.89	3.745	28
	Control	2.73	3.727	33
	Total	2.34	3.728	61

Table 10.29 Main effect showing changes over time regarding willingness to do repeat LS again

Time	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	1.472	.359	.753	2.191
2	1.425	.338	.749	2.102
3	2.310	.480	1.350	3.270

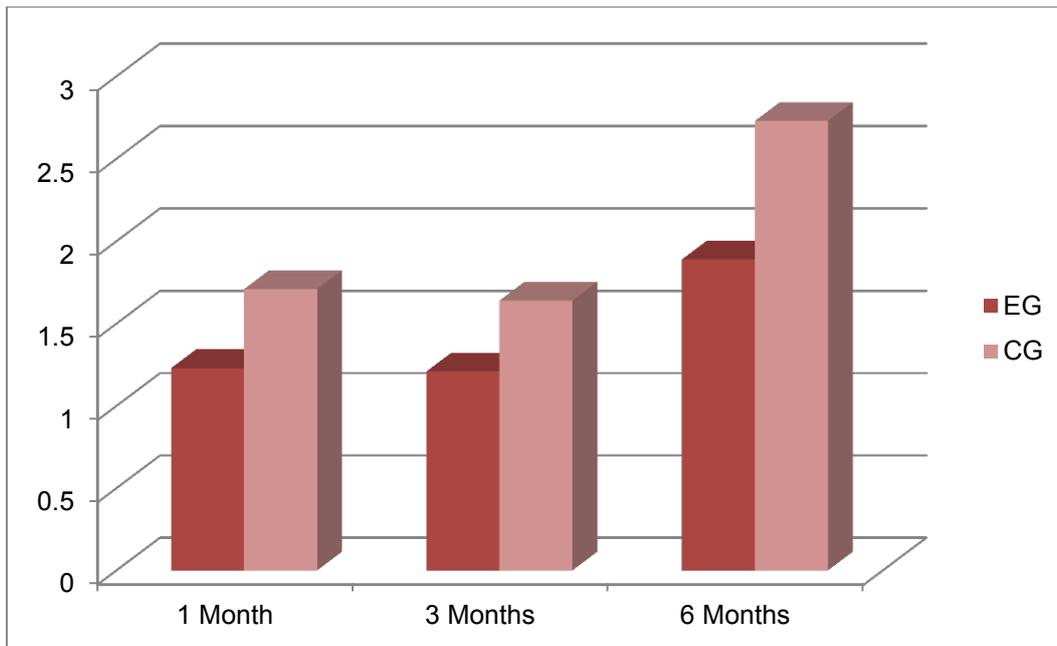


Figure 10.15 Differences between EG and CG regarding doing the LS again

10.3.9.5 The surgery met my expectations.

There was no significant interaction between the two groups on whether the surgery met their expectations, $F(2,118)=0.523$, $p=0.583$, $\eta^2=0.009$ (power=0.132). The main effects of group was significant ($p=0.020$) suggesting that the experimental group felt that the surgery met their expectations more so than the control group; however, the main effect of time was not significant ($p=0.748$) suggesting their opinions did not change over time. There were no differences with the ITT analysis (Tables 10.30 and 10.31; Figure 10.16)

Table 10.30 Descriptive statistics of the EG and CG regarding LS meeting expectations

	Experimental condition	Mean	Std. Deviation	N
Surgery met expectations 1 month	Experimental	1.52	2.234	28
	Control	2.89	2.778	33
	Total	2.26	2.615	61
Surgery met expectations 3 months	Experimental	1.43	2.617	28
	Control	3.39	3.201	33
	Total	2.49	3.086	61
Surgery met expectations 6 months	Experimental	1.86	3.472	28
	Control	3.09	3.485	33
	Total	2.52	3.505	61

Table 10.31 Main effect showing changes over time for LS meeting expectations

Experimental condition	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Experimental	1.601	.470	.661	2.541
Control	3.126	.433	2.260	3.992

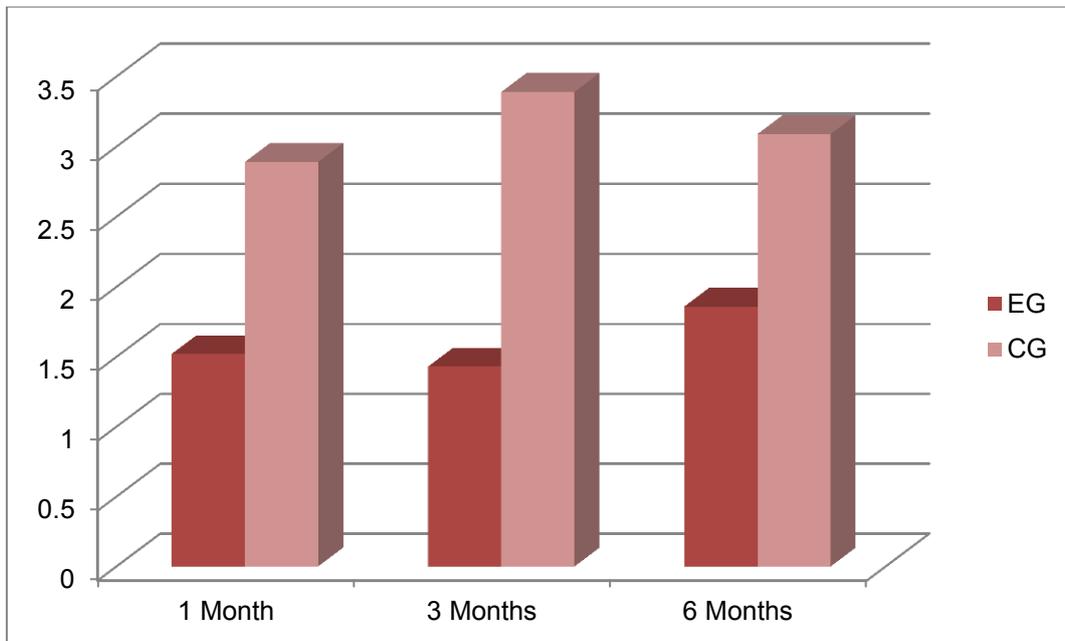


Figure 10.16 Differences between EG and CG regarding surgery meeting expectations

10.3.10 Postoperative medical expenses

The overall postoperative medical costs of treatment were higher for the control group than they were for the treatment group, $t(59)=2.190$, $p=0.032$. They were also significantly higher for radiographs ($p=0.041$), family doctor expenses ($p=0.011$), and physiotherapy ($p=.021$). None of the other subgroup expenses were significantly different, $ps>.059$ (Table 10.32 and figures 10.17 and 10.18)

Table 10.32 Healthcare utilization at 6-month follow-up

	Experimental condition	N	Mean	Std. Deviation	Std. Error Mean
X-Ray total	Experimental	28	120.00	257.624	48.686
	Control	33	305.45	404.329	70.385
MRI total	Experimental	28	785.71	1370.513	259.003
	Control	33	727.27	1097.518	191.053
CT Scan total	Experimental	28	100.00	367.171	69.389
	Control	33	127.27	408.712	71.148
Blood Test total	Experimental	28	12.50	25.909	4.896
	Control	33	13.64	38.064	6.626
Nerve Conduction Test total	Experimental	28	53.57	283.473	53.571
	Control	33	181.82	497.151	86.543
Myelogram total	Experimental	28	.00	.000 ^a	.000
	Control	33	.00	.000 ^a	.000
Spine Surgeon total	Experimental	28	339.29	313.392	59.225
	Control	33	484.85	507.519	88.348
Family doctor total	Experimental	28	96.43	150.855	28.509
	Control	33	250.91	294.877	51.331
Physiotherapy total	Experimental	28	339.29	658.471	124.439
	Control	33	863.64	1003.063	174.611
Other Specialist total	Experimental	28	.00	.000	.000
	Control	33	68.18	209.843	36.529
Chiropractor total	Experimental	28	45.00	114.649	21.667
	Control	33	2.12	12.185	2.121
Massage Therapist total	Experimental	28	25.71	66.189	12.509
	Control	33	21.82	125.336	21.818
Acupuncture total	Experimental	28	.00	.000 ^a	.000
	Control	33	.00	.000 ^a	.000
Psychologist total	Experimental	28	4.46	23.623	4.464
	Control	33	3.79	21.760	3.788
Psychiatrist total	Experimental	28	6.43	34.017	6.429
	Control	33	.00	.000	.000
Other tests total	Experimental	1	1000.00	.	.
	Control	6	816.67	633.772	258.736
Grand total	Experimental	28	1964.11	2101.990	397.239
	Control	33	3199.24	2270.548	395.252

^a t cannot be computed because the standard deviations of both groups are 0.

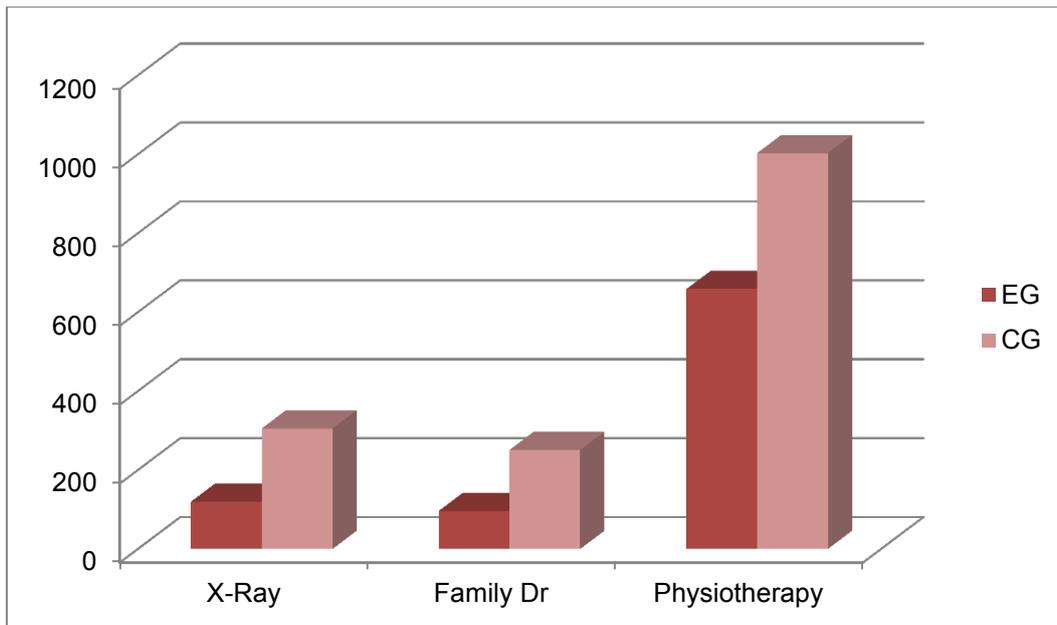


Figure 10.17 Differences between the CG and EG in regards to medical tests and treatments that reached statistical significant differences ($p < 0.05$)

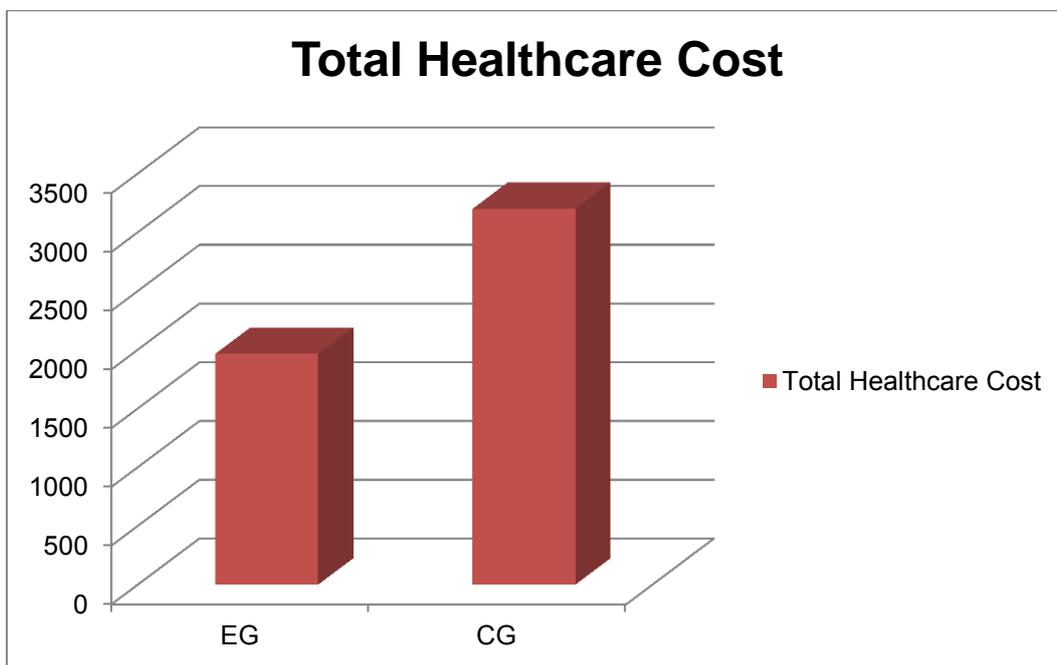


Figure 10.18 Differences between the CG and EG in regards to total healthcare expenditures following LS for medical tests and treatments that reached statistical significant differences ($p = 0.05$)

10.4 Discussion

Although the results from the multi-center RCT demonstrated that the PNET, compared to usual care resulted in improved pain, disability and catastrophization scores immediately and up to 3 months post-op, the intervention did not result in a statistical difference in self-report pain ratings and disability at 6-months post LS. The PNET, however, resulted in significant behavioral changes in the LS patient's utilization of healthcare services, leading to large cost-savings in healthcare. The PNET additionally allowed patients to experience LS as being much more of a positive experience, despite persistent pain and disability.

The hypothesis of the study was that the addition of a pain NE program would result in a superior outcome related to pain and disability, compared to usual care (UC), for patients undergoing LS for radiculopathy. Immediate 1-month postoperative measurements did show such a trend favoring the NE group, concurring with the initial case series. None of these immediate changes, however, reached significant difference. The results, additionally, did not demonstrate such effect in the longer term (6 months). Many patients, following LS, experience persistent pain and disability and the results pertaining to pain and disability of this study concurs with various post-LS studies.^{9-11,104} A Cochrane review,¹² several RCT's^{9-11,104} and the results from this study would imply that patients undergoing LS for leg pain can realistically expect 6-12 months post-LS to experience average LBP varying between 2.5 – 3 out of 10 on a NRS. The documented results of these studies could be interpreted that LBP after LS is thus normal and to be expected. This viewpoint formed one of the cornerstones of the PNET program.³⁵⁵ Patients were informed that pain *will* be experienced following LS, but may in fact be due to a hypervigilant nervous system and increased sensitivity, rather than actual tissue pathology. This reconceptualization of pain is part of the main effect of NE.^{202,213,253} In this RCT, this reconceptualization is underscored by the fact that, despite similar pain and disability to the UC group, patients who received the PNET, saw their surgery as more successful and a positive experience, culminating in a decreased need to seek help as evident by the decreased healthcare utilization.

Similar to LBP, patients following LS also report persistent high levels of disability.^{9-11,104} Six months after LS, patients in this RCT still averaged an ODI score of 24%, indicating moderate disability, which concurs with the 12-month outcomes of the recent FASTER study by McGregor, et al.¹⁸ This persistent pain and disability is closely influenced by various psychometric measures such as fear and pain catastrophization.³⁵⁶⁻³⁵⁸ With persistent pain months after surgery, patients are likely to experience higher levels of fear and even pain catastrophization, which is evident in the results from this RCT. At 6-months post-LS, patients in

the EG still scored an average of 14.18 on the FABQ-PA scale, which is associated with a higher likelihood of failing to return to work.^{251,319} These results concur with a study by Louw, et al., who interviewed LS patients 4-weeks postoperatively, showing more than 50% of patients were very concerned and fearful about their pain getting worse.⁵⁶ Added to the complexity of persistent pain, disability, fear and pain catastrophization, a recent survey, seeking to determine the general population's beliefs regarding LS, showed high levels of fear regarding LS (Landers M, et al – submitted for publication). In this study, members of the general population reported they believe side effects are very common in LS; recovery following LS is lengthy and they would try any other treatments to reduce LBP, before undergoing LS. This negative view of LS is fueled by well-established studies indicating the general population's faulty beliefs regarding LBP.³⁵⁹⁻³⁶¹ Furthermore, LS patients are very concerned about limitations following LS,⁵⁶ further enhancing the potential self-inflicted high rates of disability reported in LS.

The limited results regarding pain and disability from this RCT must, however, be viewed in contrast to the beneficial effects of NE as reported in various RCT's^{77,79,81,202,203,212,252,253} and a recent systematic review.²⁸⁸ One consideration is time. In an effort to make NE increasingly user-friendly and cost-effective, recent NE focus has shifted to the use of more abbreviated NE education sessions,^{289,362} compared to lengthy, time-consuming CBT sessions and original NE work. The PNET was designed in line with this new development.³⁵⁵ Due to the mainly peripheral neuropathic nature of lumbar radiculopathy, the PNET was designed to focus primarily on peripheral neuropathic pain,³⁶³ with brief exposure to a more central and brain based pain education model.³⁵⁵ The results from this RCT may indeed indicate a tipping point. Pain is complex and it is acknowledge that a more elaborate NE program may indeed have altered pain and disability following LS, comparable to the CLBP studies.^{67,213} This need to positively alter pain and disability with a more elaborate and lengthier NE program for LS will, however, need to be weighed against the possibility that pain and disability is a normal occurrence after LS; increased utilization of resources and cost associated with a lengthier program and the significant benefits this RCT produced in regards to healthcare utilization and surgical experience.

Along with decreased duration, frequency and likely intensity of the PNET compared to NE sessions used to-date, it is also important to note that several NE studies did not track patients one year out, and the apparent lack of efficacy in regards to pain and disability in this RCT compared to NE, should also be viewed from this perspective.^{212,252,253} Furthermore, in line with the case series and fMRI case study (Louw, et. al – submitted for publication), the EG in several cases, i.e., LBP and leg pain, resulted in larger reductions in the immediate postoperative period and between 1 and 3 months postoperatively. Additionally, the CG in both FABQ-W and PCS

had a spiked increase compared to the EG. Cognitions, pain, disability and beliefs are intertwined.^{67,68,213} In the NE trials to date, and the immediate post-NE sessions, patients were likely exposed to continuous reinforcing positive information regarding their pain. In fact, it is proposed that patients in pain receive follow-up sessions to reinforce their reconceptualization of pain, build on previous messages and over time enhance the educational experience.^{81,364} In contrast, the PNET RCT provided a 1-time educational session (preoperatively) and then patients were tracked. It is proposed that exposure to cognitions, beliefs and experiences contrary to NE over time, may in fact also have led to a decrease potency of the PNET in comparison to the proposed immediate positive effects. Firstly, LS patients typically see surgeons 3-4 weeks postoperatively for follow-up, as well as 3 months later.^{17,347} If patients experience additional pain and disability, as evident by the results of this RCT, they will see the surgeon likely again. It could be argued that a positive NE message, downplaying tissue issues as a major source of persistent pain, could be affected by the periodic biomedical exposure by the surgeons.³⁴⁷ Secondly, a majority of patients in the RCT attended postoperative physiotherapy which may additionally erode the NE message, once again focusing on biomedical explanations for persistent pain and disability.^{56,365} Finally, the general population has poor beliefs regarding LBP³⁶⁰ as well as LS and this may have additionally diluted the NE message, which may be evident in the non-significant changes observed at 6-months in the RCT. Future studies should develop postoperative educational and rehabilitative programs aimed at boosting the effect of the original preoperative NE program to determine its efficacy. The RCT, additionally, failed to determine if patients read the PNET booklet after surgery and if so, how many times.

Several studies³⁴⁷ have shown that beliefs and expected outcomes for surgery are highly correlated with success of LS, as viewed by patients.^{51,102,107,332} Prior to the current multi-center RCT, the same authors trialed the PNET on 10 patients undergoing LS for radiculopathy (Louw A, et al – submitted for publication). The sample of patients in the case series displayed numerous poor beliefs regarding LS prior to NE,¹⁰² associated with possible poor outcomes including beliefs of LS “*fixing pain,*” “*expecting little to no pain after surgery*” and “*uncertainty about the outcome of LS.*” Pain after LS is to be expected and expectations of no pain after surgery are thus unrealistic.¹⁰⁷ Immediately following the 30-minute NE, patients in the case series shifted their expectations of back pain (*back pain after surgery is to be expected*) and leg pain (*leg pain after surgery is to be expected*) by > 50%, thus preparing them with a more realistic view of the postoperative period. After the 6-month follow-up period, patients who received the NE reported statistically significant changes in beliefs regarding being fully prepared for the surgery as well as the preoperative education session preparing them adequately for LS. This finding may also reflect a need of LS patients wanting an ability to have

questions answered and needing more information prior to surgery,⁵⁶ be it NE or a general availability of information by a healthcare provider.^{20,21} In contrast, however, a study by Ronnberg highlighted that, although patients undergoing LS are mostly satisfied with their perioperative care, they are not satisfied with the information they receive.⁵¹ This finding is supported by the fact that patients having undergone LS for radiculopathy have indicated a need for more pain education,⁵⁶ providing a potential insight into the importance of not only more time for patients to have questions answered prior to LS, but a specific need to be met, including a greater understanding of their pain.¹⁸⁴

Patients who received NE reported a significant different view of their LS at 6-months post-surgery, pertaining to meeting their expectations. This finding concurs with the proposal that pain and mild to moderate disability after LS may indeed be normal, especially when expected. Both groups reported similar LBP, leg pain, disability, fear-avoidance and pain catastrophization at 6-months, yet the NE group viewed their result as much more positive. NE aims to help patients develop a greater understanding of pain and shift patients from seeing pain, especially persistent pain, as being correlated to nociception.^{67,202,213} At 6-months, healing phases of tissue dictate LS patients should be fully healed from a tissue perspective,³⁶⁶ yet patients in this RCT and several other LS RCTs still experience LBP and even leg pain.^{9-11,104} The neuroscience view of an extra sensitive nervous system is used in contrast to a biomedical explanation of pain,³⁵⁵ which fosters a belief that “something is still wrong.”^{200,367} Pain in this case is expected. This reconceptualization of pain is a cornerstone of NE.^{67,202,213}

The most important finding of this RCT relates to healthcare utilization. As with beliefs, although both groups reported at 6-months post-LS similar pain, disability and various psychometric measures, the group that received the NE utilized 38% less medical care in the postoperative follow-up period. This finding is in direct contrast to the cost-analysis findings of a recent large multi-center RCT evaluating a postoperative treatment also aimed at educating patients regarding LS.^{18,308} Although McGregor et al’s study utilized postoperative education, whilst the current study explored preoperative education utilizing NE, it is believed that the content of the sessions may have been the key. The previous program utilized a mainly biomedical model, focusing on anatomy, biomechanics and pathoanatomy. Not only have these approaches shown to not help patients, but may indeed induce further fear and anxiety.^{199,200} This reasoning is emphasized by the fact that an expert panel review of both the postoperative RCT booklet content and the PNET revealed the postoperative study’s information to be heavily biomedical and containing three times more provocative terms than the NE. From a neuroscience perspective, these biomedical models try and explain pain to patients via tissue models. In contrast, the NE model de-emphasizes tissues and aim to provide patients a greater

understanding of the biology and physiology of their pain.^{81,288} Developing a greater understanding of pain, may indeed have helped patients see their pain as normal, as evident by rating their surgical experience as meeting their expectations and creating lesser of a need to seek medical care and attention.

Outcome measures, such as pain ratings, fear-avoidance and disability indices are all self-report.³⁶⁸ However, it could be argued that the pinnacle of outcome changes is a positive change in patient behavior, especially for educational interventions.³⁶⁹⁻³⁷¹ Although education is used in various realms to change health status of patients, including LBP,⁵⁹⁻⁶² education has shown limited efficacy in musculoskeletal disorders.⁶⁵³⁷²²⁴ A proposed reason why educational models fail is due to a limited application and internalization of the information by the patient, thus leading to a superficial learning process.^{270,271} In contrast, it is proposed that during a deep learning process,^{270,271,273} patients receive the message, internalize it, applies it to their situation and behavior change occurs, for example quitting smoking.^{373,374} This RCT provided a significant behavioral change, despite the self-report outcome measures. The behavioral change is reflected in the decreased need to seek medical care and consultation after LS, despite pain and disability. By developing a greater understanding that pain is normal and patients were taught strategies to help them with their expected postoperative pain, the NE likely enhanced self-efficacy and coping strategies. Self-efficacy is the process whereby patients are empowered to help themselves.⁵⁰ The NE emphasized pain as being normal, not an indication of the health of the tissues and several strategies help them treat the expected postoperative pain. This finding is underscored by the case series of patients who received the PNET. In the case series, immediately following NE, patients had a more than 50% positive shift in their belief that they can personally control their own pain post LS (*'I can control the amount of post-operative pain'*).

Pain and the resultant disability following LS may be normal. Educating patients about these normal responses in a neuroscience framework result in significant changes in behavior following LS. With ever-increasing concerns about money and healthcare expenditures, novel, cheap, personal and evidence-based approaches such as the PNET may have far-reaching implications for the LS patient's views of their persistent pain and disability following LS. This may improve the outcome of LS, and decrease the ongoing healthcare utilization of a large percentage of LS patients.

10.5 Limitations

This study contains various limitations. The first major limitation is that the RCT was under-powered and more subjects were needed to determine the true efficacy of the NE. A second limitation, related to design, was the lack of measuring pre- and immediate post NE pain knowledge to show an effect of the NE increasing pain knowledge as measured by the NPQ. The statistics showed that the EG had a statistically significant higher pain knowledge score compared to the usual care group at all intervals, but it was not possible to indicate if the increased knowledge was specifically due to NE, or just random. The findings from the RCT can only be applied to LS patients for radiculopathy and cannot be generalized to other types of LS patients, other spine surgeries, cervical radiculopathy and so forth.

10.6 Conclusion

Pain and disability after LS may be a normal human experience. Changing how patients see this persistent pain may have a profound effect on their behaviors following LS. Neuroscience education may have the potential to help patients not only experience surgery as successful despite pain and disability, but lead to significant healthcare utilization and cost savings.

Chapter 11: Discussion and Final Conclusion: Clinical Implications and a Way Forward

11.1 Overall findings and clinical implications

It is estimated that up to one in three patients experience persistent pain and disability, following lumbar surgery (LS).⁹⁻¹¹ Postoperative rehabilitation has shown little benefit in reducing the postoperative pain and disability^{12,18,19} and surgeons do not readily send patients to rehabilitation following LS,^{17,347} indicating many postoperative LS patients possibly suffering pain and disability. This thesis set out to develop, validate and test a preoperative neuroscience education (NE) program for patients undergoing LS for radiculopathy. Upon conclusion of the series of studies contained within this thesis, it is concluded that such a program can have a significant positive effect pertaining to various stakeholders in LS. Firstly, following NE, patients who have undergone LS for radiculopathy may develop a more realistic expectation to experience some postoperative pain; understand this pain; see this as a normal experience, which may decrease the need to seek medical care for the pain during the postoperative period. Secondly, surgeons should take note that the NE program resulted in a more positive surgical experience and higher satisfaction rate. Thirdly, the NE program resulted in significant healthcare savings, which should be of interest to third-party payers, government agencies and patients advocacy groups. In short, the preoperative NE program empowered patients, leading to meaningful behavioral changes in the postoperative period.

In the epilogue of his book *The Back Pain Revolution*,⁷⁰ Dr. Gordon Waddell states “*human beings have had back pain throughout recorded history; it has not changed; it is no different nor more severe or common than it has been before.*” He goes on by stating “*what has changed is how we think about back pain and what we do about it.*” The most meaningful statement, however, is his belief that “*we have turned a benign bodily symptom into one of the most common causes of disability in Western society.*” In a perfect world, a scientist aiming to get rid of low back pain (LBP) will develop a treatment, apply such a treatment and the LBP will disappear. However, LBP research results do not demonstrate that this has been the case.³⁷⁵

Although Waddell’s statement, countless natural history studies on LBP,^{376,377} post-LS studies^{12,18} and the results of this thesis imply that LBP after LS may indeed also be a normal human experience, this assumption is not supported by the current views of LS patients.^{56,102} LS patients expect to be pain-free.^{56,102} Persistent pain implies “*something is wrong.*” This viewpoint

is in direct contrast to the updated neuroscience view of pain.^{67,213} Why do patients believe “*something is still wrong*” when pain persists? For too long have clinicians fuelled this misbelief about pain and nociception as being synonymous. This misbelief is an example of a true biomedical approach, trying to explain pain purely by means of anatomy, biomechanics and pathoanatomy.^{213,378-380} This thesis provides several studies questioning this approach in face of the ever-increasing, ever-expensive LS industry.^{10,106,381} Chapter one provides evidence that US spine surgeons, in preparing patients for LS, teach patients about anatomy.³⁴⁷ This leads to a dichotomy. People in pain are interested in pain,^{56,253} yet clinicians try and explain pain to patients utilizing anatomy. Chapter two’s findings concur with this proposed dichotomy, indicating that preoperative education centered on a biomedical model as well as procedural information has limited effect in helping orthopedic surgery patients.³⁸² This finding is in line with two systematic reviews highlighting the limited efficacy of preoperative education in orthopedics.^{23,24} Apart from the limitations of the biomedical approach, it is also worth considering that this approach may indeed also hinder progress, let alone be ineffective. For example, it has been argued that the use of provocative language, common in orthopedic spine care, may indeed fuel fear and anxiety, ultimately leading to increased pain and disability.^{301,367} The results of this research study support that notion.

The question remains: Why do clinicians, when facing patients in pain, especially more complex pain-related issues, reach for these anatomically-based models? Additionally, why are clinicians reluctant to teach patients more about pain? First, it is proposed that this neuroscience view of pain is new. In physiotherapy literature, the neuroscience of pain, as we currently understand it, became visible in mainstream publications in the mid and late 1990’s and is thus relatively new.^{380,383,384} Even one of the pioneers in this movement, Louis Gifford, states a pivotal paradigm shift for him by the legendary Patrick Wall,³⁸⁵ was dated in the early 1990’s discussing the notion of neuroplasticity as a main mechanism behind persistent pain.³⁸⁶ With the advent of evidence based practice (EBP), NE with systematic reviews such as chapter 5 of this thesis and various RCT’s will likely be pushed faster into clinical practice and educational curriculums, which would benefit patients. It is interesting to note that clinicians and students are able to undergo significant changes in their knowledge, attitudes and beliefs regarding pain after a NE lecture or series of short lectures.^{253,387} Educators should therefore incorporate NE into current curriculums.³⁸⁸

A second reason why NE may not yet be undertaken in clinical practice, is a belief that patients may not be able to understand the complexities of pain, especially the neuroscience of pain.²⁵³ Moseley demonstrated that after a lecture on NE, patients developed significant improvement in their knowledge of the neuroscience of pain.²⁵³ It is also interesting to note that an increase in

this neuroscience knowledge of pain is associated with clinical improvements in spinal pain patients.²⁸⁹ NE changes a patient's perception of his/her pain.^{77,78} In contrast to believing pain is an indication of "something wrong," Moseley summarizes reconceptualization of pain in four points: (i) *pain does not provide a measure of the state of the tissues*; (ii) *pain is modulated by many factors from across somatic, psychological and social domains*; (iii) *the relationship between pain and the state of the tissues becomes less predictable as pain persists*; and (iv) *pain can be conceptualized as a conscious correlate of the implicit perception that tissue is in danger*.²¹³ Pain is thus produced by the brain based on perception of threat.^{67,75,213} Perceptions are powerful in determining a pain experience, as demonstrated in chapter 4 of the thesis on placebo surgery in orthopedics. In all three orthopedic surgery studies,²²²⁻²²⁴ including two spine surgery studies, patients who believed "the problem was fixed," experienced less pain and disability following surgery, even though no anatomical correction was performed. This research study, culminating in the multi-center RCT, educated patients about pain, especially the normality and likely presence of persistent pain after LS,³⁵⁵ which may have changed their perception of this postoperative pain in contrast to "*something is still wrong*." This deduction is underscored by the fact that, despite similar pain and disability, the NE group felt less of a need to seek help for their pain.

Spine surgeons should embrace the findings of this thesis. Patients undergoing LS have to weigh the risks and the benefits of surgery, with the hope that the benefits far outweigh the risks, allowing for a successful surgical experience.^{56,389} In a twisted way, surgeons are no different.³⁹⁰ In a perfect world, surgeons would perform LS on the correct patients, reduce pain and disability significantly, have satisfied patients and limited or no patients returning dissatisfied with their LS or worse, experience more pain and disability. The addition of the NE program enhanced patient's surgical experience. As with pain, perception is reality. If patients perceive their surgical experience as more favorable, despite pain and disability, they will more likely report the surgical experience as having met their needs,^{102,107,391} which was the case for the NE group. Additionally, despite pain and disability, patients in the NE group returned to fewer medical visits seeking help for their pain and disability, potentially alleviating this burden to surgeons. It is unfortunate, but surgeons are increasingly concerned about litigation.³⁹⁰ More and more studies focus on informed consent^{390,392} and it can be postulated that informed consent has become the "new" preoperative education sessions. Surgeons and their staff, instead of helping patients prepare adequately before LS, may indeed spend more time making sure all legal issues are covered before LS in an attempt to minimize potential legal action following LS.³⁴⁷ In chapter 2, covering medico-legal issues was rated as a main reason why US surgeons perform preoperative education, thus substantiating this viewpoint. In the RCT in chapter 10, patients were still at 6-months post-surgery experiencing pain, moderate disability

and high fear-avoidance indicating an increased risk of not returning to employment, yet patients receiving the NE program deemed their LS as meeting their expectations. Satisfied patients don't complain.³⁹³ Surgeon may indeed see the NE program as a way to ease this added worry of post-surgical retribution to their practice. Finally, surgeons should also see the findings of the NE trial as a way to reconceptualize their view of physiotherapists' role in LS. To date therapeutic interventions, consisting mainly of various postoperative treatments, has shown a limited effect in helping LS patients.^{12,18,19} It is therefore not surprising that spine surgeons do not readily utilize physiotherapists in and around LS^{17,347} and may even view physiotherapy in regards to LS as negative.³⁹⁴ The NE in the current RCT was performed by physiotherapists, as was done in all NE studies up to now.^{77,79,202,212,252,253} Physiotherapy, more than any other profession, may be ideally situated to treat people in pain, given time spent with patients and our knowledge of biology, movement, exercise and neuroscience.³⁸⁵

Lumbar surgery (LS) may be at a cross roads.^{106,395-397} LS is ever-increasing and up to one in three patients following LS experiences persistent pain and disability. With no perioperative management having demonstrated improvement in persistent pain and disability,^{11,12,395-398} this persistent pain and disability comes at a significant cost. This is in a time where healthcare may be seen as one of the most powerful geopolitical issues of our time.^{106,399,400} In the United States (US) alone, it is estimated that the current trend of reimbursing ever-increasing expensive treatments, such as LS, may result in the US spending its entire gross domestic product (GDP) on healthcare by the year 2050.^{399,400} If patients believe persistent postoperative pain should be addressed medically, it will come at a huge financial cost. For example, in the US alone, there is an estimated 540 000 lumbar discectomies performed annually^{10,398} and if one in three patients experience persistent pain and disability and seeks medical answers for this pain, the tests and treatments amounts are likely staggering. Furthermore, several proposed treatments for failed back surgery, has shown little to no benefit in reducing this pain and disability.⁴⁰¹⁻⁴⁰³

With global concerns regarding healthcare cost, treatments will increasingly need to focus on less expensive and less invasive methods to change healthcare behaviors, including those in LS patients.^{360,404-407} One such strategy may be meaningful education. Education is a cheap commodity in need of little to no special or expensive equipment.²⁸⁸ In fact, current best-evidence proves that one-on-one verbal communication using hand drawings and an ability to answer questions, may be the most effective form of patient education, especially in regards to pain education.²⁸⁸ This thesis systematically describes how an inexpensive, personal and evidence-based educational session focusing on NE, change patient's view of their pain, resulting in a meaningful change in behavior. This behavioral change results in a significant cost savings, as evident by the results in chapter 10. Not only should third-party payers and

healthcare agencies take note of these results, but also scientists. For too long has research focused on pain and disability as the gold standard, when aiming to determine the effect of a specified treatment.⁴⁰⁸ Seen from this perspective, the RCT in chapter 10 did not demonstrate a good outcome, but something very powerful and meaningful occurred. The NE resulted in a 38% reduction in postoperative care cost, averaging almost \$1200 US per patient 6-months following LS. With 540 000 US discectomies annually,¹⁰ the potential financial effect of the NE becomes staggering. As healthcare cost concerns mount, scientists are strongly urged to include cost-analysis into research design.

11.2 Limitations

This thesis contains a number of studies and the various limitations are included at the end of each study. The material in this thesis pertains to LS for lumbar and lumbosacral radiculopathy, thus findings may not apply to other postoperative patient groups. The majority of the research work was done from a US perspective and applied to a US LS patient population, and care should be taken to extrapolate the findings to other global locations. The results pertain to English-speaking adults between the ages of 18 and 65. The learning needs of kids and older adults are different and the NE for LS for radiculopathy may not apply to their situations.

11.3 Future directions

Global pain ratings and disability from back pain are increasing and it is imperative that clinicians embrace the neuroscience of pain. Given the positive results of the studies contained within this thesis, recommendations include:

- Familiarization by clinicians with the evidence, content and education delivery methods of NE
- Integration of NE into mainstream medical and physiotherapy curriculums
- Development of preoperative NE programs for other types of LS
- Development of preoperative NE programs for the cervical and thoracic spine
- Exploration of the PNET into other types of surgery, i.e., joint replacement surgery
- Trial of the preoperative NE program in postoperative populations to determine its efficacy
- Trial of the PNET in groups to determine its efficacy compared to individualized NE

11.4 Conclusions

Low back pain is a normal human experience. LBP may also be a normal postoperative experience for LS patients. LS patients who understand more about their pain and not view their postoperative pain as a purely nociceptive event, develop a more positive outlook of LS and feel a need to seek less medical care for their persistent pain. The addition of a preoperative NE program to usual care for LS for radiculopathy resulted in a significant behavioral change leading to a more positive surgical experience, decreased healthcare utilization and resultant savings, despite persistent pain and disability.

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Appendix 1

Ethics Approval



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01 December 2009

MAILED

Mr A Louw
Department of Physiotherapy
4th Floor, Teaching building
Stellenbosch University
Tygerberg campus
7505

Dear Mr Louw

"Preoperative Neuroscience Education for patients undergoing lumbar surgery for radiculopathy."

ETHICS REFERENCE NO: N09/09/247

RE : APPROVED

At a meeting of the Health Research Ethics Committee that was held on 14 October 2009, the above project was approved on condition that further information is submitted.

This information was supplied and the project was finally approved on 30 November 2009 for a period of one year from this date. This project is therefore now registered and you can proceed with the work.

Please quote the above-mentioned project number in ALL future correspondence.

Please note that a progress report (obtainable on the website of our Division: www.sun.ac.za/rds should be submitted to the Committee before the year has expired. The Committee will then consider the continuation of the project for a further year (if necessary). Annually a number of projects may be selected randomly and subjected to an external audit. Translations of the consent document in the languages applicable to the study participants should be submitted.

Federal Wide Assurance Number: 00001372

Institutional Review Board (IRB) Number: IRB0005239

The Health Research Ethics Committee complies with the SA National Health Act No.61 2003 as it pertains to health research and the United States Code of Federal Regulations Title 45 Part 46. This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki, the South African Medical Research Council Guidelines as well as the Guidelines for Ethical Research: Principles Structures and Processes 2004 (Department of Health).

Approval Date: 30 November 2009

Expiry Date: 30 November 2010

01 December 2009 12:14

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Appendix 2

Article: Preoperative education for lumbar radiculopathy: A survey of US spine surgeons



Preoperative education for lumbar radiculopathy: A survey of US spine surgeons

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Abstract

Background: We sought to determine current utilization, importance, content, and delivery methods of preoperative education by spine surgeons in the United States for patients with lumbar radiculopathy.

Methods: An online cross-sectional survey was used to study a random sample of spine surgeons in the United States. The Spinal Surgery Education Questionnaire (SSEQ) was developed based on previous related surveys and assessed for face and content validity by an expert panel. The SSEQ captured information on demographics, content, delivery methods, utilization, and importance of preoperative education as rated by surgeons. Descriptive statistics were used to describe the current utilization, importance, content, and delivery methods of preoperative education by spine surgeons in the United States for patients with lumbar radiculopathy.

Results: Of 200 surgeons, 89 (45% response rate) responded to the online survey. The majority (64.2%) provide preoperative education informally during the course of clinical consultation versus a formal preoperative education session. The mean time from the decision to undergo surgery to the date of surgery was 33.65 days. The highest rated educational topics are surgical procedure (96.3%), complications (96.3%), outcomes/expectations (93.8%), anatomy (92.6%), amount of postoperative pain expected (90.1%), and hospital stay (90.1%). Surgeons estimated spending approximately 20% of the preoperative education time specifically addressing pain. Seventy-five percent of the surgeons personally provide the education, and nearly all surgeons (96.3%) use verbal communication with the use of a spine model.

Conclusions: Spine surgeons believe that preoperative education is important and use a predominantly biomedical approach in preparing patients for surgery. Larger studies are needed to validate these findings.

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Keywords: Spine; Surgery; Education; Survey; Preoperative

The literature on preoperative education for lumbar spine surgery is dominated by studies that use experimental designs to measure the effects of structured educational programs on patient outcomes.^{1–4} These studies predominantly compare structured, preoperative educational interventions with the usual care that patients receive. “Usual care,” however, is largely elusive and unexplored.¹ To date, several studies have been conducted in reference to preoperative education for lumbar surgery,^{5–13} but the heterogeneous nature of these studies does not provide a clear view of what

constitutes “usual care” for preoperative education for spinal surgery. These include different surgical interventions, such as surgery for scoliosis,^{8,9} disc surgery,^{11,12} decompressive surgery,^{11,12} and “not specified.”^{6,10} The delivery methods also vary among verbal education by a nurse,^{6,9} surgeon,^{10,13} or physical therapist¹³ or video-only instruction.^{7,8} The content of preoperative education varies among cognitive behavioral therapy,^{7,8} information regarding the surgical procedure,^{6–8,10} information on activities of daily living,¹³ anatomy,⁶ risks associated with the surgery,^{6,7,10,13} general hospital procedures,^{6,7} and length of hospital stay.^{6,7} Educational interventions use various types of educational aids, including leaflets and booklets,^{6,9,10} spine models,¹⁰ posters,^{9,10} or verbal communication with no educational aids.⁹ Preoperative education is administered to adults,^{6,10} as well as adolescents and children.^{7–9} With regard to the

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timing and duration of education, only 1 study specifies preoperative education to be administered 1 to 2 weeks preoperatively for 40 minutes.⁶

It is clear from the vast variety of methods in the literature reviewed that very little is known regarding what constitutes “usual care” as it relates to the utilization, content, and preferred education delivery methods used in studies and thus also by spine surgeons in the United States. The purpose of this study was to determine the current utilization, content, and delivery methods of preoperative education by spine surgeons in the United States for patients undergoing surgery for lumbar radiculopathy. In addition, the study aimed to determine the importance that spine surgeons in the United States place on preoperative education for lumbar radiculopathy. Future studies that use experimental designs to measure the effects of structured education programs on patient outcomes may benefit from knowing what constitutes “usual care” in preoperative education for spinal surgery in the United States.

Methods

Questionnaire development and administration

Because no similar studies have been conducted, the Spinal Surgery Education Questionnaire (SSEQ) was developed to determine the utilization, content, delivery methods, and importance of education as rated by spine surgeons in the United States (Appendix 1). The questionnaire was designed based on previous surveys of physicians and surgeons related to various other surgical interventions,^{14–21} a previous study surveying patients having undergone lumbar surgery for radiculopathy,¹¹ and objectives of the study. Section 1 of the questionnaire gathered demographic and practice information from the responding spine surgeon, whereas section 2 gathered information on the content, delivery methods, utilization, and importance of spinal surgery as rated by the surgeons.

To establish face and content validity, the draft questionnaire was sent to a panel of national and international experts in the fields of patient education, questionnaire design, and spinal surgery.²² Upon completion of the expert panel review, a pilot study comprising a convenience sample of spine surgeons was conducted to review the content, the ease of completion, and the time it took to complete the questionnaire. The finalized SSEQ was uploaded on a secure Web site for use in the study. To obtain a random sample of US spine surgeons, a company tracking outcomes for spine surgeons (Visiontree, San Diego, CA, USA), as well as a marketing agency (Medical Marketing Services, Inc., Wood Dale, IL, USA), was asked to provide a random sample of spine surgeons, representing all states, to participate in the survey study. E-mail invitations were sent to 200 surgeons describing the study and asking them to participate in the online survey. Surgeons included in the study were men or women, practicing in the United States, and actively involved in performing spinal surgery. Exclusion criteria

included surgeons not fluent in reading or writing the English language and those not actively involved in spinal surgery. Data were collected over a 3-month period, with 4 separate E-mail messages sent to the surgeons as reminders and 1 sent in appreciation for their time and participation.

Statistical analysis

The survey data were captured by the Web site software and compiled in Excel spreadsheet files (Microsoft, Redmond, Washington), and statistical testing was performed with SPSS software (version 16.00; SPSS, Inc., Chicago, Illinois). This was, to a large degree, a descriptive study. Descriptive statistics such as counts and percentages, frequency distributions, means, standard deviations, and confidence intervals were used to describe variables. Some prespecified comparisons were made between certain variables. Where both variables were categorical, contingency analysis was used to detect association. Both the χ^2 test and Fisher exact test were used. Statistical significance was set at $P < .05$. When relationships between a categorical variable and a continuous outcome were analyzed, a t test or analysis of variance was used to detect significant differences. Where the assumptions of normality were violated, the nonparametric equivalents were used to analyze the data.

Results

Overview of population demographics

A total of 89 of the 200 surgeons (45%) responded to the online survey. Eight questionnaires had to be excluded because of incomplete data, resulting in a total of 81 completed questionnaires that were available for analysis. According to the biographic information captured (Table 1), 90% of the respondents were orthopedic surgeons and 10% neurosurgeons. Of the respondents, 91% were trained as medical doctors and 9% as doctors of osteopathy. Male surgeons constituted the majority in that all but 3 respondents were male spine surgeons (97.5%). The distribution among cohorts in terms of the length of time in practice indicated that the sample consisted of surgeons with extensive experience performing spinal surgery, where 46.9% had been practicing for more than 20 years; 30.9%, between 10 and 20 years; 16.1%, between 5 and 10 years; and 6.2%, less than 5 years. The majority of surgeons (56.8%) were working in a private practice exclusively, whereas 27.2% indicated that they worked in an academic setting. A small group of surgeons (13.6%) indicated that they worked in both private practice and academic settings. Almost two-thirds of the respondents (65.4%) indicated that they provide education for medical students/residents. A small percentage of surgeons ($n = 7$, 8.6%) indicated that they had additional training in pain management. Of the surgeons, 43.2% indicated that they performed fewer than 10 decompressive surgeries for lumbar radiculopathy per month, fol-

Table 1
Demographic information on respondents of SSEQ

	Data
Gender	
Male	97.5%
Female	2.5%
Medical training	
MD	91%
DO	9%
Surgical training	
Orthopedic	90%
Neurosurgery	10%
Time in practice	
<5 yr	6.1%
5–10 yr	16.1%
10–20 yr	30.9%
>20 yr	46.9%
Practice setting	
Private	56.8%
Academic	27.2%
Both private and academic	13.6%
No response	2.4%
Provide education for medical students/residents?	
Yes	65.4%
No	34.6%
No. of decompressive surgeries per month	
<10	43.2%
10–20	38.3%
>20	18.5%
Had surgeon undergone lumbar surgery?	
Yes	14.6%
No	86.4%
Had immediate family undergone lumbar surgery?	
Yes	34.6%
No	65.4%

Abbreviations: DO, doctor of osteopathy; MD, medical doctor.

lowed by 38.3% performing between 10 and 20 surgeries and 18.5% performing more than 20 surgeries per month. Most surgeons (86.4%) indicated that they had not undergone lumbar surgery themselves, whereas nearly two-thirds of the surgeons (65.4%) indicated that they did not have an immediate family member who had undergone lumbar surgery. Surgeons who had additional training in pain management were more likely to have personally undergone lumbar surgery ($P = .018$) and were more likely to have had an immediate family member undergo lumbar surgery ($P = .002$) compared with surgeons who did not have additional training in pain management.

Use of preoperative education for lumbar radiculopathy

All surgeons in the survey indicated that they provided preoperative education for lumbar radiculopathy. Nearly two-thirds of the surgeons (64.2%) indicated that their preoperative education was provided informally during the course of clinical consultation rather than a formal, designed and preplanned session providing preoperative education. Most surgeons (83.9%) indicated that they provided their preoperative education during the final consultation session at their office. The mean time from the decision to undergo

surgery to the date of surgery was 33.65 days, with a median of 17.5 days. Three-quarters of the surgeons (75.3%) indicated that the facilities where they perform surgery, such as a hospital or surgery center, did not provide structured preoperative educational sessions or classes. Thirty-six comparisons were made between orthopedic surgeons and neurosurgeons in the following 5 categories: demographics, educational sessions, content of the educational section, tools/props used for education, and physical therapy referrals. None of these showed a statistically significant difference, indicating that orthopedic surgeons and neurosurgeons have similar practice patterns regarding preoperative education for lumbar surgery for radiculopathy.

Content

Of the 19 topics listed in the SSEQ (Appendix 1), 10 were chosen by at least 80% of the surgeons to be included in preoperative education for lumbar surgery for radiculopathy. Surgeons rated topics to include in preoperative education by order of importance as follows: surgical procedure (96.3%), complications (96.3%), outcomes/expectations (93.8%), anatomy (92.6%), amount of postoperative pain expected (90.1%), hospital stay (90.1%), how surgery will affect pain (88.9%), precautions after surgery (86.4%), infection (85.2%), and smoking (83.9%). Surgeons estimated that they spent an average of approximately 20% of the preoperative education time specifically addressing pain (range, 3%–80%). Nearly two-thirds of surgeons reported that they routinely send their patients to undergo rehabilitation in physical therapy after lumbar surgery for radiculopathy. The surgeons who indicated that they send patients to rehabilitation on average send 85% of their patients to physical therapy.

Education delivery methods

Three-quarters of the surgeons (75.3%) indicated that they themselves provided the educational sessions. Nearly all surgeons (96.3%) indicated that they used verbal communication and discussion with the use of a spine model. Nearly two-thirds of the surgeons (64.2%) estimated that the educational session lasted approximately 15 minutes. Half of the surgeons (51.9%) indicated that they used booklets with images as a teaching tool, and more than 1 in 3 surgeons (38.3%) refer patients to Web sites. When asked to indicate a specific Web site used for referral, choices showed no consistent pattern.

Importance of preoperative education

More than 85% of the surgeons (85.2%) rated the importance of preoperative education as 8 or higher on a scale of 0 to 10, with the mean score being 8.8 of 10 (SD, 1.47). Surgeons' indication as to why preoperative education was important comprised a combination of the following 4 reasons: (1) it is an ethical and/or legal obligation, (2) it provided an opportunity to answer questions, (3) it helped

reduce anxiety before surgery, and (4) it provided better surgical outcomes.

Discussion

To our knowledge, this is the first study centered on determining the practice patterns of US spine surgeons related to preoperative education for lumbar surgery for radiculopathy.

Use of preoperative education

The results of this study indicate that spine surgeons in the United States do use preoperative education before lumbar surgery for radiculopathy. This finding concurs with other studies assessing preoperative education in orthopedics and spinal surgery^{6–9,11,12,23} and is in line with preoperative education in other surgical areas, such as orthopedic peripheral joint surgery,^{5,24–27} cardiac surgery,^{28–32} and abdominal surgery.^{4,33–36} The results from this study showed that surgeons use preoperative education as a means of providing better outcomes, answering patient questions, covering legal and ethical requirements, and reducing patient anxiety. These intentions correspond with studies showing that preoperative education helped increase knowledge of the surgical procedure,^{3,5,37,38} reduced anxiety,^{29,35,39–41} reduced postoperative pain,^{6,8,35,42,43} decreased length of hospital stay,^{5,26,43,44} and facilitated a faster return to preoperative functional levels.^{6,13,26,28,42}

Content of preoperative education

The majority of the content covered in preoperative education for lumbar radiculopathy addressed issues related to the outcome of the surgery. Outcomes related to spinal surgery have become a hotly debated topic in the literature.^{45–52} Studies indicate that patients often have high expectations of surgery and outcomes are often not met.^{45,53}

Of all the topics covered in preoperative education for lumbar surgery for radiculopathy, surgeons rated “surgical procedure” the highest. This finding correlates with previous studies that investigated surgeon practice patterns^{4,5,11,54} and indicated that surgeons spent most of the time discussing the impending surgical procedure and anatomic reasoning behind the proposed surgery. Discussion of the surgical procedure is expected, because surgeons are often viewed as expert technicians and thus view spinal disorders from a technical point of view.^{55–59} It is important to note that in a recent study that surveyed patients having undergone lumbar surgery for radiculopathy,¹¹ patients were asked to rate the importance of various topics covered during preoperative education and “surgical procedure” was only ranked No. 9.¹¹ The survey showed that patients wanted to know how surgery would affect their symptoms (ranked No. 1) and may have had only a limited interest in a full discussion of the surgical procedure.^{11,45} In addition, the survey showed that patients were interested in knowing more about pain issues related to their impending surgical intervention.

Several pain issues, such as how pain would be affected by the surgery, complete loss of pain, preoperative pain, and other pain, were rated more important than “surgical procedure.”¹¹ In our study, surgeons on average estimated that they spent 20% of their educational session specifically addressing pain. Because surgery data indicate that the primary reason for lumbar surgery is pain,^{11,12,45,51} this finding may show a shortcoming in the surveyed preoperative education by not adequately addressing a more detailed discussion of pain.¹¹ Although several studies have implicated unrealistic expectations on the patient’s part and possible improper presentation of these expectations by the surgeon,^{13,53} it may also reflect the potential lack of provision of adequate information explaining in detail to patients their pain. A more comprehensive discussion of pain would imply use of a more elaborate biopsychosocial approach. Previous studies have implicated that psychosocial factors are powerful determinants in surgical outcome and need to be addressed before surgery, including the determination of whether surgery should even be performed.^{60,61} The results of this survey portray a traditional biomedical model focusing on the faulty tissue (“surgical procedure” ranked No. 1 and “anatomy” ranked No. 4 by surgeons), rather than a larger, more comprehensive biopsychosocial approach.^{60,62} Two recent studies highlighted the influence of psychological factors in spinal surgery and recommended that these factors be addressed in preoperative education for lumbar surgery.^{63,64}

Another interesting finding from this study is that surgeons, regardless of their training, academic involvement, personal and family history of spinal surgery, experience, and additional pain management training, agreed on the topics needed for inclusion preoperatively, as well as their ranking. Surgeons are known to have different viewpoints related to various topics, including the use of new technology, diagnostics, complications, outcomes, and rehabilitation after surgery.^{14,17,21,23,46,65} This study showed that despite considering a number of variables among spine surgeons thought to produce different results, it did not do so. The positive implication is that surgeons are all doing the same things, because there seemed to be agreement as to what should be included in preoperative education for lumbar surgery for radiculopathy. Future studies that use experimental designs to measure the effects of structured education programs on patient outcomes should benefit from knowing what constitutes usual care in preoperative education for spinal surgery in the United States.¹ The negative implication of this finding is that if the preoperative educational program surgeons are using in the United States is lacking in any way, the preoperative education that is provided may be universally suboptimal. This concern is highlighted by the results of this study indicating that nearly half of the surgeons did not choose “strategies to cope with pain” as an option to include in their preoperative educational program. Furthermore, it is well-established that the preoperative environment is associated with increased levels of anxiety and

fear,^{32,66–71} which has the potential to negatively impact outcomes of surgery.^{60,61} Addressing fear and anxiety forms part of a true biopsychosocial approach,^{60,62,72} and several studies have shown that educational strategies aimed at reducing fear and anxiety have the potential to do exactly that.^{7,25,67,73–75} In our study, of the 4 main reasons surgeons felt the need to include in preoperative education, “reducing anxiety” was rated least important. This may reflect a potential lack of applying a true biopsychosocial approach to preoperative education for lumbar surgery for radiculopathy.

Education delivery methods

The choice of verbal one-on-one education by the surgeons concurs with other studies that indicate that surgeons tend to take the lead in providing the education before surgery.^{4,11} Mordiffi et al.⁷⁶ investigated the preferred method of preoperative information delivery in 67 patients and found that about 90% of the respondents preferred information to be delivered verbally by the surgeon. This finding is further validated by the fact that surgeons view preoperative education as a means for them to answer patient questions. Considering that surgeons rated “surgical procedure” most highly as a factor to be included in preoperative educational sessions and that education delivery mainly consists of verbal one-on-one communication, it can be argued that the surgeon should perform the educational session, because he or she will be performing the surgical procedure. Although the majority of surgeons indicated that they perform the education and patients prefer surgeons to perform the educational session,¹¹ the results from this study showed that almost 25% of the education sessions were delivered by other healthcare professionals. Several studies have highlighted time constraints on physicians, especially surgeons.^{77–80} There has been a gradual increase in surgeons using allied healthcare professionals, such as physician assistants, nurses, and nurse practitioners.^{5,81–85} Future studies should investigate this trend and its potential impact on preoperative education for lumbar surgery.

The benefits of one-on-one verbal education seem to outweigh the potential shortcomings. One-on-one verbal education is what peers are using; patients request it; it provides a chance to answer the patient’s questions and is more personable and provides an ability to alter the message to meet the educational needs of the patient.^{4,76,86,87} Problems associated with one-on-one verbal-only communication include difficulty with limited recall, language barriers, learning disabilities, educational level, age, and cultural considerations.^{4,88–90} Considering all the potential barriers to optimal learning, it becomes clear that one-on-one verbal education should also be accompanied with educational material, which has shown to aid recall of information presented to the patient through one-on-one verbal communication.^{91–93} The results from this study showed that surgeons preferred to accompany their verbal one-on-one educational session with the use of a spine model. This finding

is not surprising, considering that surgeons rated “surgical procedure” (ranked No. 1), “anatomy” (ranked No. 4), and “surgery affecting pain” (ranked No. 7) high in terms of content used to educate patients before lumbar surgery for radiculopathy. The surgeon will thus use this information to describe to the patient the anatomic reason for the patient’s pain and how the surgical procedure aims to correct the problem.^{53,94} This information is deemed necessary to help patients weigh risks and benefits from surgery and help establish realistic goals and expectations regarding their surgical outcome.⁴⁵ This educational model is a true biomedical model with a heavy focus on anatomy and patho-anatomy.^{60,62} This finding is underscored by the fact that 96% of the surgeons in this study chose “spine model and verbal communication” compared with only 9% choosing “verbal only.” The biomedical model assumes that the patient’s pain is a result of an anatomic problem, such as a herniated disc,^{46,94} spinal degeneration,^{95,96} or stenosis.^{97,98} Surgical decompression aims to alleviate the irritation on the neuromeningeal tissues, thus alleviating the patient’s pain and neurologic deficit and restoring function.^{46,53,94} Although it is not argued that these interventions are beneficial for patients with lumbar radiculopathy,⁴⁶ this model may not adequately include factors that have been shown to impact surgical outcomes, such as fear, anxiety, expectations, coping skills, and catastrophization.^{2,60,71,75,99,100}

Conclusion

The results of this survey show that spine surgeons in the United States regularly use preoperative education and believe it to be an important aspect in preparing patients for lumbar surgery. However, surgeons tend to use biomedical models in their preoperative education and focus on the surgical procedure rather than explaining the patients’ pain through a more comprehensive biopsychosocial approach. Future research should examine postoperative outcomes with the current preoperative education (biomedical model) and compare them with preoperative neuroscience education (biopsychosocial model) in surgery for lumbar radiculopathy. From a clinical perspective, it would be prudent for surgeons to balance the contemporaneous biomedical educational approach with a biopsychosocial approach to provide a more rounded and medicolegally defensible approach to patient management.

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Appendix 1

The SSEQ is aimed at developing a greater understanding of preoperative education provided to patients undergoing lumbar surgery for radiculopathy. Preoperative education is defined as a set of planned educational activities delivered to a patient before surgery, designed to improve a patient's health behavior, health status, or both. Such activities are aimed at facilitating a patient's knowledge base.

Section 1 (demographic/practice information)

Please complete the following demographic information sheet.

1. Are you an orthopedic surgeon or a neurosurgeon?
2. Please circle your medical qualification: MD DO
3. Gender: Male Female
4. Age: _____
5. In which state do you primarily/mostly practice? _____
6. How long have you been in practice? <5 years 5–10 years 10–20 years >20 years
7. Do you work in an academic setting or in a private practice?
8. Are you actively involved in teaching residents and/or medical students? Yes No
9. Do you have any specialized/extra training in pain management (eg, fellowship or residency)? Yes No
10. On average, how many decompressive surgeries for lumbar radiculopathy do you perform per month? <10 10–20 >20
11. Have you personally undergone spinal surgery? Yes No
12. Has any immediate family member undergone spinal surgery? Yes No
13. In your practice, what is the average time (days) it takes for a patient to go from having decided to undergo surgery to the actual surgical procedure? _____

Section 2

1. How would you describe your preoperative education sessions for lumbar surgery for radiculopathy?
 - formal (specially designed and planned session to provide education and interaction with the patient)
 - informal (during the course of the clinical consultation)
2. In your office, who provides the majority of the preoperative education for patients undergoing lumbar surgery for radiculopathy?
 - You (the surgeon)
 - Nurse
 - Physician assistant
 - Office personnel
 - Other; please specify _____
3. When do you provide the preoperative educational information?
 - At the last consultation in your clinic
 - In the hospital before surgery
 - At the first visit to the patient after surgery
 - Other; please specify _____
4. On average, how much time would you estimate is spent on preoperative education/information per patient undergoing lumbar surgery for radiculopathy?

- <5 minutes
- 5–15 minutes
- >15 minutes

5. Do you, or the hospital/institution with which you are affiliated, provide a formal (structured) preoperative education program for spinal surgery, such as a class or referral to a person/group that performs such preoperative education?

- No
- Yes

If yes:

Who delivers the education (profession)? _____

How long does it last? _____ minutes

Is it mandatory to attend? Yes No

6. On the basis of your experience, please indicate on the line graph below how important you view preoperative education/information for your patients, from 0, indicating “not important,” to 10, indicating “very important.”

|-----|
 Not important Very important

7. Indicate why you would include preoperative education/information for your surgery patients:

- I am obliged to (ethically and/or legally)
- It provides an opportunity to answer patient questions
- It helps reduce anxiety before surgery
- It provides “better” surgical outcomes
- Other; please specify _____

8. Below, you will find a list of topics related to spinal surgery. Please check off the items that form part of your preoperative educational/informational program. Indicate as many as you need.

- Anatomy
- Biomechanics
- Surgical procedure
- Blood work before surgery
- Medicine use before surgery
- Smoking
- Food intake before surgery
- Hospital issues (admission and so on)
- Complications
- Outcomes/expectations
- Consent
- Surgical scar
- Surgery affecting pain
- Amount of postoperative pain
- Physical therapy
- Strategies to cope with pain
- Infections
- Hospital stay
- Precautions after surgery
- Other; specify _____

9. Of all the items listed above, please indicate from the menu below which of the following categories you rate as the single most important aspect to cover before lumbar surgery for radiculopathy.

- Surgical procedure (anatomy, biomechanics, instrumentation)
- Medical care preoperatively (blood work, medicine use, smoking, hospital admission)
- Outcomes (pain, function, strength)
- Legal (consent, possible complications, risks/benefits)
- Postoperative (physical therapy, physician visit, limitations after surgery)

10. What percentage of your preoperative education is dedicated to specifically address pain experienced by the patient?
_____%

11. In providing preoperative education, please choose from the list below any tools/props you use during the educational session:

- Spine model and verbal description/communication
- Only verbal description/communication
- Booklet with images
- Booklet with no images, only words of advice
- DVD/video of the surgery
- Referral to a Web site; if so, which one? _____
- Other; please explain _____

12. Do you routinely send patients after lumbar surgery for radiculopathy to physical therapy for rehabilitation?

- No
- Yes

When you do, approximately what % of your patients? _____%

Thank you for your time.

Appendix 3

Article: Efficacy of preoperative education addressing postoperative pain in orthopedics

Preoperative education addressing postoperative pain in total joint arthroplasty: Review of content and educational delivery methods

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ABSTRACT

Objective: Evaluate content and educational delivery methods of preoperative education in total joint arthroplasties of the hip and knee (THA and TKA) addressing postoperative pain. **Data sources:** Systematic searches conducted on Biomed Central, BMJ.com, CINAHL, the Cochrane Library, NLM Central Gateway, OVID, ProQuest (Digital Dissertations), PsycInfo, PubMed/Medline, ScienceDirect, and Web of Science. Secondary searching (pearling) was undertaken. **Data extraction:** Data were extracted utilizing the participants, interventions, comparisons, and outcomes approach. **Study selection:** All randomized controlled trials (RCTs) evaluating the effect of preoperative education on postoperative pain in THA and TKA surgery were considered for inclusion. **Limitations:** Studies published in English; published within the last 20 years and patients over the age of 18. No limitations were set on specific outcome measures of pain. **Data synthesis:** This review included 13 RCTs involving a total of 1,017 subjects who underwent THA or TKA. Educational delivery methods comprised verbal one-on-one or group education sessions, delivered within 4 weeks of surgery lasting an average of 30 minutes, and accompanied by other written materials. The educational content centered on descriptions of preoperative preparation, hospital stay, surgical procedure, immediate/intermediate experiences, expectations following surgery, rehabilitation, encouragement/reassurance, and answering common question associated with the surgical experience. **Conclusions:** Preoperative education centered on a biomedical model of anatomy and pathoanatomy as well as procedural information has limited effect in reducing postoperative pain after THA and TKA surgeries. Preoperative educational sessions that aim to increase patient knowledge of pain science may be more effective in managing postoperative pain.

INTRODUCTION

Pain is a common postoperative issue that many patients are left to face (Cheung, Callaghan, and Chang, 2003; Douglas, Mann, and Hodge, 1998; Fisher et al, 2004; LaMontagne, Hepworth, Salisbury, and Cohen, 2003; Pellino et al, 1998). In 1975 and 1978, two pioneer studies by Hayward and Boore

(Oshodi, 2007a, 2007b) found that structured preoperative education had an effect on postoperative pain, anxiety, and recovery. Since these early studies, numerous articles have been published on the effect of preoperative education on alleviating postoperative complications. These areas of research include cardiac surgery (Arthur et al, 2000; Deyirmenjian, Karam, and Salameh, 2006; Roth-Isigkeit et al, 2002; Shelley and Pakenham, 2007; Wang, Shen, Lu, and Yang, 2008), abdominal surgery (Cheung, Callaghan, and Chang, 2003; Oshodi, 2007a; Wilhelm et al, 2009; Young, de Guzman, Matis, and McClure, 1994; Zieren, Menenakos, and Mueller, 2007), dental surgery (Mladenovski and Kieser,

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2008; Muglali and Komerik, 2008; Ng, Chau, and Leung, 2004), surgery for cancer (Caumo et al, 2001; Cumbo et al, 2002; Oshodi, 2007b), and anesthesia prior to surgery (Bondy et al, 1999; Hering, Harvan, Dangelo, and Jasinski, 2005; Lee, Chui, and Gin, 2003; Macario, Weinger, Truong, and Lee, 1999; Oshodi, 2007b). These approaches incorporated various teaching strategies and tools including: DVD/video (Bondy et al, 1999; Chen and Yeh, 2005; Lin, Lin, and Lin, 1997; McEwen et al, 2007; Wilhelm et al, 2009), audio cassettes (Daltroy et al, 1998; Krackow and Buyea, 2001; Whyte and Grant, 2005), phone calls (Arthur et al, 2000; Mancuso et al, 2001), online education and websites (Heikkinen et al, 2008; Macario et al, 2003; Saryedine et al, 2008), and booklets/pamphlets (Adam et al, 2008; Bondy et al, 1999; Cheung et al, 2007; Courtney, 1997). Education through these sources has been shown to help: increase knowledge of the surgical procedure (Cheung et al, 2007; Heikkinen et al, 2008; Hering, Harvan, Dangelo, and Jasinski, 2005; Johansson et al, 2005), reduce anxiety (Belleau, Hagan, and Masse, 2001; Bondy et al, 1999; Cheung, Callaghan, and Chang, 2003; Cupples, 1991; Deyirmenjian, Karam, and Salameh, 2006), reduce postoperative pain (Cheung, Callaghan, and Chang, 2003; Douglas, Mann, and Hodge, 1998; Fisher et al, 2004; LaMontagne, Hepworth, Salisbury, and Cohen, 2003; Pellino et al, 1998), decrease length of hospital (LOH) stay (Johansson et al, 2005; McGregor et al, 2004; Oshodi, 2007b; Pellino et al, 1998), and reduce the time to return to preoperative functional levels (Arthur et al, 2000; Douglas, Mann, and Hodge, 1998; Fisher et al, 2004; McGregor et al, 2004; Ronnberg et al, 2007).

Several studies have shown that pain is a significant issue following many orthopedic procedures and surgeries (Niskanen and Strandberg, 2005; Parker, Handoll, and Griffiths, 2004; Pitimana-aree et al, 2005; Sinatra, Torres, and Bustos, 2002; Wulf et al, 1999). Persistent levels of postoperative pain and the limited effect of medication addressing postoperative pain (Axelsson et al, 2005; Mahoney, Noble, Davidson, and Tullos, 1990) have led researchers to investigate ways to positively impact postoperative pain control after these surgeries. Preoperative education has been used as one strategy in this regard as several studies have shown that increased anxiety in the preoperative period is associated with increased postoperative pain (Muglali and Komerik, 2008; O'Conner-Von, 2008; Rice, Glasper, Keeton, and Spargo, 2008; Rosen, Svensson, and Nilsson, 2008; Salzwedel et al, 2008; Wang, Shen, Lu, and Yang, 2008). Providing patients with education to address said anxiety in the preoperative period would seem

an appropriate intervention to decrease postoperative pain.

The U.S. population is aging (Kent, Funk, and Crandall, 2002) and more individuals have need for total knee arthroplasty (TKA) and total hip arthroplasty (THA) surgeries (McDonald, Hetrick, and Green, 2004; Swanson, Schmalzried, and Dorey, 2009) and subsequent need for postoperative pain control. A systematic review of the literature regarding the content and delivery methods of preoperative education addressing postoperative pain is needed. The primary research question for this systematic review was to determine if any preoperative education strategies utilized in orthopedic surgery for THA and TKA could be shown to positively affect postoperative pain, and to also determine the best content and delivery methods of that preoperative education.

METHODS

The protocol for this study was reviewed and deemed excluded from Institutional Review Board review by Stellenbosch University Board of Institutional Review/Ethics.

Definitions

The following terms and definitions were applied to the review:

- *Preoperative*: Care given before surgery when physical and psychological preparations are made for the operation, according to the individual needs of the patient. The preoperative period starts from the time the patient is admitted to the hospital or surgery center to the time that the surgery begins (Webster's, 2008).
- *Perioperative*: The period of time extending from when the patient goes into the hospital, clinic, or doctor's office for surgery until the time the patient is discharged home (Webster's, 2008).
- *Patient education*: Any set of planned educational activities designed to improve a patient's health behaviors, health status, or both. Such activities are aimed at facilitating the patient's knowledge base (Lorig, 2001; Oshodi, 2007a).

Search strategy

An electronic search was performed in February 2011, covering the last two decades (1990–2011) of the following databases: Biomed Central, BMJ.com,

TABLE 1 Inclusion criteria used in the systematic review.

Criterion	Justification
English language 1990–2011	Major journals in this area are published in this language Twenty years captures the most recently used treatments in clinical practice
Humans over 18 years of age	This increased the homogeneity of participants between studies and educational needs are different for infants, adolescents, and teenagers
RCTs	RCT's provide high levels of evidence. Study designs other than RCT were not included in this review because of the low level of evidence they provide
Patient education	No limitations were set on the content or methods used in patient education, since it was one of the aims of this review to source the content and education delivery methods
Outcomes: postoperative pain	The primary outcome measure chosen for this review was postoperative pain. No limitations were set on the measurement tool used to examine the effect of preoperative education on postoperative pain
Preoperative	All studies that intervened with an educational strategy prior to the surgical procedure were included. No limitations were set on the timing of the education prior to surgery

TABLE 2 Hierarchy of evidence, study design, based on the Australian NHMRC Hierarchy of Evidence.

Level	Definition	Studies
I	Evidence obtained from a systematic review of all relevant RCTs	
II	Evidence obtained from at least one properly designated RCT	Beaupre, Lier, Davies, and Johnston (2004); Clode-Baker et al (1997); Daltroy et al (1998); Doering et al (2000); Ferrara et al (2008); Giraudet-Le Quintrec et al (2003); Gocen et al (2004); Lilja, Ryden, and Fridlund (1998); McDonald, Freeland, Thomas, and Moore (2001); McGregor et al (2004); Sjoling, Nordahl, Olofsson, and Asplund (2003); Vukomanovic, Popovic, Durovic, and Krstic (2008)
III-1	Evidence obtained from well-designed pseudo-RCTs (alternate allocation or some other method)	Gammon and Mulholland (1996)
III-2	Evidence obtained from comparative studies (including systematic reviews of such studies) with concurrent controls and allocation not randomized, cohort studies, case-control studies, or interrupted time series with a control group	
III-3	Evidence obtained from comparative studies with historical control, two or more single arm studies, or interrupted time series without a parallel control group	
IV	Evidence obtained from case series, either post-test or pre- test/post-test	

CINAHL, the Cochrane Library, NLM Central Gateway, OVID, ProQuest (Digital Dissertations), PsycInfo, PubMed/Medline, ScienceDirect, and Web of Science. Each database has its own indexing terms and functions, and therefore different search strategies were developed for each database by the authors. The main key words used for the search items were: *preoperative, perioperative, pre-admission, orthopedic, surgery, arthroplasty, replacement, spine, education, instruction, advice, inform, consultation, and pain*. In PubMed, medical subject headings (MeSH) terms were used where possible, with Boolean operators. The search strategies for reviewing the remaining databases included searches using

synonyms of the main keyword search items. Secondary searching in the form of “pearling” was undertaken, whereby reference lists of all included articles were searched for additional relevant studies not identified in the primary search. The titles and abstracts of all the identified literature were screened by the one reviewer using the selected inclusion criteria. The full text of all potentially relevant articles were retrieved and then screened by the remaining three reviewers using the same criteria to determine the eligibility of the paper for inclusion in the review. All members of the team are engaged in research on pain science education and have successfully published in this area.

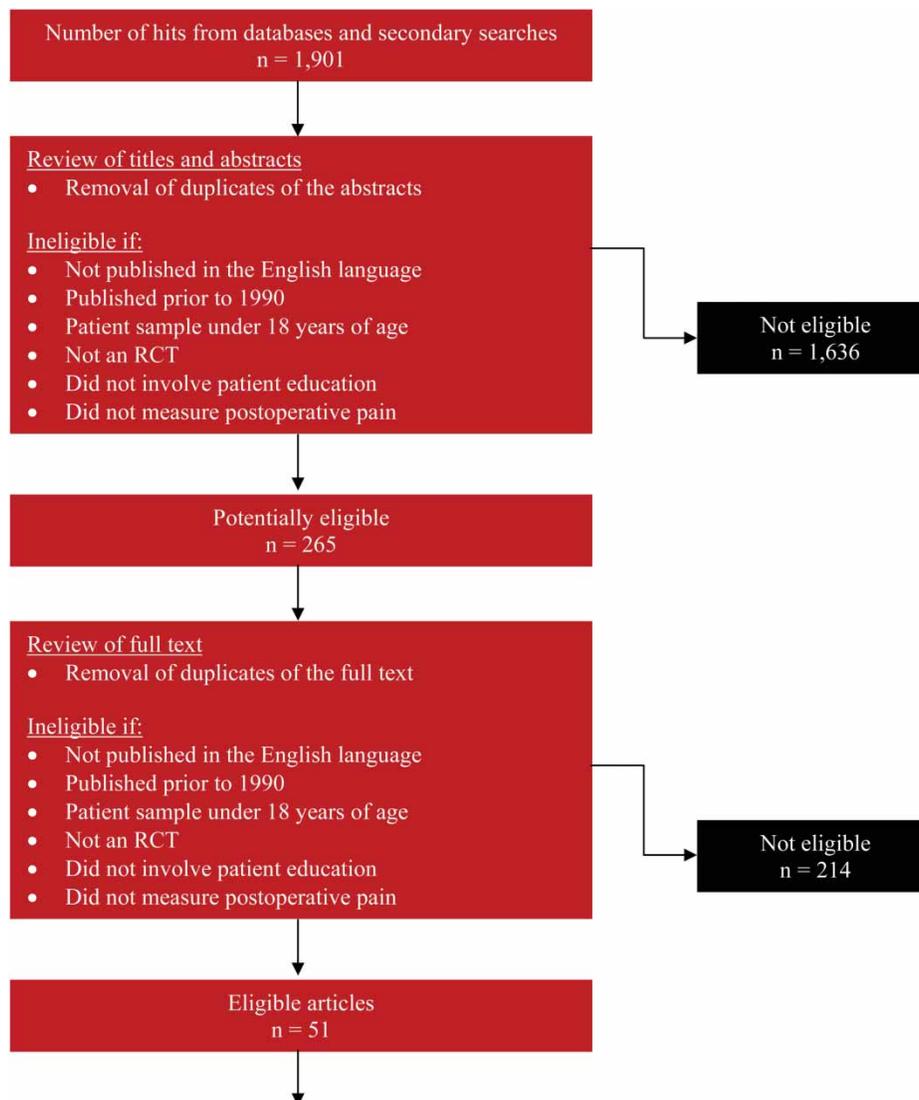


FIGURE 1 Retrieval and review process.

Inclusion criteria

All titles and abstracts were read to identify relevant papers. Papers were included in this systematic review if they met the inclusion criteria listed in Table 1. When there was uncertainty regarding the eligibility of the paper from the abstract, the full text version of the paper was retrieved and evaluated against the inclusion criteria. The full text version of all papers that met the inclusion criteria were retrieved for data extraction.

Quality assessment

Critical appraisal of each included study was conducted by determining the level of evidence on the Australian National Health and Medical Research

Council (NHMRC) Hierarchy of Evidence (Table 2). This provides a broad indication of bias based on study design. Studies higher on the hierarchy contain less potential bias than those that are lower on the hierarchy.

Data extraction

Data were extracted by the authors using the participants, interventions, comparisons, and outcomes approach (Stone, 2002).

- *Participants*: type of surgical intervention, age, and gender;
- *Interventions*: type, intensity, duration, educational tools/props, and in combination or stand-alone education;

TABLE 3 Studies included in this systematic review.

Author	Year	Journal	Title
1. Beaupre, Lier, Davies, and Johnston	2004	Journal of Rheumatology	The effects of a preoperative exercise and education program on functional recovery, health related quality of life, and health service utilization following primary total knee arthroplasty
2. Clode-Baker et al	1997	Journal of Health Psychology	Preparing patients for total hip replacement: A randomized controlled trial of a preoperative educational intervention
3. Daltroy et al	1998	Arthritis Care and Research	Preoperative education for total hip and knee replacement in patients
4. Doering et al	2000	Psychosomatic Medicine	Videotape preparation of patients before hip replacement surgery reduces stress
5. Ferrara et al	2008	Clinical Rehabilitation	Effect of preoperative physiotherapy in patients with end-stage osteoarthritis undergoing hip arthroplasty
6. Gammon and Mulholland	1996	International Journal of Nursing Studies	Effect of preparatory information prior to elective total hip replacement on postoperative physical coping outcomes
7. Giraudet-Le Quintrec et al	2003	Clinical Orthopedics and Related Research	Positive effects of patient education for hip surgery: A randomized controlled trial
8. Gocen et al	2004	Clinical Rehabilitation	The effect if preoperative physiotherapy and education on the outcome of total hip replacement: A prospective randomized controlled trial
9. Lilja, Ryden, and Fridlund	1998	Intensive and Critical Care Nursing	Effects of extended preoperative information on perioperative stress: An anesthetic nurse intervention for patients with breast cancer and total hip replacement
10. McDonald, Freeland, Thomas, and Moore	2001	Research in Nursing and Health	Testing a preoperative pain management intervention for elders
11. McGregor et al	2004	Journal of Arthroplasty	Does preoperative hip rehabilitation advice improve recovery and patient satisfaction?
12. Sjoling, Nordahl, Olofsson, and Asplund	2003	Patient Education and Counselling	The impact of preoperative information on state anxiety, postoperative pain and satisfaction with pain management
13. Vukomanovic, Popovic, Durovic, and Krstic	2008	Vojnosanitetski Pregled	The effects of short-term preoperative physical therapy and education on early functional recovery of patients younger than 70 undergoing total hip arthroplasty

- *Comparison:* to another treatment, no treatment, or “usual” treatment;
- *Outcomes:* domains and tools used to measure the effects of the intervention. The outcome chosen for this review was postoperative pain.

RESULTS

Search strategy yield

Initially, 1,901 hits were gained from databases and secondary searches. After review of the titles and abstracts, those articles that did not meet the inclusion criteria were removed (Figure 1). The reviewers found 265 potentially eligible abstracts. Review of these abstracts suggested 51 full text articles to further review. These full text articles were then analyzed for duplications and non-applicability, leaving only 13 published studies fully meeting the criteria for inclusion in this systematic review. This systematic review is based on these 13 published studies (Table 3).

Critical appraisal

Hierarchy of evidence

The 13 studies reviewed in this study included 12 randomized controlled trials (RCTs): 1) Beaupre, Lier, Davies, and Johnston (2004), 2) Clode-Baker et al (1997), 3) Daltroy et al (1998), 4) Doering et al (2000), 5) Ferrara et al (2008), 6) Giraudet-Le Quintrec et al (2003), 7) Gocen et al (2004), 8) Lilja, Ryden, and Fridlund (1998), 9) McDonald, Freeland, Thomas, and Moore (2001), 10) McGregor et al, (2004), 11) Sjoling, Nordahl, Olofsson, and Asplund (2003), and 12) Vukomanovic, Popovic, Durovic, and Krstic (2008); and one pseudo RCT (Gammon and Mulholland, 1996).

Patient characteristics

The reviewed articles included a sample of 1,021 patients receiving preoperative education: 712 patients

TABLE 4 Participants, interventions, controls, and outcomes for the studies included in this systematic review.

Author	Participants			Intervention	Control	Outcomes	
	n	Sample	Diagnosis			Instruments	Follow-up
Beaupre, Lier, Davies, and Johnston (2004)	131	Experimental group (EG) (n = 66); 67 ± 7 years of age; 39 females Control group (CG) (n = 65); 67 ± 6 years of age; 33 females	TKA	Educator: Physiotherapist Six weeks prior to surgery = exercise/education program Education: • Instruction on crutch walking, stairs, bed mobility and transfers, and postoperative ROM routine Exercises: • Stretches and strengthening with warm-up and cool down periods Program applied 3 × /week for 4 weeks for 12 visits	Continue with their regular activities during the last 6 weeks prior to TKA	<ul style="list-style-type: none"> Western Ontario MacMaster Osteoarthritis Index (WOMAC) Pain Stiffness Function ROM (goniometer) Quadriceps and hamstring strength (handheld dynamometer) Medical Outcome Study Short Form (SF-36) Overall health status Health service utilization 	<p>Preoperatively; 3, 6, and 12 months</p> <p>No difference in strength No difference in ROM No difference in function No difference on health-related quality of life EG = fewer postoperative visits and decreased LOH stay</p>
Claude-Baker et al (1997)	78	EG (n = 41) CG (n = 37) 52 females; 26 males – no indication which numbers in EG or CG No age mean age provided by the authors	THA	Educator: None One month prior to surgery, video, booklet and set of plastic models, mailed to patients with letter encouraging them to use the information; (92% reported that they reviewed the information prior to surgery) 20-minute video: • Progress of a patient having a THA • Arriving at the hospital • Going to the operating theatre • Returning to the ward • Postoperative recovery • Exercise • Visiting home showing benefit of having surgery Booklet: • Arthritis • THA • Hospital stay • Postoperative exercise • Advice from previous THA patients • Frequent questions and answers Plastic models (life-size) of the hip: • Normal hip joint • Osteoarthritis • THA joint • Separate THA prosthesis • Photographs of the models included in the booklets • Demonstrations using the models used in the video	No booklet, video, or joint models	<ul style="list-style-type: none"> Hip function evaluation N Nottingham Health Profile Hospital Anxiety and Depression Scale Stress Arousal Checklist Postoperative pain (descriptive ordinal scale) Sleep disturbance Satisfaction questionnaire LOH 	<p>Preoperatively; Each day of the first seven postoperative days</p> <p>No difference between EG and CG for: • HAD • Nottingham • Health Profile • Stress Arousal Checklist EG: more satisfied with information provided prior to surgery than CG EG: Less confronted by information upon arrival at the hospital No difference between EG and CG in postoperative pain No difference in sleep disturbance No difference in LOH</p>
Dahroy et al (1998)	222	Total sample: Female 66% (n = 146) Mean age 64 ± 12 THA: 47% (n = 104) TKA: 53% (n = 118) CG (n = 54) Relaxation only (n = 58) Information only (n = 58) Information and relaxation (n = 52)	THA and TKA	Educator: Research Assistant Information only: • 12-minute audiotape slide program • Research assistant 1-day prior to surgery at bedside • Program designed by multidisciplinary team • Orient to hospital • Orient to staff and their roles • Events of surgery and rehabilitation • Life in the hospital • Pictures from the patient's viewpoint • Told of various stressful aspects of hospitalization, including pain, immobility, work involved in rehabilitation, lights and noises, altered sleep schedule and dietary, and smoking restrictions • Reassured various sensations, emotions, and difficulties will pass • Information used in addition to usual preoperative information, i.e., coughing • Booklet left with patient describing milestones • Relaxation only: • Oral and written instructions	None	<ul style="list-style-type: none"> LOH Pain (pain medication use) State Anxiety Mental State (Mini Mental State Exam) Frequency of use of interventional tools, 	<p>LOH – time of discharge or more surgery</p> <p>Relaxation: No change in postoperative outcomes Pain, anxiety, and mental state in the first 4 days postoperatively Information only: decreased LOH, reduced anxiety, and cognitions No change in postoperative pain ratings for any intervention</p>

<p>• 18-minute audio tape, portable tape player and headphones</p> <p>• Instructed in the relaxation the day prior to surgery and encouraged to practice</p> <p>Information plus relaxation:</p> <ul style="list-style-type: none"> • Combination of the above • Relaxation taught after informational session 	<p>Usual preoperative care with no video presentation</p>	<p>• Anxiety (STAI)</p> <p>• Pain (VAS)</p> <p>• Intraoperative heart rate</p> <p>• Intraoperative blood pressure</p> <p>• Postoperative use of pain medication</p> <p>• Urinary levels of cortisol, epinephrine, and nor epinephrine</p> <p>• No change in catecholamines</p>	<p>Five consecutive days starting on the preoperative day</p> <p>EG showed less anxiety the morning of the surgery and first 2 days after surgery compared to CG</p> <p>EG had decreased blood pressure compared to CG</p> <p>No difference in pain ratings</p> <p>EG used less pain medication compared to CG</p> <p>EG had less secreted cortisol compared to CG</p> <p>No change in catecholamines</p>
<p>• 18-minute audio tape, portable tape player and headphones</p> <p>• Instructed in the relaxation the day prior to surgery and encouraged to practice</p> <p>Information plus relaxation:</p> <ul style="list-style-type: none"> • Combination of the above • Relaxation taught after informational session 	<p>Usual preoperative care with no video presentation</p>	<p>• Barbel Index</p> <p>• SF-36</p> <p>• WOMAC</p> <p>• Hip Harris Score</p> <p>• Pain (VAS)</p> <p>• British Medical Research Council (BMRC) measures of strength and ROM</p>	<p>One month prior to surgery; the day prior to surgery; 15 days after surgery; 4 weeks after surgery and 3 months after surgery</p> <p>Barbel</p> <p>No difference between EG and CG in SF-36</p> <p>No difference between EG and CG in WOMAC</p> <p>No difference between EG and CG in HHS</p> <p>No difference between EG and CG in pain ratings after surgery</p>
<p>• 18-minute audio tape, portable tape player and headphones</p> <p>• Instructed in the relaxation the day prior to surgery and encouraged to practice</p> <p>Information plus relaxation:</p> <ul style="list-style-type: none"> • Combination of the above • Relaxation taught after informational session 	<p>Usual preoperative care without additional teaching program</p>	<p>• Physical Indicators of Coping Questionnaire</p> <p>• Linear Analog Coping Scale</p> <p>• Oral analgesia</p> <p>• Intramuscular analgesia</p> <p>• LOH</p> <p>• Movement</p>	<p>Day of discharge</p> <p>No difference in oral analgesia to manage pain</p> <p>EG used less intramuscular analgesia compared to the CG</p> <p>EG were able to mobilise sooner than the CG</p> <p>EG performed breathing and leg exercises more frequently than the CG</p> <p>EG had shorter LOH compared to CG</p> <p>No difference in postoperative complications</p>
<p>• 18-minute audio tape, portable tape player and headphones</p> <p>• Instructed in the relaxation the day prior to surgery and encouraged to practice</p> <p>Information plus relaxation:</p> <ul style="list-style-type: none"> • Combination of the above • Relaxation taught after informational session 	<p>Usual preoperative care with no video presentation</p>	<p>• Educational and physiotherapy program</p> <p>• Group and individual exercise 5 days/week</p> <p>• Sessions lasted 60 minutes/day</p> <p>• Small group exercises lasted 40 minutes and individual lasted 20 minutes</p> <p>• Strength and flexibility programs</p> <p>• Exercise bike and cardiovascular exercises</p> <p>• Postural exercise</p> <p>• Movements that should be avoided to prevent dislocation</p> <p>• Use of assistive devices</p> <p>• Posture</p> <p>• ADL</p>	<p>100 EG (<i>n</i> = 46)</p> <p>Age 58.7 ± 10.8</p> <p>Female, <i>n</i> = 21 (46%)</p> <p>CG (<i>n</i> = 54)</p> <p>Age 60.4 ± 8.7</p> <p>Female, <i>n</i> = 17 (31%)</p>
<p>• 18-minute audio tape, portable tape player and headphones</p> <p>• Instructed in the relaxation the day prior to surgery and encouraged to practice</p> <p>Information plus relaxation:</p> <ul style="list-style-type: none"> • Combination of the above • Relaxation taught after informational session 	<p>Usual preoperative care with no video presentation</p>	<p>• Educational and physiotherapy program</p> <p>• Group and individual exercise 5 days/week</p> <p>• Sessions lasted 60 minutes/day</p> <p>• Small group exercises lasted 40 minutes and individual lasted 20 minutes</p> <p>• Strength and flexibility programs</p> <p>• Exercise bike and cardiovascular exercises</p> <p>• Postural exercise</p> <p>• Movements that should be avoided to prevent dislocation</p> <p>• Use of assistive devices</p> <p>• Posture</p> <p>• ADL</p>	<p>23 EG (<i>n</i> = 11; 7 females; 64%; mean age 63.82 ± 9.01</p> <p>CG, <i>n</i> = 12; 7 females; 58%; mean age 63.08 ± 6.89</p>
<p>• 18-minute audio tape, portable tape player and headphones</p> <p>• Instructed in the relaxation the day prior to surgery and encouraged to practice</p> <p>Information plus relaxation:</p> <ul style="list-style-type: none"> • Combination of the above • Relaxation taught after informational session 	<p>Usual preoperative care with no video presentation</p>	<p>• Educational program:</p> <p>• Procedural information</p> <p>• Sensory information</p> <p>• Coping information</p> <p>• Checklist to ensure all information was covered</p> <p>• Booklet reinforcing information provided</p> <p>• Postoperatively: patients visited twice weekly to reinforce the message and address problems; prior to discharge, patients received second educational session regarding issues at home.</p> <p>Information reinforced with a booklet</p> <p>Education content:</p> <p>• Preoperative information: Hospital, surgical, and anesthesia procedural information</p> <p>• Sensory information including feelings experienced</p> <p>• Coping information including relaxation and distraction</p> <p>• Postoperative information: Postoperative procedural information</p> <p>• Postoperative sensory information</p> <p>• Coping information postoperatively</p>	<p>82 EG (<i>n</i> = 41); female, 66% (<i>n</i> = 27)</p> <p>CG (<i>n</i> = 41), female 71% (<i>n</i> = 29)</p> <p>Age range 44 – 82 years</p>

TABLE 4 Continued

Author	Participants		Intervention	Control	Instruments	Outcomes	
	n	Sample				Diagnosis	Follow-up
Giraudet-Le Quintree et al (2005)	100	EG (n = 48); mean age 62.7 ± 8.8; female 50% (n = 24) CG (n = 52); mean age 64.3 ± 9.5; female 38% (n = 20)	THA	<p>Discharge information: Procedural – movement, limitations, positions; functional activities</p> <p>Sensory information – weakness, fatigue</p> <p>Coping information – family support and displacement</p> <p>Educator: Multidisciplinary team – rheumatologist; orthopedic surgeon; anesthetist, physiotherapist, psychiatrist</p> <p>Usual verbal information and informational leaflet</p> <p>Multidisciplinary information session 2–6 weeks before surgery</p> <ul style="list-style-type: none"> Invited to bring a spouse, relative, or significant other Three to six patients per session Session lasted half a day Overhead transparencies Multidisciplinary team varied on different days, but consisted of: Surgeon Anesthetist Questions and answers Pamphlet reinforced traditional verbal communication <p>Content:</p> <p>Osteoarthritis of the hip – rheumatologist's part (half an hour); presentation of the team; normal anatomy of the hip and osteoarthritis of the hip; explanation of the disease, risk factors, disease process, and its consequences; principle and benefit of THA; duration of hospitalization, sequence of events associated with hospitalization; practical details concerning hospitalization (telephone numbers, furniture, contention, socks, crutches, discharge arrangements, what to bring to the hospital); patient's questions</p> <ul style="list-style-type: none"> Surgery – orthopedic surgeon's part (half an hour): surgical replacement procedure: prosthesis used, technique (trochanteric osteotomy), and demonstration of materials, radiographs; duration of the surgery; potential complications and risks of the surgery (dying, dislocation, infection, nerve injury, loosening, heterotopic ossification) and prevention; scar wound precautions; time that it takes before the hip surgery ceases to be the focus of the patient's life; the importance of regular follow up with the surgeon (loosening and wear); protection against infection; patient's questions Anesthesia – anesthetist's part (half an hour): preparation for anesthesia (autologous blood transfusion, laboratory tests, cardiac preparation, avoiding drugs); pre-anesthesia visit, postoperative course, and monitoring equipment; post-anesthesia care unit; the anesthetic procedure: type of anesthesia; anesthetic drugs, duration, loss of control; potential complications and risks (dying, cardiac, pulmonary, brain injuries, bleeding, pain); postoperative pain control; unpleasant side-effects (bed rest, sleeping difficulties, nausea, suction, bladder catheter); deep vein thrombosis prevention; postoperative drugs (pain medication, non-steroidal anti-inflammatory drugs, anticoagulation therapy, precautions); nutrition and blood sample; patient's questions Rehabilitation – physiotherapist's part (half an hour): rehabilitation procedure (bed rest, sitting up, exercises, beginning to walk, walker, dangerous movements, stair climbing); rehabilitation period (going home or to a specific center: necessity, duration, physiotherapy); the role of social workers; bathing, driving, sports participation; sexual activities; patient's questions Patients' questions – Psychiatrist's and rheumatologist's part; discussion with the patients; personal patient wait, physical, and emotional preparation, benefits of THA, personal or collective problems, and long-term precautions 	<ul style="list-style-type: none"> State Anxiety Inventory Pain: use of pain medication Rehabilitation LOH 	<p>Prior to education; just before surgery; 1 and 7 days after surgery</p>	

Author	Year	Sample	Intervention	Comparison	Outcomes
Groen et al. (2004)	60	EG (n = 30): 46.93 ± 11.48 years of age; 16 females CG (n = 30): 55.5 ± 14.44 years of age; 22 females	THA	THA	<p>Educator: Physiotherapist</p> <p>Education:</p> <ul style="list-style-type: none"> Advice on movements that need to be avoided Use of assistive devices Posture Lifting and carrying Washing/bathing <p>Exercise:</p> <ul style="list-style-type: none"> Straight leg raising exercise; hamstring stretches; hip flexor stretches; upper extremity strengthening <p>Exercises done for 8 weeks prior to surgery; instructed to do exercises 3 × /day; 10 repetitions each; exercise monitored by a physiotherapist</p> <p>at 2-week intervals</p> <p>Educator: Anesthetic nurse</p> <p>Preoperative and postoperative routines instructed by the ward nurse</p> <p>Extended formalized information</p> <ul style="list-style-type: none"> Additional information regarding anesthesia 30-minute session Day prior to surgery <p>Content:</p> <ul style="list-style-type: none"> Participation: the importance to the recovery of patient participation in the planning of care before, during and after operation Information: about anesthesia and the surgical procedure Education: to explain the importance of preoperative patient preparation and to motivate postoperative interventions Support: to support the patient before and during the anesthesia and to attend to the patient's needs Environment: to describe the operating theatre General care: to inform about care in relation to anesthesia and operation Training: mobilization after surgery Observation: to explain observation procedures during anesthesia Special care: to discuss the pre-medication Continuity: that the same anesthetic nurse meets the patient in the operating theatre Coordination: scheduling
Lilja, Ryden, and Fridlund (1998)	50	THA patient median age 65 EG (n = 22); female, n = 9; 41% CG (n = 28); female, n = 8; 29%	THA	THA	<p>Preoperative and postoperative routines instructed by the ward nurse</p> <p>Cortisol: day before surgery; day of surgery; first and third postoperative day.</p> <p>HADS: day before surgery and day of surgery</p> <p>VAS: first 3 postoperative days</p> <p>No change in anxiety</p> <p>No changes in cortisol</p> <p>No difference in pain ratings</p>
McDonald, Freedland, Thomas, and Moore (2001)	31	Mean age 74 ± 6.16 Females, n = 23 (74.2%)	THA and TKA	TKA	<p>Educator: Nurse</p> <p>Preoperative joint replacement class – preparation prior to surgery and what to expect following surgery, exercise, discharge planning, typical postoperative pain management – PCA, and medication</p> <p>Pain education</p> <ul style="list-style-type: none"> PowerPoint slide show Basic pain management and communication skills <p>Pain management education content:</p> <ul style="list-style-type: none"> General pain overview; defining pain, understanding the causes of pain, pain assessment and use of pain-rating scales for communicating pain, using preventative approach to control pain Pharmacological management of pain: overview of drug management for pain, myths about addiction, controlling unpleasant side effects Non-pharmacological management of pain: importance of non-pharmacological management of pain; use of non-pharmacological strategies in conjunction with medication; use of previously successful pain interventions; description of massage, relaxation, and distraction <p>Pain communication education content:</p> <ul style="list-style-type: none"> Interpersonal control strategies: the person as the expert of his or her own pain experience; responsibility for reporting pain and the response to treatment, importance of teamwork in decreasing pain Interpretability strategies: describing your pain using the pain-intensity scales, describing your pain using pain location, describing your pain using pain sensation, evaluating and describing changes, determining if the health provider understood your message <p>Preoperative joint replacement class – preparation prior to surgery and what to expect following surgery; exercise; discharge planning; typical postoperative pain management – PCA and medication</p> <p>Slide show reviewing the 0–10 and Wong-Baker pain intensity scales; (time = 10 minutes)</p> <p>McGill Pain Questionnaire, Short Form (MPQ-SF)</p> <p>Night of the surgery; postoperative days 1 and 2</p> <p>EG reported less pain at all intervals postoperatively compared to the CG</p>

Continued

TABLE 4 Continued

Author	Participants		Diagnosis	Intervention	Control	Instruments	Outcomes	
	n	Sample					Follow-up	Main results
McGregor et al (2001)	35	EG (n = 15); mean age: 70.8 ± 9.3 CG (n = 20); mean age: 72.8 ± 10.1 25 females (71%) Mean age: 71.9 ± 9.3	THA	<ul style="list-style-type: none"> Discourse management strategies; how to introduce the pain/pain management topic (ineffective pain relief, unpleasant medication side-effects, use of complementary pain treatments, pain goals); promoting an effective response by your health-care provider; actively participating in the pain management discussions; efficient use of time during the pain management discussion Approximation strategies: some basics about how people communicate (speech rate, eye contact, nonverbal); adjusting the way you talk and the effect that may have on the other person Color handout with large face type summarizing key points of the slides; seventh-grade reading level <p>Total time = 30 minutes</p> <p>Educator: Not stated</p> <p>Rehabilitation program and booklet</p> <p>Preoperative hip class 2–4 weeks prior to surgery and an informational booklet; preoperative class reinforced the booklet and ensure all patients could do the exercises and how to use walking aids postoperatively; ensured patient knew about adaptations needed to be made at home</p> <p>Booklet:</p> <ul style="list-style-type: none"> Information on the surgery All preoperative and postoperative stages Rehabilitation stages including exercise regimens <p>Series of answers to commonly asked questions regarding THA</p>	Standard pathway of care – including description of surgery; risks; estimated LOH	<ul style="list-style-type: none"> Western Ontario and McMaster Universities Index (WOMAC) HHS Barthel ADL Index Pain (VAS) Positive Affect Negative Affect Scale Helplessness short subscale of the Rheumatology Attitudes Index Cantril Life Satisfaction Ladder VAS for fatigue Economic Analysis 	Admission, before discharge, and 3 months postoperatively	<p>EG reported higher levels of satisfaction at discharge and 3 months post-surgery</p> <p>EG had a shorter LOH compared to the CG</p> <p>EG reduced cost associated with THA compared to CG</p> <p>EG had more realistic expectations compared to CG</p> <p>No difference between EG and CG in pain</p> <p>No difference in functional levels between EG and CG</p>
Sjoling, Nordahl, Olofsson, and Asplund (2003)	60	EG (n = 30); females 60%, n = 18; mean age 71 CG (n = 30); females 60%, n = 18; mean age 71	TKA	<p>Educator: Nurse</p> <p>One to four days prior to surgery. Positive way as to not increase fear; Personal, private educational sessions; education lasted 20–40 minutes; routine preoperative information written and verbally; information were mainly procedural – what happens before surgery; blood samples; machines; people they will meet; VAS scale</p> <p>Additional information (verbal and leaflet):</p> <ul style="list-style-type: none"> Emphasize patient's own role in pain management Improved knowledge Being active in their own treatment – asking for help with pain management Benefits of well-treated postoperative pain Physiotherapy crucial for recovery Easier to prevent pain than treat existing pain Use of basic medication prior to exercise <p>Ask questions about pain management in hospital stay</p> <p>Physiatrist (education) and physiotherapist (exercise)</p> <p>Education:</p> <ul style="list-style-type: none"> Information about the surgery Precautions Postoperative rehabilitation following THA Physiatrist performed education once Brochure <p>Exercise:</p> <ul style="list-style-type: none"> Instruction by physiotherapist – twice Postoperative program prior to surgery Bed mobility, crutch use, transfers, and stairs 	One to four days prior to surgery; positive way as to not increase fear; personal, private educational sessions; education lasted 20–40 minutes; routine preoperative information written and verbally; information were mainly procedural – what happens before surgery; blood samples; machines; people they will meet; VAS scale	<ul style="list-style-type: none"> Pain (VAS) State and trait Anxiety Satisfaction with pain management Satisfaction with nursing care 	Pain measured preoperatively, every 3 hours for the first 3 postoperative days	<p>No difference between EG and CG in VAS scores</p> <p>No difference between EG and CG in terms of oral analgesics</p> <p>No difference in LOH</p> <p>No difference in anxiety</p> <p>EG group was more satisfied than the CG regarding information provided</p>
Vukomanovic, Popovic, Durwicz, and Kestic (2008)	45	EG (n = 23); 60.05 ± 11.0 years of ages; 14 females CG (n = 22); 56.2 ± 18.45 years of ages; 16 females	THA	<p>Physiatrist (education) and physiotherapist (exercise)</p> <p>Education:</p> <ul style="list-style-type: none"> Information about the surgery Precautions Postoperative rehabilitation following THA Physiatrist performed education once Brochure <p>Exercise:</p> <ul style="list-style-type: none"> Instruction by physiotherapist – twice Postoperative program prior to surgery Bed mobility, crutch use, transfers, and stairs 	No education or exercise	<ul style="list-style-type: none"> VAS ROM (goniometry) Hip flexion Hip abduction HHS Hip score of the Japanese Orthopedic Association Oxford hip score 	Pre-admission, discharge, 15 months after surgery	<p>EG climbed stairs, used a toilet and increased independence regarding ADL's after surgery compared to CG</p> <p>EG had better endurance than the CG; EG needed less postoperative physiotherapy visits</p>

Notes: STAI: State-Trait Anxiety Inventory; PCA: Patient Controlled Analgesia.

(69.7%) undergoing THA, 309 (30.3%) undergoing TKA, and no other orthopedic surgeries. Of the patients, 591 (58%) were female. The average age of patients ranged from 55.5 ± 14.4 years (Gocen et al, 2004) to 74.6 years (McDonald, Freeland, Thomas, and Moore, 2001) and the mean age (calculated as the mean of the mean reported ages) of those reviewed patients in years was 63.7 years of age.

Content of educational sessions

Details of the specific content of the educational sessions used in the studies are found in Table 4. In summary, the contents of the preoperative education sessions in orthopedics addressing pain included discussion of: mobility (i.e., crutches, bed mobility, and transfers) (Beaupre Lier, Davies, and Johnston, 2004; Doering et al, 2000; Ferrara et al, 2008; Gammon and Mulholland, 1996; Giraudet-Le Quintrec et al, 2003; Gocen et al, 2004; Lilja, Ryden, and Fridlund, 1998; McGregor et al, 2004; Vukomanovic, Popovic, Durovic, and Krstic, 2008), range of motion (ROM) (Beaupre, Lier, Davies, and Johnston, 2004; Doering et al, 2000; Giraudet-Le Quintrec et al, 2003; Gocen et al, 2004), preadmission procedures (hospital/administrative) (Clode-Baker et al, 1997; Daltroy et al, 1998; Doering et al, 2000; Gammon and Mulholland, 1996; Giraudet-Le Quintrec et al, 2003; Lilja, Ryden, and Fridlund, 1998; Sjoling, Nordahl, Olofsson, and Asplund, 2003), preparation procedures for surgery (Clode-Baker et al, 1997; Daltroy et al, 1998; Doering et al, 2000; Gammon and Mulholland, 1996; Lilja, Ryden, and Fridlund, 1998; McDonald, Freeland, Thomas, and Moore, 2001; McGregor et al, 2004; Sjoling, Nordahl, Olofsson, and Asplund, 2003), surgical procedure (Clode-Baker et al, 1997; Daltroy et al, 1998; Doering et al, 2000; Gammon and Mulholland, 1996; Giraudet-Le Quintrec et al, 2003; Lilja, Ryden, and Fridlund, 1998; McGregor et al, 2004; Vukomanovic, Popovic, Durovic, and Krstic, 2008), hospital stay (Clode-Baker et al, 1997; Daltroy et al, 1998; Doering et al, 2000; Gammon and Mulholland, 1996; Giraudet-Le Quintrec et al, 2003; Sjoling, Nordahl, Olofsson, and Asplund, 2003), postoperative procedures (Clode-Baker et al, 1997; Daltroy et al, 1998; Doering et al, 2000; Gammon and Mulholland, 1996; Lilja, Ryden, and Fridlund, 1998; McDonald, Freeland, Thomas, and Moore, 2001; McGregor et al, 2004), anatomy of normal joints (Clode-Baker et al, 1997; Giraudet-Le Quintrec et al, 2003), pathoanatomy of arthritic joints (Clode-Baker et al, 1997; Giraudet-Le Quintrec et al, 2003), advice from past joint replacement patients (Clode-Baker et al, 1997;

Doering et al, 2000), frequently asked questions (Clode-Baker et al, 1997; Giraudet-Le Quintrec et al, 2003; McGregor et al, 2004), medical and support staff and their roles (Daltroy et al, 1998; Giraudet-Le Quintrec et al, 2003; Sjoling, Nordahl, Olofsson, and Asplund, 2003), discussion of stressful scenarios associated with surgery (i.e., pain, immobility, and noises) (Daltroy et al, 1998; Doering et al, 2000; Gammon and Mulholland, 1996; Lilja, Ryden, and Fridlund, 1998), complications (i.e., blood clots, bleeding, and death) (Giraudet-Le Quintrec et al, 2003), anesthesia and medication (Giraudet-Le Quintrec et al, 2003; Lilja, Ryden, and Fridlund, 1998; McDonald, Freeland, Thomas, and Moore, 2001), reassurance (Daltroy et al, 1998; Doering et al, 2000; Gammon and Mulholland, 1996; Lilja, Ryden, and Fridlund, 1998; Sjoling, Nordahl, Olofsson, and Asplund, 2003), milestones (Daltroy et al, 1998), movements to avoid (Ferrara et al, 2008; Giraudet-Le Quintrec et al, 2003; Gocen et al, 2004; Vukomanovic, Popovic, Durovic, and Krstic, 2008), posture (Ferrara et al, 2008; Gocen et al, 2004), activities of daily living (ADL) (Ferrara et al, 2008; Giraudet-Le Quintrec et al, 2003; Gocen et al, 2004), and pain education (i.e., pain overview, pain management – pharmacological and non-pharmacological, and pain communication) (McDonald, Freeland, Thomas, and Moore, 2001; Sjoling, Nordahl, Olofsson, and Asplund, 2003).

Educational delivery methods

Professionals performing preoperative education in orthopedics

Preoperative education in these cases was mostly performed by physiotherapists and nurses though other health-care practitioners were also involved (Table 4). The complete list (in order of most utilized to least) includes

- 1 Physiotherapist (Beaupre, Lier, Davies, and Johnston, 2004; Ferrara et al, 2008; Giraudet-Le Quintrec et al, 2003; Gocen et al, 2004; Vukomanovic, Popovic, Durovic, and Krstic, 2008)
- 2 Nurse (Gammon and Mulholland, 1996; Lilja, Ryden, and Fridlund, 1998; McDonald, Freeland, Thomas, and Moore, 2001; Sjoling, Nordahl, Olofsson, and Asplund, 2003)
- 3 Psychologist/psychiatrist (Doering et al, 2000; Giraudet-Le Quintrec et al, 2003; Vukomanovic, Popovic, Durovic, and Krstic, 2008)
- 4 Physician (Doering et al, 2000; Giraudet-Le Quintrec et al, 2003)

TABLE 5 Outcomes measures used to assess preoperative education in orthopedics for postoperative outcomes.

Function	Western Ontario McMaster Osteoarthritis Index (WOMAC) – pain, stiffness, and function ^{a-c} Hip function evaluation ^d Hip Harris Score ^{b,e,c,f} Barthel ADL Index ^c Days till walking, climbing stairs, and transfers ^e Hip Score of the Japanese Orthopedic Association ^f Oxford Hip Score ^f Barthel Index ^b
Pain	Postoperative pain (descriptive ordinal scale) ^d Pain medication use ^{e-j} VAS ^{h,b,e,k,c,l,f} MPQ-SF ^m
ROM	ROM – goniometer ^{a,f} • BMRC measures of ROM ^b • Movement ^l
Strength	Quadriceps and hamstring strength – handheld dynamometer ^a BMRC measures of strength ^b
Psychological	HADS ^{d,k} Stress Arousal Checklist ^d State Anxiety ^{g,h,j,l} Mental State (Mini Mental State Exam) ^g Urinary levels of cortisol, epinephrine, and nor epinephrine ^{h,k} Physical Indicators of Coping Questionnaire ⁱ Linear Analog Coping Scale ⁱ Positive and negative affect scale ^c Helplessness short subscale of the Rheumatology Attitudes Index ^c Cantril Life Satisfaction Ladder ^c
General health	Medical Outcome Study Short Form (SF-36) ^a Nottingham Health Profile ^d Sleep disturbance ^d Intraoperative heart rate ^h Intraoperative blood pressure ^h VAS for fatigue ^c
Health-care utilization	Health-care utilization – LOH ^{a,d,g,i,j} Economic analysis ^c
Compliance	Frequency of use of interventional tools ^g Rehabilitation ^j
Satisfaction	Satisfaction with pain management ^l Satisfaction with nursing care ^l

^aBeaupre, Lier, Davies, Johnston (2004).

^bFerrara et al (2008).

^cMcGregor et al (2004).

^dClode-Baker et al (1997).

^eGocen et al (2004).

^fVukomanovic, Popovic, Durovic, and Krstic (2008).

^gDaltroy et al (1998).

^hDoering et al (2000).

ⁱGammon and Mulholland (1996).

^jGiraudet-Le Quintrec et al (2003).

^kLilja, Ryden, and Fridlund (1998).

^lSjoling, Nordahl, Olofsson, and Asplund (2003).

^mMcDonald, Freeland, Thomas, and Moore (2001).

5 None – no health-care provider involved; only packet containing video, booklet, and plastic joint models (Clode-Baker et al, 1997)
6 Research assistant (Daltroy et al, 1998)

7 Multidisciplinary team (Giraudet-Le Quintrec et al, 2003)
8 Rheumatologist (Giraudet-Le Quintrec et al, 2003)

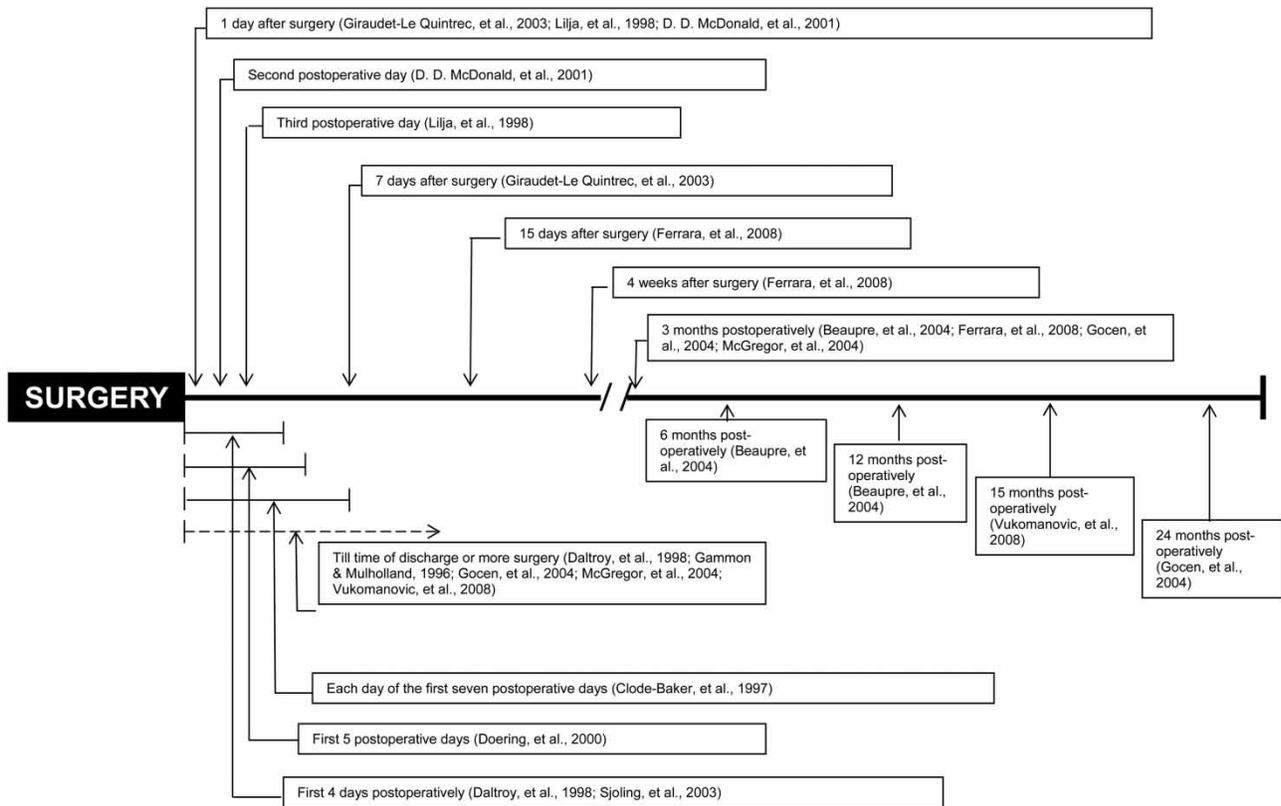


FIGURE 2 Effects of preoperative education were examined at varying time intervals following surgery by the studies included in this review.

- 9 Anesthetist (Giraudet-Le Quintrec et al, 2003)
- 10 Not specified (McGregor et al, 2004)

Timing and duration of preoperative education

The timing and duration of the preoperative educational sessions provided in the reviewed studies varied considerably. Timing of provision of preoperative education was as soon as 6 weeks prior to surgery in one study (Beaupre, Lier, Davies, and Johnston, 2004), and as late as the day before scheduled surgery in four studies (Daltroy et al, 1998; Gammon and Mulholland, 1996; Lilja, Ryden, and Fridlund, 1998; Sjoling, Nordahl, Olofsson, and Asplund, 2003). Timing for the remaining studies varied from 2 and 4 weeks before scheduled surgery (Clode-Baker et al, 1997; Ferrara et al, 2008; Giraudet-Le Quintrec et al, 2003; McGregor et al, 2004). Duration of the educational sessions also varied considerably (Table 4), with some sessions (video) as short as 12 minutes (Doering et al, 2000), and others as long as half a day (4 hours) (Giraudet-Le Quintrec et al, 2003). Only six of the studies reported

an exact duration of the educational session and the median reported time spent on education (in the studies that reported it) was 30 minutes. The duration of the educational sessions are listed below in ascending order

- Half day (Giraudet-Le Quintrec et al, 2003)
- 20–40 minutes (Sjoling, Nordahl, Olofsson, and Asplund, 2003)
- 30 minutes (Lilja, Ryden, and Fridlund, 1998; McDonald, Freeland, Thomas, and Moore, 2001)
- Video session lasted 20 minutes (Clode-Baker et al, 1997)
- Video lasted 12 minutes (Doering et al, 2000)

Educational format and tools

The format in which the preoperative education was delivered was primarily by means of either one-on-one verbal communication (Beaupre, Lier, Davies, and Johnston, 2004; Ferrara et al, 2008; Giraudet-Le Quintrec et al, 2003; Sjoling, Nordahl, Olofsson, and Asplund, 2003; Vukomanovic, Popovic, Durovic, and Krstic, 2008) or group sessions with

TABLE 6 Main findings related to pain.

Study	Positive effect	Neutral	Negative effect
1. Beaupre, Lier, Davies, and Johnston (2004)		No difference in pain ratings	
2. Clode-Baker et al (1997)		No difference in postoperative pain	
3. Daltroy et al (1998)		No difference in postoperative pain	
4. Doering et al (2000)		No difference in postoperative pain	
5. Ferrara et al (2008)		No difference in postoperative pain	
6. Gammon and Mulholland (1996)	Experimental group used less intramuscular analgesia compared to the control group	No difference in oral analgesia	
7. Giraudet-Le Quintrec et al (2003)		No difference in postoperative pain	
8. Gocen et al (2004)		No difference in postoperative pain	
9. Lilja, Ryden, and Fridlund (1998)		No difference in postoperative pain	
10. McDonald, Freeland, Thomas, and Moore (2001)	Experimental group reported less pain in all intervals postoperatively compared to the control group		
11. McGregor et al (2004)		No difference in postoperative pain	
12. Sjoling, Nordahl, Olofsson, and Asplund (2003)		No difference in postoperative pain	
13. Vukomanovic, Popovic, Durovic, and Krstic (2008)		No difference in postoperative pain	

several patients (Ferrara et al, 2008; Giraudet-Le Quintrec et al, 2003; McDonald, Freeland, Thomas, and Moore, 2001; McGregor et al, 2004). One published paper delivered the preoperative education via video and a booklet only with no personal communication (Clode-Baker et al, 1997). Details of the specific educational sessions can be found in Table 4.

Adjunct treatment to the preoperative education for THA and TKA surgery addressing pain

Several different research designs are represented in this review. In some studies, patients received various forms of other therapeutic interventions along with the preoperative education addressing postoperative pain. The therapeutic activities that accompanied preoperative education included either exercise (Beaupre, Lier, Davies, and Johnston, 2004; Ferrara et al, 2008; Gocen et al, 2004; McGregor et al, 2004) or relaxation (Daltroy et al, 1998). Only one study (Daltroy et al, 1998) examined the

independent effect of an adjunct treatment (relaxation) compared to educational strategies and found no positive effect for this adjunct program. Conversely, several studies utilized education-only sessions preoperatively (Clode-Baker et al, 1997; Daltroy et al, 1998; Doering et al, 2000; Lilja, Ryden, and Fridlund, 1998) resulting in various positive outcomes (Table 4), these authors suggest that the educational sessions may be more important than the adjunct treatments in providing superior postoperative outcomes.

Control groups

In the majority of the studies, the researchers compared the experimental protocol (preoperative education) to “usual preoperative care”, which was defined as “advice and support that would routinely be given to patients by medical and nursing staff” (Doering et al, 2000; Gammon and Mulholland, 1996; Giraudet-Le Quintrec et al, 2003; Lilja, Ryden, and Fridlund, 1998; McGregor et al, 2004; Sjoling, Nordahl, Olofsson, and Asplund, 2003). Several studies also compared preoperative education to no education and intervention (Beaupre, Lier,

Davies, and Johnston, 2004; Clode-Baker et al, 1997; Daltroy et al, 1998; Ferrara et al, 2008; Gocen et al, 2004; Vukomanovic, Popovic, Durovic, and Krstic, 2008).

Outcome measures

The studies in this review utilized a wide variety of outcomes measures (Table 4). The outcome of greatest interest to this review was pain. However, other measures included: function, ROM, strength, psychological issues, general health, health-care utilization, compliance, and satisfaction (Table 5).

Outcome intervals

The effect of preoperative education for these patients undergoing THA and TKA surgery was examined at various time intervals. These compared preoperative measurements to immediate postoperative, short-, intermediate-, and long-term results (Figure 2 and Table 4).

Outcomes related to pain

The primary aim of this review was to critically analyze the content and educational delivery methods associated with preoperative education for THA and TKA surgery and the effect on postoperative pain. Table 6 provides a summary of the outcomes related to pain from the studies in this review and it is evident that only one study (McDonald, Freeland, Thomas, and Moore, 2001) had a positive effect on postoperative pain as rated by patients. None of the other 12 studies produced any significant change in postoperative pain.

DISCUSSION

Efficacy of preoperative education in THA and TKA surgery

In the orthopedic domain, most studies on preoperative education have been conducted on patients undergoing: hip replacement (Butler et al, 1996; Daltroy et al, 1998; Johansson et al, 2005; McDonald, Hetrick, and Green, 2004; McGregor et al, 2004); or knee replacement (Beaupre, Lier, Davies, and Johnston, 2004; Daltroy et al, 1998; Johansson et al, 2005; Mancuso et al, 2001; McDonald, Hetrick,

and Green, 2004). In 2004 and 2005, two systematic reviews evaluated the efficacy of preoperative education for TKA and THA (Johansson et al, 2005; McDonald, Hetrick, and Green, 2004). The review by Johansson et al (2005) reported on 11 RCTs involving 1,044 hip and knee arthroplasty patients. This review provided a detailed description of the educational interventions, which varied widely, and showed that preoperative education has a positive effect on preoperative anxiety levels and patient knowledge, but no changes in postoperative outcomes including pain, ROM, function, or length of hospitalization. The second review (Cochrane) conducted by McDonald, Hetrick, and Green (2004) consisted of nine studies involving 782 patients with knee or hip arthroplasty. The results from the review concurred with Johansson et al (2005) showing a wide variety of content and educational tools and the authors concluded that there is little evidence that preoperative education provides superior results in regards to pain, functioning, and length of hospitalization when compared to “usual care” in total hip and knee replacement patients. The Cochrane review by McDonald, Hetrick, and Green (2004) did however show that preoperative education has a modest effect in decreasing anxiety prior to surgery, which concurs with the Johansson et al (2005) review. Since these two reviews, several RCTs have been published evaluating the effect of preoperative education in orthopedic surgery, including TKA (Beaupre, Lier, Davies, and Johnston, 2004; Thomas and Sethares, 2008; Yoon et al, 2009) and THA (Chen and Yeh, 2005; Ferrara et al, 2008; Gocen et al, 2004; Johansson, Salantera, and Katajisto, 2007; Lubbeke, Suva, Perneger, and Hoffmeyer, 2009; McGregor et al, 2004; Thomas and Sethares, 2008; Vukomanovic, Popovic, Durovic, and Krstic, 2008; Yeh, Chen, and Liu, 2005; Yoon et al, 2009). Although our review set out primarily to determine the content and educational delivery methods utilized prior to THA and TKA surgeries to address postoperative pain, the results concur with previous systematic reviews showing that preoperative education classes do not help alleviate postoperative pain following these orthopedic surgeries.

Education delivery methods

A summary of the educational delivery methods indicates that preoperative education for THA and TKA surgery are mainly performed by nurses or physical therapists; usually occur within 4 weeks prior to surgery; and the educational sessions have a mean duration of 30 minutes. The educational material is

presented in either a one-on-one verbal format or small group sessions and is accompanied by a booklet as an adjunct to the verbal presentation. The education delivery methods used in THA and TKA surgery concur with other non-orthopedic surgery studies (Oshodi, 2007a, 2007b). Considering that this review showed a limited effect for preoperative education changing postoperative pain in THA and TKA surgery, and that the education delivery methods were similar to other types of surgery, it could be argued that the limited efficacy might be attributable to the content of the education. This argument is supported by the fact that the only study that demonstrated a benefit to decreasing postoperative pain used a similar education delivery method, but had a unique pain science education component, when compared to all to other papers reviewed (McDonald, Freeland, Thomas, and Moore, 2001).

Content of preoperative education in THA and TKA surgery addressing pain

The content covered in preoperative education in THA and TKA surgery was vast. However, of all topics covered by the various studies, only two topics covered were unique to a single study, indicating that more than 90% of the topics listed were covered by more than one study. This finding may indicate a potential agreement among the various authors on the content of preoperative education for the selected orthopedic surgeries. The content of the educational sessions include a description of preoperative preparation, hospital stay, surgical procedure, immediate/intermediate experiences and expectations following surgery, rehabilitation, encouragement/reassurance, and answering common questions associated with the surgical experience (Johansson et al, 2005; McDonald, Hetrick, and Green, 2004; Oshodi, 2007a, 2007b). In order to gain a deeper insight into the possible reason for preoperative education not positively affecting postoperative pain for THA and TKA surgery patients, the content needs further exploration. The study by McDonald, Freeland, Thomas, and Moore (2001) was the only one that showed a positive effect for preoperative education on pain, even though the educational delivery methods concurred with all the other studies in this review. McDonald, Freeland, Thomas, and Moore (2001) study, however, was unique in that its content taught basic pain management information and communication skills regarding pain prior to surgery. As a result of this education, the patients had less pain on the day

of surgery and days 1 and 2 postoperatively. Although the authors were unable to determine independently if the communication skills or the content was the reason for the reduced postoperative pain, the authors concluded that "...the pain difference between the groups may be a result of the pain management education alone" (McDonald, Freeland, Thomas, and Moore, 2001). Patients are interested in learning about pain (Louw, Louw, and Crous, 2009) and recent studies in non-surgical orthopedic patients with chronic low back pain (LBP) (Moseley, 2002, 2004; Moseley, Hodges, and Nicholas, 2004) and whiplash associated disorders (Van Oosterwijck et al, 2011) have shown that patients are able to understand the presumed complexities of pain science education. Furthermore, education regarding pain science is shown to be associated with decreased perception of pain, increased function, increased movement, and changes in cognitions. These studies, which taught patients more about pain science and pain processing, rather than tissue models describing anatomy and pathology, concur with the content described by McDonald, Freeland, Thomas, and Moore (2001). It is proposed that educational programs that aim to increase a patient's understanding of pain and the biological processes behind the pain experience may be of benefit to patients undergoing orthopedic surgery to affect postoperative pain.

The study by McDonald, Freeland, Thomas, and Moore (2001) and discussion of pain science education in non-surgical orthopedic cases highlights another possibility as to why the other studies in this review failed to provide a favorable outcome in postoperative pain. Traditional educational models are based on a biomedical model discussing anatomy, biomechanics, and pathoanatomy (Henrotin et al, 2006; Houben et al, 2005; Spoto and Collins, 2008; Weiner, 2008). Not only have these models shown limited efficacy in minimizing pain and disability, they may enhance fear (Greene, Appel, Reinert, and Palumbo, 2005; Morr et al, 2010). All the other studies in this review, and several studies in the two recent systematic reviews, indicate that anatomical, pathoanatomical, and surgical "correction" of such pathoanatomy is discussed at length with patients. Such discussion may in fact increase anxiety and fear, thus negatively impacting postoperative pain.

The proposed mechanism and future interest in developing a pain science-based educational model in orthopedics may be due to such educational strategies' ability to enhance the patient's ability to down-regulate input from the affected surgical area (ter Riet, de Craen, de Boer, and Kessels, 1998; Villeneuve and Fields, 2004). Even though patients are anesthetized during surgery and therefore unlikely to

be aware of any sensory stimuli from the surgical site during the surgery, the central nervous system continues to receive an enormous barrage from the surgical site due to tissue trauma generated by the surgeon (Woolf, 2007; Woolf and Mannion, 1999; Woolf and Salter, 2000). The sensory inflow generated by this noxious stimulus will produce central sensitization, an enhanced state of excitability within the nervous system (Nijs, Van Houdenhove, and Oostendorp, 2010; Woolf, 2007). When the surgery is complete and the patient awakens, likely with no recollection of the surgery, the nervous system has, in a sense, a recollection or memory of the surgery in that it is hyperexcitable. The exaggerated sensitivity the patient experiences postoperatively may be a reflection of this altered state of excitability. This postoperative pain is managed primarily via administration of drugs aimed at counteracting the pain (Mahoney, Noble, Davidson, and Tullos, 1990; Warfield and Kahn, 1995). Increasing a patient's knowledge of pain science may alter their perception of threat and they may then experience less fear and anxiety. Additionally, the increased knowledge and understanding of pain science may help modulate the pain experience. In a case study of a patient with chronic LBP, a single pain education session led to a significant reduction in cortical activation of various areas associated with processing pain in a functional magnetic resonance imaging study (Moseley, 2005). Considering that pain science education can lead to changes in pain beliefs, such as a reduction in the conviction that pain is associated with harm and tissue damage and that pain is necessarily associated with disability (Moseley, 2005; Moseley, Hodges, and Nicholas, 2004), it seems most likely that these observed changes in brain activation might reflect reduced threat.

Limitations

This systematic review has limitations that should be acknowledged. The review is limited by the number of studies available, likely due to the narrow setting of the inclusion and exclusion criteria. Due to the heterogeneous nature of the studies, specifically the outcome measures used by the various authors, statistical pooling of the results was not possible and the reported efficacy of preoperative education addressing postoperative pain in orthopedic surgery is based on narrative review. The review contains only patients with THA and TKA and the effect of preoperative education on other non-THA and non-TKA orthopedic surgeries cannot be determined by the results of this review. Additional limitations include English-

only studies and patient populations, thus excluding potential benefits shown by studies published in the non-English language literature. This review also excluded younger patients, thus eliminating a possible positive effect of preoperative education for younger patients facing the uncertainty of various orthopedic surgeries.

CONCLUSION

Preoperative education has little effect on postoperative pain in patients undergoing orthopedic surgery. Even though educational delivery methods utilized in preoperative education is similar to other non-orthopedic surgeries, it is suggested that content focusing on a biomedical model of anatomy, biomechanics, and pathoanatomy is limited in affecting postoperative pain. Educational sessions which aim to enhance patient knowledge of pain science and pain processing by the nervous system may help patients experience less fear and anxiety, and ultimately help alleviate postoperative pain. It is recommended that future research be undertaken to explore a pain education module's ability to alleviate postoperative pain in orthopedics.

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Appendix 4

Article: Efficacy, content and delivery methods of neuroscience education in musculoskeletal disorders

SYSTEMATIC REVIEW

The Effect of Neuroscience Education on Pain, Disability, Anxiety, and Stress in Chronic Musculoskeletal Pain

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ABSTRACT. Louw A, Diener I, Butler DS, Puentedura EJ. The effect of neuroscience education on pain, disability, anxiety, and stress in chronic musculoskeletal pain. *Arch Phys Med Rehabil* 2011;92:2041-56.

Objective: To evaluate the evidence for the effectiveness of neuroscience education (NE) for pain, disability, anxiety, and stress in chronic musculoskeletal (MSK) pain.

Data Sources: Systematic searches were conducted on Biomed Central, [BMJ.com](http://www.bmj.com), CINAHL, the Cochrane Library, NLM Central Gateway, OVID, ProQuest (Digital Dissertations), PsycInfo, PubMed/Medline, ScienceDirect, and Web of Science. Secondary searching (PEARLing) was undertaken, whereby reference lists of the selected articles were reviewed for additional references not identified in the primary search.

Study Selection: All experimental studies including randomized controlled trials (RCTs), nonrandomized clinical trials, and case series evaluating the effect of NE on pain, disability, anxiety, and stress for chronic MSK pain were considered for inclusion. Additional limitations: studies published in English, published within the last 10 years, and patients older than 18 years. No limitations were set on specific outcome measures of pain, disability, anxiety, and stress.

Data Extraction: Data were extracted using the participants, interventions, comparison, and outcomes (PICO) approach.

Data Synthesis: Methodological quality was assessed by 2 reviewers using the Critical Review Form—Quantitative Studies. This review includes 8 studies comprising 6 high-quality RCTs, 1 pseudo-RCT, and 1 comparative study involving 401 subjects. Most articles were of good quality, with no studies rated as poor or fair. Heterogeneity across the studies with respect to participants, interventions evaluated, and outcome measures used prevented meta-analyses. Narrative synthesis of results, based on effect size, established compelling evidence that NE may be effective in reducing pain ratings, increasing function, addressing catastrophization, and improving movement in chronic MSK pain.

Conclusions: For chronic MSK pain disorders, there is compelling evidence that an educational strategy addressing neurophysiology and neurobiology of pain can have a positive effect on pain, disability, catastrophization, and physical performance.

Key Words: Education; Musculoskeletal System; Neurophysiology; Neurosciences; Pain; Rehabilitation.

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PAIN IS A POWERFUL motivating force that guides treatment-seeking behaviors in patients.¹⁻³ Patient education has long been explored in the management of pain, anxiety, and stress associated with low back pain (LBP).⁴⁻⁷ In the orthopedic domain, there are a number of studies on the effect of patient education on pain, with outcomes ranging from “excellent”⁸ to “poor.”^{9,10} The study by Udermann et al⁸ demonstrated that introduction of an individualized educational booklet on back biomechanics can result in decreased pain and frequency of LBP episodes in patients with chronic LBP (CLBP). In contrast to those findings, 2 systematic reviews^{9,10} on the effect of individualized and/or group education for LBP and mechanical neck pain showed little efficacy for such education.

Most education programs for orthopedic patient populations have used anatomic and biomechanical models for addressing pain,^{4,11-14} which not only have shown limited efficacy,^{4,11,12,15,16} but may even have increased patient fears, anxiety, and stress, thus negatively impacting their outcomes.^{11,17-19} Several educational strategies are advocated for patients with LBP, including biomechanical/back school type of education, evidence-based guideline education (ie, *The Back Book*²⁰), cognitive behavioral therapy, and recently, neuroscience education (NE).

NE can be best described as an educational session or sessions describing the neurobiology and neurophysiology of pain, and pain processing by the nervous system. Instead of a

List of Abbreviations

BPPT	brachial plexus provocation test
CFS	chronic fatigue syndrome
CLBP	chronic low back pain
CONSORT	Consolidated Standards of Reporting Trials
LBP	low back pain
MSK	musculoskeletal
NE	neuroscience education
NPRS	numeric pain rating scale
PCI	Pain Coping Inventory
PCS	Pain Catastrophization Scale
PICO	participants, interventions, comparison, outcomes
PPT	pressure pain threshold
PSEQ	Pain Self-Efficacy Questionnaire
RCT	randomized controlled trial
RMDQ	Roland Morris Disability Questionnaire
SLR	straight leg raise
SOPA(R)	Survey of Pain Attitudes (Revised)
TSK	Tampa Scale of Kinesiophobia
VAS	visual analog scale
WAD	whiplash-associated disorders

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Table 1: Inclusion Criteria Used in the Systematic Review

Criterion	Justification
English Language 1999–2010	Major journals in this area are published in this language. Ten years captures the most recently used treatments in clinical practice. First such study to be published was by Moseley ²⁷ in 2002.
Humans older than 18 years	This increased the homogeneity of participants between studies, and educational needs are different for infants, adolescents, and teenagers. ^{82,83}
MSK pain	This increased the homogeneity of conditions being managed with educational strategies incorporating NE.
Quantitative study design including RCTs, nonrandomized clinical trials, or case series	Study designs other than RCTs were included in this review because they provide complementary and relevant clinical detail to the current state of our knowledge and its limitations. ^{84,85} Single case studies were not included because of the low level of evidence they provide.
NE	Patient education is widely used to address pain, anxiety, and stress, but this review focused on educational strategies incorporating NE.
Outcomes: pain, disability, anxiety, and fear	The primary outcome measures chosen for this review were pain, disability, anxiety, and fear. No limitations were set on the measurement tool used to examine the effect of NE on pain, disability, anxiety, and fear.

traditional model of connecting tissue injury or nociception and pain, NE aims to describe how the nervous system, through peripheral nerve sensitization, central sensitization, synaptic activity, and brain processing, interprets information from the tissues and that neural activation, as either upregulation or downregulation, has the ability to modulate the pain experience. Patients are thus educated that the nervous system's processing of their injury, in conjunction with various psychosocial aspects, determines their pain experience and that pain is not always a true representation of the status of the tissues. By reconceptualizing their pain as the nervous system's interpretation of the threat of the injury, rather than an accurate measure of the degree of injury in their tissues, patients may be more inclined to move, exercise, and push into some discomfort. Depending on the timing of its administration, NE may be viewed as a preventive measure in acute pain situations and as a treatment/rehabilitation intervention in chronic pain situations.

Research into educational strategies for patients with CLBP shows an increased use of NE.^{14,21–23} NE is a cognitive-based education intervention that aims to reduce pain and disability by helping patients gain an increased understanding of the biological processes underpinning their pain state.²⁴ NE differs from traditional education strategies such as back school and biomechanical models, by not focusing on anatomic or biomechanical models, but rather on neurophysiology, neurobiology, and the processing and representation of pain.^{22,24,25} Patients are interested in knowing more about pain,³ and it has been demonstrated that patients are capable of understanding the neurophysiology of pain, while professionals have underestimated patients' ability to understand the "complex" issues related to pain.²⁶

Studies that used NE have been shown to decrease fear and positively change a patient's perception of their pain²¹ and have an immediate effect on improvements in patients' attitudes about pain.¹³ This education intervention also resulted in improvements in pain, cognition, and physical performance¹⁴; increased pain thresholds during physical tasks²³; improved outcomes of therapeutic exercises²⁷; and a significant reduction in widespread brain activity characteristic of a pain experience.²² In 1 NE study,²⁷ results extended beyond the short-term and were maintained at 1-year follow-up.

Despite the proposed positive effects reported as a result of NE and the apparent increased use of NE, very little is known

about the efficacy, content, and delivery methods of NE. Therefore, the objective of this systematic review was to source and critically evaluate NE. The results of this review could be used to make evidence-based recommendations regarding the utilization of NE for pain, disability, anxiety, and stress in chronic musculoskeletal (MSK) pain.

METHODS

Search Strategy

An electronic search was performed between February 2010 and July 2010, covering the last decade (1999–2010) from the following databases: Biomed Central, [BMJ.com](http://www.bmj.com), CINAHL, the Cochrane Library, NLM Central Gateway, OVID, ProQuest (Digital Dissertations), PsycInfo, PubMed/Medline, ScienceDirect, and Web of Science. Each database has its own indexing terms and functions, and therefore different search strategies were developed for each database by the authors. The main search items were *neuroscience*, *neurobiology*, *neurophysiology*, *pain*, *pain education*, *pain science*, *education*, *stress*, and *anxiety*. In PubMed, medical subject headings (MeSH) terms were used where possible, with Boolean operators. The search strategies for remaining databases included synonyms of the main search items. Secondary searching (PEARLing) was undertaken, whereby reference lists of the selected articles were reviewed for additional references not identified in the primary search. The titles and abstracts of all the identified literature were screened by 1 primary reviewer using the inclusion criteria below. The full text of all potentially relevant articles was retrieved and screened by 2 reviewers using the same criteria, to determine the eligibility of the article for inclusion in the review.

Inclusion Criteria

All titles and abstracts were read to identify relevant articles. Articles were included in this systematic review if they met the inclusion criteria listed in table 1. Although outcome measures aimed at addressing MSK pain, disability, anxiety, and stress were included, no parameters were set on the exact measurement tools used to assess the effect of NE on pain, disability, anxiety, and stress, since a wide variety of outcome measures were used in the studies. When there was uncertainty regarding the eligibility of the article from the abstract, the full text

Table 2: Hierarchy of Evidence and Study Design, Based on the Australian National Health and Medical Research Council Hierarchy of Evidence*

Level	Definition	Studies
I	Evidence obtained from a systematic review of all relevant RCTs	
II	Evidence obtained from at least 1 properly designated RCT	Ryan et al, ²⁴ Meeus et al, ²⁵ Moseley, ^{14,21,27} Moseley et al ²³
III-1	Evidence obtained from well-designed pseudo-RCTs (alternate allocation or some other method)	Moseley ²⁶
III-2	Evidence obtained from comparative studies (including systematic reviews of such studies) with concurrent controls and allocation not randomized, cohort studies, case-control studies, or interrupted time series with a control group	
III-3	Evidence obtained from comparative studies with historical control, 2 or more single-arm studies, or interrupted time series without a parallel control group	Van Oosterwijck et al ⁴¹
IV	Evidence obtained from case series, either posttest or pretest/posttest	

*Australian National Health and Medical Research Council.⁸⁷

version of the article was retrieved and evaluated against the inclusion criteria. The full text versions of all articles that met the inclusion criteria were retrieved for quality assessment and data extraction (fig 1).

Quality Assessment

Critical appraisal of each included study was conducted by determining the following:

- *The level of evidence:* The level of evidence on the Australian National Health and Medical Research Council Hierarchy of Evidence (Australian National Health and Medical Research Council, 1999) provides a broad indication of bias based on study design (table 2). Studies higher on the hierarchy potentially contain less bias than those that are lower on the hierarchy.
- *The methodological quality:* The methodological quality of each study was assessed using the Critical Review Form–Quantitative Studies.²⁸ This tool can be used to appraise all types of quantitative studies ranging from randomized controlled trials (RCTs) to case series. Thus, all quantitative studies on NE for pain, disability, anxiety, and stress were included in this review and evaluated for quality using the same tool. This made the quality of results comparable between the different study designs.²⁹ Standardized guidelines on the interpretation and scoring of each item were used.³⁰ Items were scored as 1 (completely fulfills the criterion) or 0 (does not completely fulfill the criterion). The scores of the 16 closed-ended questions were tallied to provide an overall score of quality, where the maximum score of 16 indicated excellent quality.³¹ Two researchers independently scored the studies and where disagreement occurred, consensus was achieved by discussion. Quality scores were arbitrarily divided into 5 categories: poor (score, ≤ 8), fair (score, 9–10), good (score, 11–12), very good (score, 13–14), and excellent (score, ≥ 15).³² The Critical Review Form–Quantitative Studies²⁸ includes 17 of the 22 items that are contained in the Consolidated Standards of Reporting Trials (CONSORT) statement.^{33,34} It does not include items 1 (study design stated in title or abstract); 8, 9, and 10 (randomization: sequence generation, allocation concealment, and implementation, respectively); or 19 (adverse events). The CONSORT statement was not designed to evaluate methodological quality.³³ However, in this review, it was documented whether these 5 CONSORT

criteria were fulfilled by the RCTs. This step provides further methodological quality information.

Outcome Assessment

To determine the possible influence of NE on pain, disability, anxiety, and stress for chronic MSK pain, results were posted in narrative form, and outcomes were defined as “positive” (experimental group obtained a significantly greater improvement than the control group), “neutral” (there were no statistically significant differences between the groups), or “negative” (the control group obtained a significant greater improvement than the experimental group). An α of $P < .05$ was used to define a significant outcome measure. This method, used in previous systematic reviews, demonstrated 4 levels of scientific evidence on the quality and the outcome of the trials^{35,36}.

1. *Strong evidence:* Multiple, relevant, high-quality RCTs with generally consistent outcomes.
2. *Moderate evidence:* One relevant, high-quality RCT AND 1 or more relevant, low-quality RCTs with generally consistent outcomes.
3. *Limited evidence:* One relevant, high-quality RCT OR multiple, relevant, low-quality RCTs with generally consistent outcomes.
4. *Inconclusive evidence:* Only 1 relevant, low-quality RCT; no relevant RCTs; or randomized trials with inconsistent outcomes.

A study was considered “relevant” when at least 1 of the outcome measures concerned pain or disability. For being “generally consistent,” at least 75% of the trials that analyzed the same NE had to have the same result (positive, neutral, or negative).

Data Extraction

Data were extracted by the authors using the PICO (participants, interventions, comparison, outcomes) approach.³⁷

- *Participants:* Diagnosis treated, age, sex, duration of the symptoms, type of referral source, and diagnostic criteria.
- *Interventions:* Type, intensity, duration, educational tools/props, in combination or stand-alone physical therapy.
- *Comparison:* To another treatment, no treatment, or “usual” treatment.
- *Outcomes:* Domains and tools used to measure the effects of the intervention. Outcomes chosen for this review included pain, disability, anxiety, and stress.

Data on the effectiveness of the NE were also extracted for each study. To determine the effect of the NE on each outcome measure, the mean and 95% confidence intervals for the between-group differences were calculated for RCTs and comparative studies, based on the results provided in each article.³⁸ Moreover, the mean changes between pretreatment and post-treatment (and 95% confidence intervals) were calculated for the RCTs and comparative studies. Pain reduction of more than 20%, irrespective of the measurement tool used, was considered clinically worthwhile.^{39,40} It was expected that there would be heterogeneity in participants, interventions, comparisons, and outcomes. Therefore, the results of the studies were synthesized in a narrative format.

RESULTS

Search Strategy Yield

Initially, 15,382 hits were gained from databases and secondary searches. After review of the titles and abstracts, those articles that did not meet the inclusion criteria were removed. After reviewing 779 abstracts, the full text of 43 articles was reviewed. On further review, duplicates were removed, leaving 8 studies for the systematic review. This systematic review is based on 8 published studies.^{14,21,23-27,41}

Critical Appraisal

Hierarchy of evidence. There were 6 RCTs,^{14,21,23-25,27} 1 pseudo-RCT,²⁶ and 1 comparative study⁴¹ (see table 2).

Methodological quality. There was 100% agreement in scoring between the researchers conducting the systematic review. Variation in methodological quality was noted (table 3), with scores ranging from 11 to 15 (mean, 13/16). Most articles were “good” in quality, 2 were “very good,” and 2 were “excellent.” No articles were rated as “poor” or “fair.” Table 3 provides details regarding the criteria that were fulfilled on the Critical Review Form—Quantitative Studies.²⁸ It demonstrated that all studies provided adequate detail to allow for reproduction of their intervention (criterion 10). Six studies reported on the reliability of all their measurement tools (criterion 9), and 1 justified sample size (criterion 6). All studies were free from major biases (criterion 4), and 5 studies reported on the validity of all their measurement tools (criterion 8).

CONSORT criteria 1, 8, 9, 10, and 19. Table 3 also provides details regarding the fulfillment of the CONSORT criteria. Only about half of the studies complied with item 9 by reporting the method used to implement a random allocation sequence. Four studies^{23-25,27} complied with item 10 by reporting who generated the allocation sequence, enrolled participants, and assigned participants to their groups. No studies complied with item 19 by reporting whether there were any adverse events in the intervention group.

Naming the intervention. NE is new and described as an educational intervention that aims to reduce pain and disability by explaining the biology of the pain experience to a patient.^{22,24} In this review, it is noteworthy that the intervention of explaining the biological process behind a patient's pain state is described differently by the different authors:

- *Neurophysiology of pain education*^{23,26,27}
- *Pain physiology education*^{14,21,25}
- *Pain biology education*²⁴
- *Pain neurophysiology education*⁴¹

Patient characteristics. In this review, NE was administered to 401 patients, of whom 63% were women (n=252). The average age of the patients ranged from 24±10 years²³ to

45.5±9.5 years,²⁴ with a mean age (calculated as the mean of the mean reported ages) of the patients receiving NE as 38.2 years. NE was presented to patients with LBP, chronic fatigue syndrome (CFS), widespread pain, and chronic whiplash-associated disorders (WAD). The LBP studies primarily focused on CLBP, with the average duration of symptoms ranging from 13.7±10.2 months²⁴ to 48±18 months,²⁶ with an average duration (calculated as a mean of the mean scores) of 31.2 months.

Content of NE. Details of the specific content of the educational sessions used in the studies are found in table 4. In summary, NE session contents included the following:

- Neurophysiology of pain^{14,21,23-27,41}
- No reference to anatomic or pathoanatomic models^{23,27}
- No discussion of emotional or behavioral aspects of pain²³
- Nociception and nociceptive pathways^{14,23,41}
- Neurons^{14,41}
- Synapses^{14,23,41}
- Action potential^{14,41}
- Spinal inhibition and facilitation^{14,23,41}
- Peripheral sensitization^{14,23,41}
- Central sensitization^{14,23,41}
- Plasticity of the nervous system^{23,41}

It is also noteworthy that 4 studies^{14,24,25,41} refer directly to the text, *Explain Pain*, as a source of the content of the NE used in their studies.

Educational Delivery Methods

Professionals performing NE. NE in the reviewed studies was performed by physical therapists. Only 1 study²⁵ failed to clearly identify the professional qualifications of the educator.

Duration and frequency of NE. The duration and frequency of the NE sessions were quite varied. Educational sessions lasted as long as 4 hours,²¹ while more recent studies^{25,41} reported sessions lasting 30 minutes. Educational sessions were also varied between single educational sessions^{14,21,23-26} and multiple sessions.^{21,27,41} The most common frequency between multiple educational sessions was 1 week apart.^{21,27,41} Considering studies varied between single educational interventions and multiple interventions, total education time was also determined. On the high end, 1 study²⁷ spent 8 hours on NE, while the 2 studies^{25,41} with the least amount of total time only spent 30 to 60 minutes on NE. The remainder of the studies averaged between 2.5 and 4 hours of total education time.

Educational format. The format in which the NE was delivered was primarily by means of one-on-one verbal communication.^{14,21,23,25,27,41} Only 2 studies^{21,26} used group sessions.

Educational tools. Details of the specific educational tools used during NE sessions are found in table 4. In summary, NE sessions are accompanied by the following:

- Prepared pictures^{14,23-25,41}
- Examples^{23,25,41}
- Metaphors⁴¹
- Hand drawings^{14,24,26}
- Workbook with reading/question-answer assignments^{23,27}
- Neurophysiology Pain Questionnaire⁴¹

Adjunct treatment to the NE. Several different research designs are included in this review. In all the studies, patients received various forms of other therapeutic interventions at various stages of the studies for various reasons. NE was thus

Table 3: Study Quality of the RCTs (n=8) Using the CONSORT Statement^{33,34}

No.	Criterion–Critical Review Form	Moseley ²⁷ 2002	Moseley ²¹ 2003	Moseley ²⁶ 2003	Moseley ¹⁴ 2004	Moseley et al ²³ 2004	Ryan et al ²⁴ 2010	Meeus et al ²⁵ 2010	Van Oosterwijk et al ⁴¹ 2011	Total
1	Purpose clearly stated	1	1	1	1	1	1	1	1	8
2	Literature review relevant	1	1	1	1	1	1	1	1	8
3	Study design appropriate to study design aims	1	1	1	1	1	1	1	1	8
4	No biases present	0	0	0	0	0	0	0	0	0
5	Sample description in detail	1	1	1	1	1	1	1	1	8
6	Sample size justified	0	0	0	0	0	0	1	0	1
7	Informed consent gained	0	1	0	1	0	1	1	0	4
8	Validity of outcome measures used	0	0	0	1	1	1	1	1	5
9	Reliability of outcome measures used	0	0	1	1	1	1	1	1	6
10	Intervention described in detail	1	1	1	1	1	1	1	1	8
11	Statistical reporting of results	1	1	1	1	1	1	1	1	8
12	Appropriate statistical analysis	1	1	1	1	1	1	1	1	8
13	Clinical importance reported	1	1	1	1	1	1	1	1	8
14	Appropriate conclusions	1	1	1	1	1	1	1	1	8
15	Clinical implications reported	1	1	1	1	1	1	1	1	8
16	Study limitations acknowledged	1	1	1	1	1	1	1	1	8
	TOTAL	11	12	12	14	12	15	15	13	
	Quality category*	Good	Good	Good	Very good	Good	Excellent	Excellent	Very good	
	Criterion–CONSORT statement†									
1	Study design stated in the title or abstract	X	X	X	X	√	√	√	X	
8	Randomization: sequence generation	√	X	X	X	√	√	X	X	
9	Randomization: allocation concealment	√	X	√	X	√	√	√	X	
10	Randomization: implementation	√	X	X	X	√	√	√	X	
19	Adverse events	X	X	X	X	X	X	X	X	

*Quality category: poor (score, ≤ 8); fair (score, 9–10); good (score, 11–12); very good (score, 13–14); and excellent (score, 15–16).³²

†√, criterion fulfilled; X, criterion not fulfilled.

preceded by, combined with, or followed by various therapeutic activities. The therapeutic activities that accompanied NE included the following:

- Manual therapy, including spinal mobilization and manipulation²⁷

- Soft tissue treatment/massage²⁷
- Neural tissue mobilization²⁷
- Spinal stabilization exercises^{21,24,27}
- Home exercises²⁷
- Circuit training²⁴

Table 4: Participants, Interventions and Outcomes in the Reviewed Studies

Author	Participants		Interventions		Outcomes		
	n	Sample Characteristics	Diagnostic Criteria	Treatment	Control	Outcome Instruments	Time of Assessment
Moseley ²² 2002	57	<ul style="list-style-type: none"> • LBP >2 months • Women: 59% • Age (y): EG, 43±7; CG, 38±7 • Duration of symptoms (mo): EG, 39±18; CG, 37±12 	NA	Two physiotherapy sessions per week for 4 weeks Manual therapy including mobilization and manipulation, soft tissue massage, muscle and neural mobilization techniques, but no electrophysical modalities Specific trunk stabilization program Maintain home exercises indefinitely One-hour educational session once a week for 4 weeks One-on-one education format by an independent therapist Content: neurophysiology of pain with no reference to lumbar spine, accompanied by workbook with 1 page of revision material and 3 comprehensive exercises per day for 10 days	Ongoing medical care as advised by their general practitioner No attendance of physiotherapy	<ul style="list-style-type: none"> • NRS: meaningful difference set at 2 points • RMDQ: meaningful difference set at 4 points • NNT 	Baseline; 1 month after intervention and 1 year after intervention
Moseley ²¹ 2003	276 288	<p><u>Patients:</u></p> <ul style="list-style-type: none"> • Women: trained group, 61%; untrained group, 68% • Age (y): trained group, 43±9; untrained group, 37±17. • Duration of pain (y): trained group, 4±1.5; untrained group, 3±1 <p><u>Professionals:</u></p> <ul style="list-style-type: none"> • 21 exercise therapists • 30 medical practitioners • 36 nurses • 44 occupational therapists • 44 psychologists • 57 physiotherapists • 28 rehabilitation counselors 	NA	<p><u>Patients:</u></p> Direct lecture from a specifically trained physiotherapist Hand-drawn images Neurophysiology of pain <p><u>Professionals:</u></p> Seminar on neurophysiology of pain–3 hours in AV format provided by a physiotherapist	None	<ul style="list-style-type: none"> • Neurophysiology of pain questionnaire 	Trained group: Immediately after the educational session Untrained group: Questionnaire before and after the educational session
Moseley ²⁶ 2003	41	<ul style="list-style-type: none"> • LBP >3 months • Women: EG, 67%; CG, 60% • Age (y): EG, 40±7; CG, 42±7 • Duration of symptoms (mo): EG, 33±11; CG, 30±14 	NA	Individual 4 × 1-hour educational session on the physiology of pain and injury by a physiotherapist Additionally received 2 physiotherapy sessions per week for 4 weeks focusing on spinal stabilization exercises	Group session involved a single 4-hour session with a group of 7–10 patients provided by a physiotherapist Physiology of pain and injury Additionally received 2 physiotherapy sessions per week for 4 weeks focusing on spinal stabilization exercises	<ul style="list-style-type: none"> • NRS • RMDQ • NNT 	Baseline; 1 month after “ongoing medical treatment” and 1 and 2 months after educational and physiotherapy sessions

Table 4 (Cont'd): Participants, Interventions and Outcomes in the Reviewed Studies

Author	Participants		Interventions		Outcomes		
	n	Sample Characteristics	Diagnostic Criteria	Treatment	Control	Outcome Instruments	Time of Assessment
Moseley ¹⁴ 2004	121	<ul style="list-style-type: none"> • LBP >4 months. • Women: EG, 50%; CG, 65%. • Age (y): EG, 36±6; CG, 35±7 	NA	<p>Single one-on-one educational session by a physiotherapist</p> <p>Physiology of pain and nociception</p> <ul style="list-style-type: none"> - The neuron: receptor, axon, terminal - The synapse: neurotransmitters, chemically driven ion channel, postsynaptic membrane potential, action potential - Spinal and descending inhibition and facilitation - Peripheral sensitization - Central sensitization: potentiation of the postsynaptic membrane, altered genetic expression, and receptor field growth <p>Lectures accompanied by hand drawings and prepared pictures with interactive commentary</p> <p>Sessions lasted approximately 3 hours</p>	<p>Single one-on-one educational session by a physiotherapist: Anatomy and physiology of the lumbar spine</p> <ul style="list-style-type: none"> - The intervertebral disk: structure and physiology and the effect of aging - Vertebral canal and intervertebral foramen: thecal sac, spinal nerve root, ligamentum flavum - The facet joint: anatomy and biomechanics - The muscles: anatomy, physiology, antagonist and synergistic roles - Spinal biomechanics: curvatures, posture, and ergonomics <p>Lectures accompanied by hand drawings and prepared pictures with interactive commentary</p> <p>Sessions lasted approximately 3 hours.</p>	<ul style="list-style-type: none"> • Brief SOPA(R) • PCS • SLR (inclinometer) • Forward bending test (tape measure– longest finger to floor in flexed position) 	<p>Baseline data</p> <p>Preeducation and immediate posteducation</p>
Moseley et al ²³ 2004	58	<ul style="list-style-type: none"> • LBP >6 months • Age (y): EG, 24±10; CG, 45± 6 • Duration of pain (mo): EG, 18±11; CG, 20±11 	NA	<p>Education session by a physiotherapist in one-to-one seminar format:</p> <ul style="list-style-type: none"> - Session lasted 3 hours; diagrams and hypothetical examples used as teaching tools - At conclusion: Workbook with 10 sections; patients asked to read 1 section per day and answer 3 questions on each session <p><u>Neurophysiology Education:</u> No specific application was made to the lower back, or to emotional and behavioral patterns commonly associated with chronic pain such as catastrophic thought processes or fear avoidance.</p> <p><i>The Nervous System</i> Presentation of the basic structure of the nervous system, with a focus on the components of the nociception/pain pathways. This section included an outline of the functional significance of each component.</p> <p><i>Synapses</i> Presentation of how nerves “talk to each other,” including the concept of “chemicals” (neurotransmitters), postsynaptic receptors, and a conceptual “volume knob” (postsynaptic excitation and inhibition), with a special focus on the “danger messenger nerve” (second-order nociceptive neuron)</p> <p><i>Plasticity of the Nervous System</i> The adaptability of the nervous system including the following: afferent and efferent pathways; the variable state of neural structures including normal state, peripheral, and central sensitization; receptor synthesis; axonal sprouting; the neural response to inactivity; and movement control</p>	<p>Education session by a physiotherapist in one-to-one seminar format:</p> <ul style="list-style-type: none"> - Session lasted 3 hours; diagrams and hypothetical examples used as teaching tools - At conclusion: Workbook with 10 sections; patients asked to read 1 section per day and answer 3 questions on each session <p><u>Back Education:</u> Anatomy and physiology of the bones and joints of the lumbar spine; the intervertebral disk; the trunk and back muscles; normal spinal curves; posture and movements, including analysis of postures and activities according to intradiskal pressures and joint forces; lifting techniques and lifting loads; lifting aids and ergonomic advice; principles of stretching; and strength, endurance, and fitness training. It did not include information about the nervous system, except for outlining the location and course of the spinal cord and the spinal nerve roots. It was similar to education material that has been researched elsewhere and the education components of back schools and functional restoration programs.</p>	<ul style="list-style-type: none"> • RMDQ • Brief SOPA(R) • PCS • SLR (inclinometer) • Forward bending range (distance from longest finger to floor) • Abdominal draw-in task 	<p>Pretreatment; 3 weeks</p>

Table 4 (Cont'd): Participants, Interventions and Outcomes in the Reviewed Studies

Author	Participants		Interventions		Outcomes		
	n	Sample Characteristics	Diagnostic Criteria	Treatment	Control	Outcome Instruments	Time of Assessment
Ryan et al ²⁴ 2010	38	<ul style="list-style-type: none"> • LBP >3 months • <u>Education group:</u> <ul style="list-style-type: none"> • n=18 • 11 women • Age (y): 45.5±9.5 • Duration of pain (mo): 13.7±10.2 • <u>Education and exercise group:</u> <ul style="list-style-type: none"> • n=20 • 14 women • Age (y): 45.2±11.9 • Duration of pain (mo): 7.6±7 	NA	<p><u>Pain Biology Only:</u> 2.5-hour pain biology education session Cognitive behavioral intervention focused on reshaping participants' beliefs and attitudes about their back pain, attempting to decrease fear avoidance and harm beliefs, increase self-efficacy, and decrease avoidance behavior</p> <p>The biology of pain Verbal communication, prepared diagrams, and freehand drawings</p> <p>Additionally, all participants received <i>The Back Book</i>.</p>	<p><u>Pain Biology and Exercise:</u> 2.5-hour pain biology education session Cognitive behavioral intervention focused on reshaping participants' beliefs and attitudes about their back pain, attempting to decrease fear avoidance and harm beliefs, increase self-efficacy, and decrease avoidance behavior</p> <p>The biology of pain Verbal communication, prepared diagrams, and freehand drawings</p> <p>Additionally, all participants received <i>The Back Book</i>.</p> <p><u>Exercise Component:</u> "Back to Fitness exercise classes"; 6 classes, 1 a week for 6 weeks. The classes involved circuit-based, graded, aerobic exercise with some core stability exercises. The classes involved a warm-up phase (10min), an aerobic phase (20-30min), and a warm-down phase (10-15min). The aerobic phase involved circuit-based exercise. For most exercises there was an easy, moderate, and hard version, and the participant could choose which version to perform.</p>	<ul style="list-style-type: none"> • RMDQ • NRS • Repeated sit-to-stand test • The 50-foot walk test • 5-minute walk test • TSK-13 • PSEQ • Step count (activPAL activity monitor^c) 	Pretreatment and 8 weeks later; 3 months later
Meeus et al ²⁵ 2010	46	<ul style="list-style-type: none"> • CFS and widespread pain • Women: EG, 22; CG, 18 • Age (y): EG, 38.3±10.6; CG, 42.3±10.2 	1994 Centers for Disease Control and Prevention criteria for CFS ⁸⁶	<p><u>Pain Physiology:</u> One 30-minute interactive session Physiology of the nervous system in general and of the pain system in particular The theoretic information was illustrated with pictures and examples. The objective of the education was to teach patients the function, mechanisms, and modulation of (chronic) pain, and so forth.</p>	<p><u>Pacing and Self-Management:</u> One 30-minute interactive session Pacing and self-management education was provided to all participants in the control group. Pacing is a strategy in which patients are encouraged to achieve an appropriate balance between activity and rest in order to avoid exacerbation and to set realistic goals for increasing activity. Following this energy management strategy, patients should avoid activities at an intensity that exacerbates symptoms, or they should intersperse activities with periods of rest.</p>	<ul style="list-style-type: none"> • Neurophysiology of Pain Test • PCS • PCI • TSK • Pain threshold assessment (Fisher algometer^b) 	Pretreatment and immediately posttreatment

Table 4 (Cont'd): Participants, Interventions and Outcomes in the Reviewed Studies

Author	Participants		Interventions		Outcomes		
	n	Sample Characteristics	Diagnostic Criteria	Treatment	Control	Outcome Instruments	Time of Assessment
Van Oosterwijck et al ⁴¹ 2011	6	<ul style="list-style-type: none"> • WAD grade I-II • 5 women, 1 man • Mean age (y): 35.6 • Mean duration of symptoms (mo): 50.3 	WAD I-II according to Quebec Task Force on Whiplash-Associated Disorders	<p>Two educational sessions and a leaflet on the neurophysiology of pain:</p> <p>One-on-one education session on neurophysiology of pain lasting 30 minutes; physiotherapist delivered the education session. Content and pictures based on the <i>Explain Pain</i> text; physiology of the nervous system in general and of the pain system in particular; pictures, examples, and metaphors were used. Topics addressed during the educational sessions included the characteristics of acute vs chronic pain; the purpose of acute pain; how acute pain originates in the nervous system (nociceptors, ion gates, neurons, action potential, nociception, peripheral sensitization, synapses, synaptic gap, inhibitory/excitatory chemicals, spinal cord, descending/ascending pain pathways, brain role, pain memory, and pain perception); how pain becomes chronic (plasticity of the nervous system, modulation, modification, central sensitization, pain neuromatrix theory); and potential sustaining factors of central sensitization such as emotions, stress, pain cognitions, and pain behavior.</p> <p>Educational session in line with the content of the Neurophysiology of Pain Test in such a way that after having received the education, patients should be able to answer all questions of the test correctly.</p> <p>The educational information was presented verbally (explanation by the therapist) and visually (summaries, pictures, and diagrams on computer and paper).</p> <p>Patients also received an information leaflet about the neurophysiology of pain and were asked to read it carefully at home.</p> <p>During the second session, the therapist answered and explained additional questions that arose after reading the information leaflet.</p>	None	<p>Primary outcome measures:</p> <ul style="list-style-type: none"> • Neck Disability Index • PPT (Fisher algometer) <p>Secondary outcomes:</p> <ul style="list-style-type: none"> • WAD symptom list • PCS • PCI • TSK • Neck extension test • VAS • BPPT 	<p>A-B-C design:</p> <p>Period A, assessment before intervention (2-3wk);</p> <p>Period B, intervention (1wk)</p> <p>Period C, postintervention assessment (3wk)</p> <p>Total time, 7 weeks</p>

Abbreviations: CG, control group; EG, experimental group; NA, not applicable; NNT, numbers needed to treat; NRS, numeric rating scale.

Table 5: Efficacy of NE on Pain, Disability, Anxiety, and Stress for MSK Conditions

Outcome	Moseley ²¹ 2003	Moseley ²⁷ 2002	Ryan et al ²⁴ 2010	Van Oosterwijk et al ⁴¹ 2011	Meeus et al ²⁵ 2010	Moseley ²⁶ 2003	Moseley et al ²³ 2004	Moseley 2004 ¹⁴
Decrease pain ratings	+	+	+	+				
Increase knowledge of pain					+	+		
Increase pain tolerance				+	N			
Alter self-report whiplash symptoms				N				
Improve function and disability	+	+	N	+			+	
Decrease fear of reinjury			N	+	N			
Decreased pain catastrophization				N	+		+	+
Develop strategies to cope with pain				+	N			
Develop healthy attitudes regarding pain			N				+	+
Improve physical movement and performance			N	+			+	+

NOTE. + = positive (experimental group obtained a significantly greater improvement than the control group); N = neutral (there were no statistically significant differences between the groups).
Abbreviation: ●●●.

- Aerobic exercise²⁴
- None (NE only)^{14,23,25,26,41}

Use of Control Groups

Several different comparisons were made to groups receiving NE. Control interventions varied in the studies and included NE sessions compared with the following:

- Ongoing medical care²⁷
- Not attending physical therapy²⁷
- Health care professional knowledge of pain²⁶
- Group session of NE²¹
- Anatomy and physiology of the lumbar spine^{14,23,24}
- *The Back Book*²⁴
- Exercise and NE combination²⁴
- Pacing and self-management program²⁵
- None⁴¹

Outcome Measures

There was great variability in outcome measurements across the studies in terms of the number and type of outcome measures used and the number of occasions they were used (see table 4). Researchers and clinicians using NE were interested in determining whether NE affected issues related to pain, disability, psychological issues associated with pain, and movement. A review of the outcome measures used in the studies revealed that most of the outcome measures fit into 1 of 4 categories:

1. Outcomes directly measuring issues related to pain
 - Pain ratings (numeric pain rating scale [NPRS] and visual analog scale [VAS])^{21,24,27,41}
 - Pain knowledge (Neurophysiology of Pain Test)^{25,26}
 - Pressure pain thresholds (PPTs)^{25,41}
 - Self-report symptoms (WAD symptom list)⁴¹
2. Outcomes related to function and disability
 - Roland Morris Disability Questionnaire (RMDQ)^{21,23,24,27}

- Neck Disability Index⁴¹
3. Outcomes related to psychosocial issues
 - Tampa Scale of Kinesiophobia (TSK)^{24,25,41}
 - Pain Catastrophization Scale (PCS)^{14,23,25,41}
 - Pain Coping Inventory (PCI)^{25,41}
 - Survey of Pain Attitudes (Revised) (SOPA[R])^{14,23}
 - Pain Self-Efficacy Questionnaire (PSEQ)²⁴
 4. Movement
 - Neurodynamic tests: Straight leg raise (SLR) and brachial plexus provocation test (BPPT)^{14,23,41}
 - Trunk forward flexion and neck extension^{14,23,41}
 - Abdominal draw-in maneuver²³
 - Endurance: Sit-to-stand, 50-foot walk test, 5-minute walk test, and step count²⁴

Measurement periods were variable, ranging from immediate effect of NE^{14,25,26,41} to 1-year follow-up,^{21,27} but several studies also reported intermediate effects of NE.

Effectiveness of NE Data gained from the RCTs could not be pooled because of the heterogeneity of the outcome measures and comparison groups. Results are thus reported in narrative form and summarized in table 5.

NE addressing pain. Six of the 8 studies in this review examined the effectiveness of NE addressing issues associated with pain.^{21,24-27,41} Methodological quality of the 6 studies addressing pain ranged from 11 (good) to 15 (excellent), with a mean score of 13.

- An NE session for patients with CLBP by itself produces a more favorable immediate effect on decreasing pain ratings (range, 0-100) (39.3 ± 26.2 to 8.4 ± 7.5) than a program combining NE and an exercise program (28.1 ± 20.4 to 23.9 ± 23.3) ($P < .025$), but loses its superior efficacy at 3-month follow-up.²⁴
- NE for patients with CLBP decreased pain in both short-term (1mo) and long-term (1y) interventions ($P < .01$), compared with patients receiving ongoing medical care

without physical therapy.²⁷ The mean improvement of the NE session was 1.5 points on the NPRS.

- NE sessions for patients with CLBP delivered as single one-on-one sessions or as group sessions decreased pain significantly ($P < .05$), yet individual one-on-one educational sessions were associated with a more favorable outcome, compared with the group educational sessions ($P = .004$).²¹ The average reduction in pain was 3.1 (1.8–4.2) for the individual education group versus 2.7 (1.6–3.9) in the group education session.
- After an NE session, patients with chronic WAD had a significant reduction in pain (VAS) during a neck extension test without fixation ($P = .04$) and with fixation ($P = .04$).⁴¹ Perceived pain on the VAS was decreased 43.5% for the test without fixation and 59.2% with fixation.
- In patients with CFS, a 30-minute NE session is able to increase their knowledge of pain, compared with a program focused on pacing and self-management ($P < .001$).²⁵
- A single NE session will increase the knowledge of pain in patients with CLBP.²⁶
- NE did not improve PPT in patients with CFS,²⁵ while PPT was significantly increased (decreased sensitivity of the nervous system) in patients with chronic WAD (trapezius, $P = .03$; calf, $P = .04$).⁴¹
- Of all the self-report WAD symptoms on the WAD symptoms list (photophobia, neck mobility, and sweating), NE showed only a significant effect on decreasing photophobia ($P = .04$).⁴¹

NE addressing function and disability. Five of the 8 studies in this review examined the effectiveness of NE addressing issues associated with function and disability.^{21,23,24,27,41} Methodological quality of the 5 studies addressing pain ranged from 11 (good) to 15 (excellent), with a mean score of 12.6.

- NE sessions for patients with CLBP delivered as single one-on-one sessions or as group sessions decrease disability (RMDQ) significantly ($P < .05$; average decrease 5.5 points), yet individual one-on-one educational sessions were associated with a more favorable outcome, compared with the group educational sessions ($P = .004$).²¹ The change in RMDQ in this study was clinically meaningful and comparable to studies showing manipulation (3 RMDQ points)⁴² and exercise (2.9 RMDQ points)⁴³ effects on changing disability.
- An NE session for patients with CLBP alters disability as measured by RMDQ ($P = .02$), but because of effect size (< 2 points on the RMDQ) was clinically insignificant.
- NE for patients with CLBP decreased perceived disability in both the short-term (1mo) and long-term (1y) ($P < .01$), compared with patients receiving ongoing medical care without physical therapy.²⁷ The mean improvement on the RMDQ was 3.9 points for the experimental group, which is clinically significant.²⁷
- NE reduced perceived disability in patients with CLBP, but failed to reach significance ($P = .127$). The immediate effect leveled off at 3-month follow-up.
- In measuring perceived disability from whiplash, Van Oosterwijk et al⁴¹ showed that NE was able to decrease perceived disability ($P = .046$), which was reduced from 28.26% to 22.72%. This reduction is comparable to the disability decrease achieved by Moseley.²⁷

Outcome related to psychosocial issues. *Tampa Scale of Kinesiophobia.* Three studies^{24,25,41} used the TSK as an outcome measure to assess fear of (re)injury resulting from movement.

- A single NE session for patients with chronic WAD decreased fear of (re)injury ($P = .03$).⁴¹
- An NE program alone compared with an NE and exercise program failed to show any significant difference in pain-related fear as measured by the TSK ($P > .05$).²⁴
- In a study²⁵ of patients with CFS, an NE session failed to show a significant difference in fear of (re)injury compared with a pacing and self-management program ($P > .05$).

Pain Catastrophization Scale. Four studies^{14,23,25,41} used the PCS as an outcome measure to assess pain catastrophization.

- Meeus et al²⁵ evaluated the effect of NE compared with pacing and self-management for patients with CFS and found that NE changed 1 of the PCS factors (ruminating) by a statistically significant difference compared with the control group ($P < .05$).
- A single NE session for patients with chronic WAD showed no effect on pain catastrophization ($P > .05$).⁴¹
- An RCT²³ of patients with CLBP comparing NE to a back education program showed a statistical significant effect in decreasing pain catastrophization ($P < .001$).
- NE has been shown to decrease pain catastrophization ($P < .001$), which was correlated to increased SLR and forward bending.¹⁴

Pain Coping Inventory. Two studies^{25,41} used the PCI as an outcome measure to assess cognitive and behavioral pain-coping strategies.

- In a study evaluating the effect of NE on patients with chronic WAD, NE changed passive coping strategies ($P = .03$), but not in the other PCI categories of retreating and worrying.
- Meeus²⁵ evaluated the effect of NE compared with pacing and self-management for patients with CFS and found that NE failed to produce a significant change in PCI ($P > .05$).²⁵

Pain attitudes. Two studies^{14,23} used the SOPA(R) as an outcome measure to assess attitudes and beliefs regarding pain.

- In an RCT comparing NE to back education, the NE session provided a significant change in patient attitudes and beliefs regarding pain, compared with the back education group ($P < .001$). Patients who received NE were less likely to seek care from others when they experienced pain; more likely to believe that they could control their pain; more likely to believe pain is affected by emotional distress; and less likely to believe pain is caused by tissue injury.²³
- The study by Moseley¹⁴ showed that an NE session altered 2 SOPA(R) factors significantly ($P < .05$)—harm and disability—which in turn were associated with increased physical performance.

Pain Self-Efficacy Questionnaire. Only 1 study²⁴ used the PSEQ as an outcome measure to determine individuals' beliefs regarding their ability to carry out activities and function despite their pain.

- In a study²⁴ comparing NE to a NE and exercise session, no statistically significant changes were found between the groups ($P > .05$).

NE addressing physical movement. Four^{14,23,24,41} of the 8 studies in this review examined the effectiveness of NE in addressing issues associated with physical movement. Methodological quality of the 4 studies addressing physical movement ranged from 12 (good) to 15 (excellent), with a mean score of 13.5.

- *Neurodynamic tests*: NE compared with back education causes an immediate increase in SLR range of motion ($P < .01$)^{14,23} including taking into consideration measurement error,⁴⁴ and decreased pain perception during a BPPT in patients with chronic WAD.⁴¹
- *Spine movements*: NE compared with back education causes an immediate increase in trunk forward flexion in patients with CLBP ($P < .01$),^{14,23} and decreased pain perception during neck extension movements in patients with chronic WAD.⁴¹
- *Motor control*: NE compared with back education resulted in no statistical difference between the groups ($P > .05$).²³
- *Physical performance*: NE compared with an NE and exercise program did not show a statistically significant difference ($P > .05$).²⁴

DISCUSSION

Utilization of NE is increasing.^{14,21-23,45,46} This is the first systematic review of NE for pain, disability, anxiety, and stress in patients with MSK pain. Although this review comprised a rather heterogeneous sample of studies using NE, the results indicate compelling evidence for the use of NE in decreasing pain ratings, increasing physical performance, decreasing perceived disability, and decreasing catastrophization in patients with chronic MSK pain.

NE focuses on a detailed description of the biology and physiology of the nervous system and brain's processing of pain and nociceptive input.^{23,41} This approach is in direct contrast to prevailing biomedical models, which focus on tissues and tissue injury.⁴⁷⁻⁴⁹ Orthopedic-based professions such as orthopedic surgeons and physical therapists commonly use anatomy- and pathoanatomy-based models to explain pain to their patients.⁴⁷⁻⁵⁰ Not only have these models shown limited efficacy in decreasing pain and disability, but they may increase fear in patients, which in turn, may increase their pain.^{51,52}

Although NE features an anatomic component (anatomy of the nervous system), it deemphasizes tissue injury (ie, disk or joint),^{23,27} rather using the anatomy to describe pathways to process nociceptive input.^{23,41} A key message that NE tries to impart to the patient is the clear difference between "nociception" and "pain." Patients are taught that the nervous system has the ability to increase or decrease its sensitivity (neuroplasticity) to help them cope with persistent pain.^{23,41} Considering that other educational models use similar education delivery methods as NE, it could be argued that the content of NE may be the key element in its efficacy compared with the more traditional models of explaining pain to patients.^{13,14,22,23,27}

The results indicate that one-on-one education was used the most^{14,23-25,41} and is superior with respect to outcomes, when compared with group sessions.²⁶ Considering the individualistic and complex processing of pain, it should not be surprising that one-on-one educational sessions produced superior results.^{13,26} Various brain pathways process nociception, and these pathways are influenced by personal experiences, thoughts, feelings, and emotions, thus creating an individual neural signature of the event.^{13,53}

Although this review failed to identify the optimal duration and frequency of NE sessions, it is noteworthy that the 3 most recently published studies used considerably less education delivery time.^{24,25,41} This reduction in time could be the result of an increased proficiency in applying NE, and also a potential means to develop an NE session that could be clinically useful,²⁵ potentially alleviating issues of time constraints in clinical practice.⁵⁴⁻⁵⁶ This trend may allow clinicians to not only provide NE in as little as 30 to 45 minutes, but to also combine

it with other physical treatments. The combination of NE and exercise^{24,27,45} is in line with best-evidence guidelines for managing patients with chronic pain.⁵⁷⁻⁵⁹ Physical therapists provided all the NE in this review.^{14,21,23,25,27,41} Physical therapists' knowledge of neurophysiology and a movement-based approach may indicate a unique role for physical therapists in managing patients with chronic pain.

Educational sessions were also accompanied by various teaching tools, including hand-drawn images, prepared pictures, and workbooks.^{14,23-25,41} The use of booklets concurs with patient education studies highlighting booklets as valuable tools in aiding information retention compared with verbal communication only.⁶⁰⁻⁶² In 2 of the NE studies,^{23,27} patients were also asked to complete daily tasks. Patient tasks would likely aid in the development of much-needed deep learning processes, since the patient is active compared with a more passive education endeavor.⁶³⁻⁶⁷

Although various definitions for pain are provided in the scientific literature,^{13,53} patients often see pain as a measure of the health of their tissues.^{51,52} Pain is complex, and recent authors have highlighted that pain could possibly be a better measure of potential threat, rather than true tissue health.^{13,22,68,69} The larger the threat, the more pain is perceived.²² Patients' pain perception attributable to tissue health is yet another example of an anatomy and pathoanatomy model driving pain. Considering that NE purposefully deemphasizes tissue injury, focuses on the processing of nociception, and aims to increase the patient's awareness that nociception and pain are not correlated, it could be seen as a possible mechanism to decrease the threat, thus dampening the pain perception in the patient.^{22,58}

Several studies⁷⁰⁻⁷³ have shown that patients with higher pain ratings have increased disability. Because patients view pain as an indicator of tissue health and conclude that activity may further damage their tissue, decreased physical movements may be seen as a logical protective mechanism.⁶⁹ The results of this study would indicate that with decreased pain perception and a greater understanding of the nonmechanical factors that may increase or decrease nerve sensitivity (ie, failed treatment, fear, emotions, and different explanations of their pain), patients may be inclined to see themselves as less disabled and more inclined to increase their activity.⁷⁰⁻⁷³

Persistent pain has been shown to lead not only to significant physical changes in the brain,^{22,74,75} but also to altered processing of pain and the activation of catastrophization.^{76,77} With persistent pain, failed treatment, and different explanations for their pain, patients with chronic pain may plausibly view their condition as being far worse than it actually is and their future as bleak, and thus have little hope.⁷⁸⁻⁸⁰ This irrational thought that patients have in believing their problems as being far worse than they actually are is known as catastrophization, and it appears to enhance pain processing. This review included patients with more than 2.5 years of chronic pain, which concurs with studies associating persistent pain with higher levels of catastrophization.^{76,77,81} The deemphasis of the faulty tissue model as portrayed by the NE could be seen as 1 reason for its ability to begin to alter pain catastrophization.

Finally, we should consider a particular circumstance that is relevant to patients with MSK pain and how NE may facilitate therapeutic improvement. The nature of MSK pain is unique given its subjectivity, frequent lack of an "objective" radiographic correlate, and the many erroneous and often misleading things patients are told. These factors could trigger the development of maladaptive cognitions that, without adequate education during prior medical workups, reinforce fears of movement and the perception of serious tissue damage underpinning

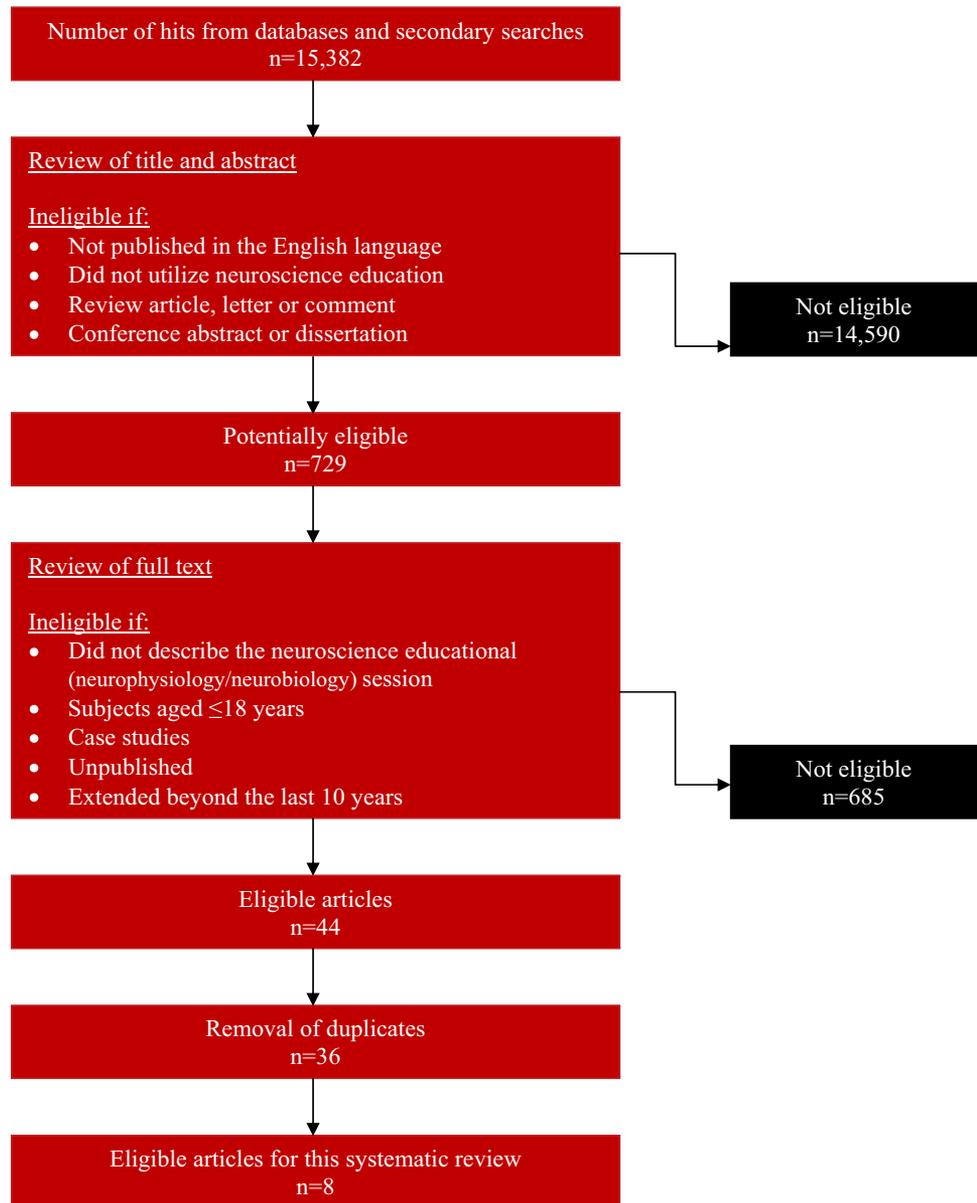


Fig 1. Retrieval and review process.

patients' pain (eg, "you have a bulging disk"; "you have degenerative joint disease"; "your nerve is being pinched"). NE may have potential impact by countermanding any iatrogenically induced maladaptive beliefs encouraged by treatment with physicians who practice pain management from the "tissue damage" perspective. These maladaptive beliefs are also often reinforced by misdirected and failed surgery or interventional procedures. Given the evidence for the importance of exercise in the management of MSK pain, these fears become primary in understanding continued disability and may help to explain why NE may be particularly well suited to interventions for MSK disorders.

Limitations

This systematic review has limitations that need to be acknowledged. The review is limited by the number of studies, as well as the need to use studies of lower levels of evidence to gain a better understanding of the effect of NE in MSK pain.

The heterogeneous nature of studies in this review precluded true meta-analyses, which would have been helpful to determine the level of NE effectiveness. Based on the lack of consistent control groups in the articles reviewed, it is not possible to draw strong conclusions about the influence of the NE content versus individual attention and the acknowledgment that perceived pain may be real. This review contains mainly patients with CLBP and carryover of the results to other MSK conditions is limited. Additional limitations include English-only studies and patient populations, as well as excluding younger patients.

CONCLUSIONS

The results of this systematic review show compelling evidence for NE affecting passive^{14,23,41} and active physical movements.^{14,23,41} Positive effects of NE on pain perception, disability, and catastrophization may allow patients to apply this new view of their pain state by reappraising their ability to

move.²³ With the decreased threat of additional tissue injury and a newly gained realization that pain may be caused by neural sensitivity rather than tissue injury, patients may be able to actively move further and allow clinicians to passively move them further.

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Appendix 5

Article: Development of a preoperative neuroscience educational tool for lumbar surgery

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EDUCATION & ADMINISTRATION

Development of a Preoperative Neuroscience Educational Program for Patients with Lumbar Radiculopathy

ABSTRACT

Louw A, Butler DS, Diener I, Puentedura EJ: Development of a preoperative neuroscience educational program for patients with lumbar radiculopathy. *Am J Phys Med Rehabil* 2013;92:00–00.

Postoperative rehabilitation for lumbar radiculopathy has shown little effect on reducing pain and disability. Current preoperative education programs with a focus on a biomedical approach feature procedural and anatomical information, and these too have shown little effect on postoperative outcomes. This report describes the development of an evidence-based educational program and booklet for patients undergoing lumbar surgery for radiculopathy using a recently conducted systematic review of neuroscience education for musculoskeletal pain. The previous systematic review produced evidence for neuroscience education as well as best-evidence synthesis of the content and delivery methods for neuroscience education for musculoskeletal pain. These evidence statements were extracted and developed into patient-centered messages and a booklet, which was then evaluated by peer and patient review. The neuroscience educational booklet and preoperative program convey key messages from the previous systematic review aimed at reducing fear and anxiety before surgery and assist in developing realistic expectations regarding pain after surgery. Key topics include the decision to undergo surgery, pain processing, peripheral nerve sensitization, effect of anxiety and stress on pain, surgery and the nervous system, and decreasing nerve sensitization. Feedback from the evaluations of the booklet and preoperative program was favorable from all review groups, suggesting that this proposed evidence-based neuroscience educational program may be ready for clinical application.

Key Words: Preoperative, Neuroscience, Lumbar, Radiculopathy, Education

The primary surgical intervention for lumbar radiculopathy is lumbar laminectomy or lumbar laminotomy with or without discectomy.¹ Studies on lumbar disc surgery for radiculopathy have shown that this surgical intervention has between 60% and 90% success rate,^{2,3} leaving 10%–40% of patients with residual pain, loss of movement, and disability.⁴ With persistent pain and disability after surgery, rehabilitation is often prescribed and is proposed to decrease disability, increase movement, and facilitate return to regular activities.^{5–8} However, postoperative rehabilitation has shown little effect on reducing postoperative disability and pain,⁸ and surgeons do not readily send patients to rehabilitation after spinal surgery.^{7,9} This may indicate that many patients experience long-term disability after lumbar disc surgery.

A strategy designed to decrease postoperative complications and disability is preoperative education.¹⁰ Preoperative education is commonly used in joint replacement surgery,^{11–13} cardiac surgery,¹⁴ and abdominal surgery.^{10,15,16} Preoperative education has been shown to help increase knowledge of the surgical procedure,^{11,17,18} reduce anxiety,^{19,20} reduce postoperative pain,^{21,22} decrease length of hospital stay,^{11,23} and facilitate faster return to preoperative functional levels.^{23,24} To date, only a handful of studies have been conducted on the outcome of preoperative education for lumbar surgery; however, they focused on procedural information and informed consent and showed little added benefit regarding postsurgical outcomes.¹¹ Three studies surveyed patients who had undergone spinal surgery to determine their preferences regarding preoperative education for spinal surgery.^{24–26} A study by Louw et al.²⁶ showed that patients wanted more preoperative information not only regarding the surgical procedure, the potential risks, and the limitations and benefits of surgery but also on their pain and how surgery would impact it. A study by McGregor et al.²⁵ showed that patients wanted preoperative information but provided little information on the exact content of this information. A study by Ronnberg et al.²⁴ showed that patients undergoing disc surgery were, in general, satisfied with the care given to them preoperatively, but not with the content of the information regarding their impending spinal surgery.

Most education programs used in orthopedic patient populations use anatomical and biomechanical models for addressing pain,²⁷ which has not only been shown to have limited efficacy²⁷ but may also lead to an increase in patients' fear, anxiety, and stress, thus negatively impacting their outcomes.^{28,29} Several educational strategies are

advocated for patients with low-back pain (LBP), including biomechanical/back school type of education, evidence-based guideline education (i.e., the Back Book³⁰), cognitive behavioral therapy,³¹ and recently, neuroscience education.^{32–34}

Recent research into educational strategies for patients with chronic LBP finds an increased use of neuroscience education.^{33,34} Neuroscience education is a cognitive-based education intervention that aims to reduce pain and disability by helping patients gain an increased understanding of the biologic process underpinning their pain state.³⁵ Neuroscience education differs from traditional education strategies such as back school and biomechanical models by not focusing on anatomical or biomechanical models, but rather on neurophysiology, neurobiology, and the processing and representation of pain.^{35,36} Patients have expressed interest in knowing more about how pain works,²⁶ and it has been demonstrated that patients are quite capable of understanding the neurophysiology of their pain, while professionals will underestimate their ability to understand the “complex” issues related to pain.³⁷

Studies that used neuroscience education have shown that it decreases fear and changes a patient's perception of his/her pain³⁸ and has an immediate effect on improvements in patients' attitudes about pain.³⁹ This education intervention has also been shown to result in improvements in pain, cognition, and physical performance;³³ increased pain thresholds during physical tasks;³⁴ improved outcomes of therapeutic exercises;⁴⁰ and significant reduction in widespread brain activity characteristic of a pain experience.⁴¹ The aim of this study was, therefore, to use the current best evidence for neuroscience education for musculoskeletal disorders to develop a preoperative neuroscience educational program for lumbar radiculopathy.

METHODS

Development of the Booklet

The content of the neuroscience education sessions as found in the systematic review on neuroscience education⁴² was used to develop appropriate messages for patients considering surgery for lumbar radiculopathy (Table 1). The educational messages were designed to be delivered as one-on-one educational sessions to patients before surgery along with the development of a patient booklet containing the same messages to provide patients with a written version of the content of

TABLE 1 Content of neuroscience education used in the development of the preoperative neuroscience educational program

Neurophysiology of pain ^{33-38,40,43}
No reference to anatomical or patho-anatomical models ^{34,40}
No discussion of emotional or behavioral aspects to pain ⁴⁰
Nociception and nociceptive pathways ^{33,34,43}
Neurones ^{33,43}
Synapses ^{33,34,43}
Action potential ^{33,43}
Spinal inhibition and facilitation ^{33,34,43}
Peripheral sensitization ^{33,34,43}
Central sensitization ^{33,34,43}
Plasticity of the nervous system ^{34,43}

the educational session. The booklet followed the general philosophy and style of the *Explain Pain* book,³⁹ which has been used in studies examining neuroscience education for pain and disability.^{33,35,36,43} The main aim of the preoperative neuroscience educational program was to help patients reconceptualize their back, hip, and leg pain as an increase in nerve sensitivity and up-regulation of the peripheral and central nervous system and defocus attention from nociceptive input via the tissues from the affected areas. The neuroscience education message aims to reduce anxiety and uncertainty and thus promote positive expectations and beliefs. The structure of the developed neuroscience education program consisted of six sections: (1) the decision to have back surgery; (2) the nervous system anatomy, physiology, and pathways; (3) peripheral nerve sensitization; (4) environmental influences on nerve sensitivity; (5) down-regulation of the nervous system; and (6) recovery after back surgery. Several drafts of the text over a period of several months refined its content, clarity, and readability. The booklet was reviewed to be at sixth grade English, and the word count (4129) was comparable with the length of the *Your Back Operation* booklet used in the UK (4622 words).²⁵

Professional evaluation of the booklet included an expert panel consisting of spine surgeons, experts in neuroscience education, pain management physicians, orthopedic nurses, physical therapists, psychologists, and specialists in patient education. The expert panel was given a copy of the booklet along with a questionnaire and were asked to send the completed questionnaire back to the researchers within 30 days. A reminder was sent to the expert panel 1 week before the deadline. The questionnaire had two parts: part 1 contained 11 forced-

choice questions on readability, style, information level, believability, length, content, and helpfulness (e.g., “I learned some new, helpful things,” “I knew most of it anyway,” and “I didn’t really find it helpful”). Part 2 contained open-ended questions about the most important messages they took from the booklet, anything they did not like or understand, whether they had any concerns that were not covered, whether they thought the booklet would change what they did after surgery, and their overall rating of the booklet on a scale from 1 to 10. The questionnaire was designed for and borrowed from a previous study.²⁵

A second evaluation consisted of a convenience sample of patients who had recently undergone lumbar surgery for radiculopathy. Patients at two orthopedic physical therapy groups (Ortho Spine and Pain clinic in Iowa and RehabAuthority in Idaho) working closely with spine surgeons were approached, and informed consent was obtained. Each patient was given a copy of the draft text to read at their leisure and were asked to complete and return an evaluative questionnaire similar to the one for the expert panel.

Third, a convenience sample from the general population was asked to evaluate the booklet and to complete the questionnaire described above. People who had undergone previous spinal surgery, who experienced low back pain at the time, or who were attending any treatment for low back pain were excluded.

RESULTS

Booklet Evaluations

The results from the expert panel and postoperative patient and the general population are found in Figure 1. All of the professional reviewers ($n = 12$) stated that they strongly supported the themes and messages of the booklet and recognized the need for such material. Although there were few and minor criticisms of the information provided, the overall comments were very positive. These comments and suggestions were discussed among the authors and changes were made to the text as appropriate. Importantly, all the spine surgeons welcomed the booklet and considered it would be useful in their practices. The overall rating of the booklet by the expert panel was 8.2 of 10.

Evaluation of the booklet was returned by five postoperative patients and five people from the general population. Of the responders, all five patients and five people from the general population reported that they found the booklet easy to read

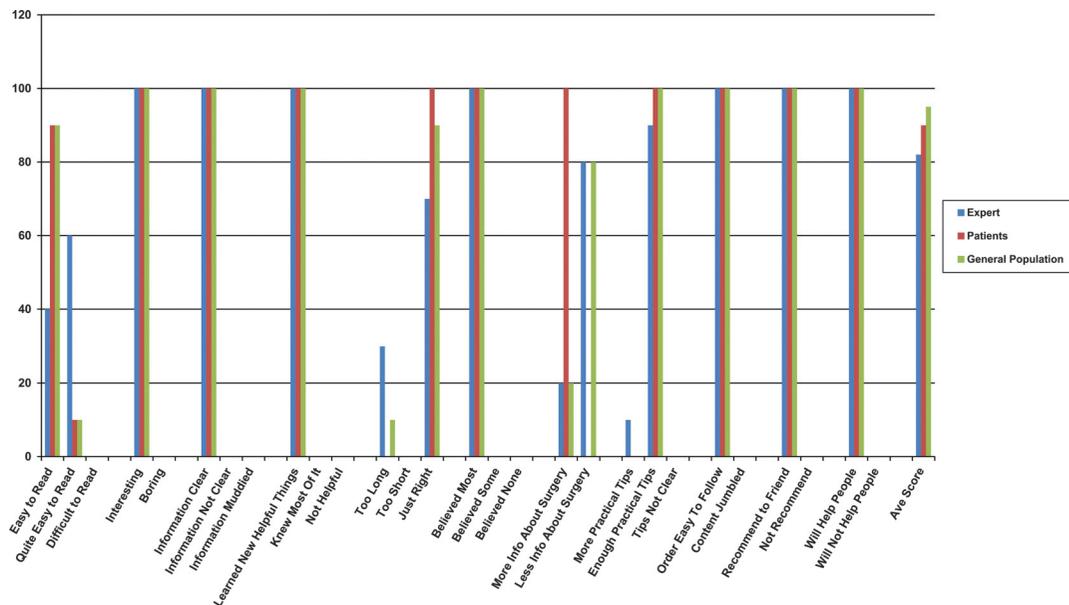


FIGURE 1 Results from the survey of the expert panel and patients and people from the general population.

and interesting, learned new things, and thought the content was easy to follow. All stated that they felt the booklets were not too long, but just right, with an adequate number of images. They thought it would help patients and they would recommend it to a family member. Although all postoperative patients and people from the general population indicated a need for more information about the operation, the booklet was designed to be an adjunct to the usual preoperative education provided by surgeons, who generally discuss the operation at length.⁹ The narrative questions showed that postoperative patients and people from the general population understood the main aim of the booklet, that is, the increased sensitization of the nervous system in radiculopathy and how nerves increase and decrease sensitivity. Postoperative patients and people from the general population further explained the greater understanding of movement and an active approach in rehabilitation after lumbar surgery (Table 2). The postoperative patients' average overall rating of the booklet was 9 of 10. The patients' responses were again discussed by the authors, and appropriate changes made to the text.

DISCUSSION

The use of neuroscience education is increasing.^{34,41,44,45} The systematic review used for the development of this study's preoperative neuroscience education program for lumbar surgery for radiculopathy is the first review of neuroscience education for pain, disability, anxiety, and stress in

musculoskeletal conditions.⁴² Although this review comprised a rather heterogenous sample of studies using neuroscience education, the results from this review indicate strong evidence for the use of neuroscience education in decreasing pain ratings, increasing physical performance, decreasing perceived disability, and decreasing catastrophization in patients with chronic musculoskeletal pain.

Neuroscience education focuses on a detailed description of the biology and physiology of the

TABLE 2 Themes captured from descriptions of the important messages from the preoperative neuroscience educational booklet by the five patients and five people from the general population

Most important messages from the booklet?
Stress affecting nerve sensitivity
How much nerve sensitivity is dependent on blood flow
How to calm nerves down
Importance of movement after surgery
Be confident in your surgery decision and don't second-guess
Hospital experiences, anxiety and its effect on nerve sensitivity
Surgery may fix the problem, but the nerves take time to calm down
Potential changes after surgery?
Decrease level of stress
Move more despite sensitivity
Other comments about the booklet?
Wish my surgeon told me this before surgery
Good booklet with easy-to-understand information for all ages
Good explanation of nerve sensors

nervous system and the brain's processing of pain and nociceptive input.^{34,43} This approach is in direct contrast to prevailing biomedical models focusing on tissues and tissue injury.^{46,47} A recent survey of United States spine surgeons⁹ showed that 97% of spine surgeons use anatomical spine models in their preoperative education, thus using an anatomy- and pathoanatomy-based model explaining pain to patients.^{46,47} Not only have these models shown limited efficacy in decreasing pain and disability, but also, they may, in fact, have increased fear in patients, which in turn may increase their pain.^{48,49} Although neuroscience education features an anatomical component (anatomy of the nervous system), it deemphasizes tissue injury (i.e., disc or joint),³⁴ rather using the anatomy to describe pathways to process nociceptive input.⁴³ A key message that neuroscience education tries to impart to the patient is a clear difference between nociception and pain. Patients are taught that the nervous system has the ability to increase or decrease its sensitivity (neuroplasticity via peripheral and/or central sensitivity) to help them cope with the injury, surgery, and recovery.^{34,43} Considering that other educational models use similar education delivery methods as neuroscience education does, it could be argued that the content of neuroscience education may be the key element as to its efficacy compared with more traditional models of explaining pain to patients.^{33,34}

Although various definitions for pain are provided in the scientific literature,⁵⁰ patients often see pain as a measure of the health of their tissues.^{48,49} Pain is complex, and recent authors have highlighted the fact that pain could possibly be a better measure of potential threat, rather than true tissue health.^{51,52} The larger the threat is, the higher the pain is perceived.⁴¹ Patients' pain perception due to tissue health is yet another example of an anatomy and pathoanatomy model driving pain. Considering that neuroscience education purposefully deemphasizes tissue injury and focuses on the processing of nociception with the aim to increase patient's awareness that nociception and pain do not correlate, it could be seen as a possible mechanism to decrease the threat, thus dampening the pain perception in the patient.^{41,53} Several studies have shown that patients with higher pain ratings have increased disability.⁵⁴⁻⁵⁶ Because patients view pain as an indicator of tissue health and the potential that activity may further damage their tissue and thus increase pain, decreased physical movements may be seen as a logical protective mechanism.⁵² The results from the systematic review⁴² suggest that with decreased pain perception and a greater un-

derstanding of nonmechanical factors that may increase or decrease nerve sensitivity (i.e., failed treatment, fear, emotions, and different explanations of their pain), patients may be inclined to see themselves as less disabled and more inclined to increase their activity.⁵⁴⁻⁵⁶ This result is the underlying premise of the preoperative neuroscience education program and accompanying booklet.

The development and use of booklets concur with patient education studies highlighting booklets as valuable tools in aiding information retention compared with verbal communication only.^{25,57} Booklets are cost-effective, simple, and a popular method of imparting healthcare information to patients.^{25,57} Booklets have also shown the ability to positively influence compliance,^{47,58,59} reduce anxiety,¹⁷ and empower patients.^{59,60} The current booklet was developed according to established principles: an extensive review of the literature searching for best evidence; careful synthesis into patient-centered messages; ensuring that text, messages, and images were appropriately designed; and evaluation by an expert panel (representative of preoperative education, surgery, and pain science), postoperative back surgery patients, and a community sample. This booklet is intended to be an adjunct to a preoperative neuroscience education program developed to be delivered in a one-on-one educational format by physical therapists for patients before undergoing lumbar surgery for radiculopathy to supplement verbal communication. It can, however, be used as a template for the verbal one-on-one educational program, allowing for more consistency in the message delivered to patients.

CONCLUSIONS

This study reports on the development of a preoperative neuroscience education program for use in patients with lumbar radiculopathy who are ready to undergo spinal surgery for their condition. It is hoped that use of this program will lead to improved outcomes after surgery in terms of postoperative pain and disability. Further research into the use of this program is required, and two pilot studies are currently being conducted to measure the effect of the preoperative neuroscience education program: a small case series measuring the immediate effects on pressure pain thresholds, physical movement (trunk flexion, straight leg raise), pain ratings, and anxiety before and after education and a single-case design pre-educational and posteducational session functional magnetic resonance imaging. Furthermore, more rigorous

evaluation of the preoperative neuroscience education program is planned as a multicenter randomized controlled trial in a group of patients undergoing lumbar surgery for radiculopathy.

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Appendix 6

Questionnaire for expert panel evaluation of the preoperative neuroscience educational tool

Letter to the expert panel: Booklet reviewUNIVERSITEIT
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To whom it may concern:

PRE-OPERATIVE EDUCATION BY SPINE SURGEONS IN THE US FOR LUMBAR SURGERY

The above mentioned title is the subject of a research project as part of the PhD course in Physiotherapy, at **Stellenbosch University** in Cape Town, South Africa. The primary researcher is a practicing physical therapist and faculty member at a physical therapy school in the US.

You have been selected by the researchers due to your experience and expertise in treating patients who undergo spinal surgery.

Since the results of this study have the potential to positively influence the field of physical therapy, spinal surgery, spine surgeons and most importantly patients undergoing lumbar surgery, you are invited to help with the review of a recently developed preoperative NEUROSCIENCE educational program for patients who are getting ready to undergo spinal surgery for radiculopathy. This booklet can best be summarized as merger of the current best-evidence on (i) neuroscience education for spinal pain and (ii) preoperative education for orthopaedic patients. We would ask that you review the booklet and complete the accompanying questionnaire and please provide feedback to the researcher by completing the attached checklist before (DATE).

Thank you for your time and participation

Adriaan Louw, PT, MSc (physio)

Dr. Ina Diener, PT, PhD

David Butler, B.Phty, GDAMT, M.App.Sc



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Booklet Questionnaire

Dear Participant,

Thank you for agreeing to participate in the evaluation of the preoperative neuroscience booklet. It is extremely important in the development of the booklet to get feedback from patients and professionals on the content and presentation.

The booklet is designed to give clear messages on what to expect from spinal surgery as a means to reduce the “threat value” of the impending surgery.

What to do now

- **Read *the booklet***
- **Complete the evaluation questionnaires**
- **Put questionnaires in the pre-paid envelope and post back to Adriaan Louw at International Spine and Pain Institute**

Thank you for your participation in this important stage in the development of this booklet. Your views are important.

Yours sincerely

Adriaan Louw, PT, MSc (physio)

Dr. Ina Diener, PT, PhD

David Butler, B.Phty, GDAMT, M.App.Sc

Preoperative Neuroscience Education Booklet – evaluation

Please check **one** box in each question which describe your reactions to the booklet

1. It was very easy to read
It was quite easy to read
It was difficult to read

2. I found it interesting
I found it boring

3. I thought the information was clear
I thought the information was not very clear
I thought the information was muddled

4. I learned some new, helpful things
I knew most of it anyway
I didn't really find it helpful

5. It is too long
It is too short
It is about right

6. I believed most of what it said
I believed some of what it said
I did not really believe any of it

7. I wanted more information about the operation
I wanted less information about the operation

- 8. **I wanted more practical tips**
- There are enough practical tips**
- The practical tips were not clear**

- 9. **The order of the contents was easy to follow**
- The contents seemed jumbled**

- 10. **I would tell a friend or family member to read**
- I would not recommend the booklet**

- 11. **I think it will help people**
- I don't think it will help people**

Please complete these questions – which are designed to explore your own ideas. Bear in mind that the final booklet will have helpful illustrations.

1. What are the 3 most important messages in the booklet for you?

.....

.....

.....

2. Are there any messages in the booklet which you do not like?

.....

.....

3. List any parts of the booklet you found difficult to understand

.....
.....

4. Is there anything the booklet didn't cover that you think it should?

.....
.....

5. How do you think this booklet will change what you do after spinal surgery?

.....
.....

6. Would you look back at the booklet from time to time, to check what to do?

.....

7. Overall rating out of 10?

.....

8. Any other comments?

.....
.....

Appendix 7

Surgeon invitation letter to participate in the RCT

Dear Dr.

Thank you for reviewing this letter.



We are conducting a randomized controlled trial of **pre-operative neuroscience education for patients undergoing spinal surgery for lumbar radiculopathy** and were hoping you would have an interest in helping us with patients for the study.

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I am PhD student (clinical neuroscience) and we have spent the last 2 years developing a preoperative education program for patients with lumbar radiculopathy aimed at providing them with a greater understanding of their pain experience and explaining nerve sensitivity to them. The aim of the program is the help patients recover better after lumbar surgery compared to usual care. The development phases of the program has been completed and submitted and accepted for publication in journals such as *Archives of Physical Medicine and Rehabilitation*, *International Journal of Spine Surgery* and *Physiotherapy Theory and Practice*.

I just presented at the **NASS conference** in Park City Utah on the development of this program and am thus excited to work with surgeons to complete the process.

Our final phase, a multi-centre, multi-clinician randomized controlled trial is now ready and we need your help. One of our sites is in Des Moines IA – other sites include Kansas City, Boise ID, Dallas TX, Las Vegas NV and North Carolina. We will gladly add a site in [LOCATION] if you are interested in participating in the experimental group.

- The study consists of 80 patients in total, with 40 in the experimental group (EG) and 40 in the control group (CG). Patients will be randomized (computer generated numbers) to either receive:
 - Usual care – information, pamphlets, instructors by the surgeon and his staff
 - Preoperative neuroscience education – our pre-op program (See addendum) as well as usual care
- We need surgeons to provide us with patients scheduled for lumbar surgery for radiculopathy (pain at least below the knee). (We are also including spinal stenosis as long as the patient has pain into the legs, below the knee and not only neurological deficit).
- We need the surgeon and/or his nurse to inform the patient they are involved in a study examining education prior to surgery and the surgeon would like the patient to go ahead and schedule the visit (see patient note).
- Patients will be asked to attend a single physical therapy visit. Patients **WILL NOT** be charged for the therapy session.
- Patients will call a number and set up the session. The session will consist of:
 - Usual care: Come to the designated therapy clinic and complete all intake forms (demographics, Oswestry Disability Index, Neurophysiology pain questionnaire, pain rating, fear-avoidance beliefs questionnaire, pain catastrophization scale and attitudes regarding surgery). Patients will be instructed that they will receive reminders via e-mail and phone by an independent research assistant at 1, 3, 6 and 12 months after surgery reminding them to complete their surveys.

- Experimental group: Same as usual care, except patients will attend one educational session with a therapist trained in the pre-op pain program for a one-on-one educational session and be given a copy of the booklet designed for the study.
- The preoperative neuroscience program IS NOT designed to have patients reconsider undergoing surgery, but rather encourage them to embrace the decision, understand more about how nerves increase sensitivity, how the surgical experience influence nerve sensitivity and that some pain after surgery is expected and will over time decrease (See addendum on topic discussed).
- The study has been approved by the Committee for Human Research at Stellenbosch University and will be conducted according to the ethical guidelines and principles of the international Declaration of Helsinki, common rule.
- The ultimate goal of the program is to help patients recover better from lumbar surgery.

Thank you for your consideration

Adriaan Louw, PT, M.App.Sc (physio), GCRM, CSMT

Ina Diener, PT, PhD

David Butler, PT, M.App.Sc (physio), GDAMT, EdD

Example: Script for 1 time physiotherapy visit preoperatively

Dear patient

You are scheduled to undergo spinal surgery for leg pain in the next few weeks. At [clinic name] we aim to provide the highest quality of care for our patients.

We are currently working with researchers on the development of a new education program aimed at helping you prepare for your surgery. We would ask that you consider attending a 1-time educational session at a physical therapy office before the operation. Please call the number below and get scheduled for an appointment as soon as possible. The session will take 90 minutes and **YOU WILL NOT BE CHARGED FOR THE ONE-TIME PHYSICAL THERAPY VISIT**. The therapist listed below is part of a research project evaluating the education material provided to patients before undergoing spinal surgery for leg pain. If you have any questions – please feel free to contact us.

[Surgeon name and clinic details]

Adriaan Louw, PT, M.App.Sc (physio), GCRM, CSMT: (816) 225-8710 or (515) 733-2699

SPINE SURGERY GROUP

Preoperative education for lumbar surgery

1 visit

Dr. XXXXXXXX

[Surgeon signature]

Preoperative Neuroscience Education Program

** The verbal educational program is supplemented with a booklet. The booklet is completed and the development of the program has been submitted for publication to Spine.

The program is based on a systematic review of 8 randomized controlled trials on neuroscience education for spinal pain. The evidence for such education is high and it has been shown patients are able to understand neurobiology concepts and healthcare providers underestimate patients' ability to grasp such concepts (Louw, A et al – accepted for publication Archives of Physical Medicine and Rehabilitation 2011).

The program covers:

- The Decision To Have Back Surgery
 - The decision has been made
 - No second-guessing
 - Taking control of the situation and helping themselves
- The Nervous System
 - Continuous nature
 - Electrical activity in nerves
 - Up-regulation and down-regulation of nerves during injury and recovery (action potentials)
- The Nerves and Back
 - Back injury resulting in increased nerve sensitive to protect and activate the alarm system
 - Nerve sensors – ability of nerves to become sensitive to stimuli such as cold, movement, altered blood flow, etc. (ion channels)
 - Anxiety and stress associated with undergoing surgery wakes up nerves a little more
 - Environmental and social issues effect on nerve sensitivity, i.e. fear.
 - Spreading nerve sensitivity to adjacent areas – quite normal and expected
- Surgery and Nerves
 - Physical properties of nerves in regards to need for space and blood flow
 - Surgery widening the spaces around nerves
 - Nerves may stay a little sensitive after the surgery, which is expected
 - Taking patient through the various hospital experiences such as admissions, anaesthesia, surgery, recovery room, etc. and how it effects the sensitivity of the nerves in the back and leg
- Calming Nerves Down
 - Strategies to help nerves calm down, including knowledge, aerobic exercise and medication
 - Modulation of pain by the brain via descending inhibition, which is enhanced by knowledge and decreased fear and anxiety
- Recovery After Surgery
 - Knowledge is important in recovery
 - Movement is essential
 - Nerves may be sensitive after surgery and will ease off over time

Appendix 8

An example of a preoperative procedural instruction sheet

General preoperative information leaflet: Kansas City Neurosurgery



4400 Broadway, Ste. 510 • Kansas City, MO 64111 • (816) 561-4655
 2750 Clay Edwards Dr., Ste. 410 • Kansas City, MO 64116 • (816) 471-8114
 6675 Holmes, Ste. 420 • Kansas City, MO 64131 • (816) 333-6663

LUMBAR MICRODISCECTOMY - HOME INSTRUCTIONS

We encourage you to relax about the home for the first few days, up as you can tolerate. After this time you may begin a walking program, start slowly with a short goal of a few blocks. Gradually increase your walking distance and time over the next few weeks. Depending on your pre-op condition you should be walking about 1 mile comfortably by the time you are seen at your one-month follow up visit.

As you start your walking program it is not uncommon to have recurrent pain down the leg again. The nerve has a bit of memory of the disc compressing it and it will take several weeks for this pain to decrease. The pain should be less intense than the pre-surgery pain, if not you may need to stop your current walking regimen for several days and let the nerve ease up then start again slowly.

No lifting, pushing or pulling on anything weighing more than 10 lbs (one gallon of milk) for the first month. No sitting longer than 30 minutes for the first 3-4 weeks. No prolonged stooped positions such as vacuuming or mopping for the first month. No running, biking, skiing, swimming or golfing until released to do so by the physician.

You may shower, however, avoid direct water pressure on the incision. There is paper tape over the incision and the sutures are under the skin and will be absorbed over time. The tape will fall off over time, if it has not all fallen by the 10th day post op you may remove it.

You do not need to wear a dressing over the incision unless your clothing irritates it or there is a small amount of drainage and you need to protect your clothing. If you wear a dressing, you will need to change it after each shower to keep the incision dry.

You may drive when comfortable, and are able to respond quickly in traffic. You may ride in the car as tolerated. You may need to take frequent rest stop breaks. A small pillow at the small of the back lends additional support when driving or riding.

You may resume sexual relations when you feel comfortable.

Wean your pain medications off over the 1st month. You can take ibuprofen, naproxen sodium or other pain medications but no acetaminophen (Tylenol) while on prescription pain medications. You may use any topical agent such as icy hot or Ben-Gay to areas around the incision, but avoid the incision itself. You also may use ice or heat to the area muscles but again avoid the incision itself for 2 weeks. Heat and ice should only be used in 30 minute increments.

Notify our office of any changes in the wound, increase in redness, fever of more than 101.5, or non healing in the incision area.

You may return to work when you desire as long as you can work with the restrictions listed here. Otherwise we will discuss return to work issues when you are seen at your one-month appointment.

Appendix 9

Informed consent and information sheet regarding RCT

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PATIENT INSTRUCTIONS AND CONSENT

PARTICIPANT INFORMATION LEAFLET & CONSENT FORM

TITLE OF THE RESEARCH PROJECT: **Pre-operative neuroscience education for patients undergoing spinal surgery for lumbar radiculopathy**

REFERENCE NUMBER: N09/09/247

PRINCIPAL INVESTIGATOR: Adriaan Louw

ADDRESS: 618 Broad Street Story City, IA 50248 USA

CONTACT NUMBERS: (515) 733-2699 or (816) 225-8710

E-MAIL: adriaan@ispinstitute.com

FAX: (515) 733-2744

You are being invited to take part in a research project. Please take some time to read the information presented here, which will explain the details of this project. Please ask the study staff any questions about any part of this project that you do not fully understand. It is very important that you are fully satisfied that you clearly understand what this research entails and how you could be involved. Also, your participation is **entirely voluntary** and you are free to decline to participate. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw from the study at any point, even if you do agree to take part.

This study has been approved by the Committee for Human Research at Stellenbosch University **and will be conducted according to the ethical guidelines and principles of the international Declaration of Helsinki, common rule.**

What is this research study all about?

- *This study is a randomized controlled trial whereby you will receive a preoperative educational program that meet the approval of your surgeon. You randomly will receive one of two programs we are examining.*
- *This study is a randomized controlled trial of 50 patients getting ready to undergo lumbar surgery for radiculopathy (leg pain).*
- *The aim of this study is to determine the immediate effects of the educational program*

Why have you been invited to participate?

- *You have been chosen to participate in this study since you are scheduled for lumbar surgery for leg pain and have volunteered to be part of this study.*

What will your responsibilities be?

- *By agreeing to participate in this study, you will:*
 - *Receive some education regarding the impending surgery*
 - *Be asked to complete a few questions (paper questionnaires or online) regarding your pain and activities before and after receiving your education*
 - *Completing the questionnaires will take no more than 20 minutes.*

Will you benefit from taking part in this research?

- *There are no personal benefits by participating in this study. The aim of this study is to help improve the outcomes of spinal surgery.*
- *You will receive a \$25 gift certificate for your time.*

Who will have access to your personal records?

- *The only personal data we will ask for is to enable us to contact you and remind you it's time to complete your surveys. Each patient is identified by a research number corresponding to your personal information and will only be viewed and handled by an independent research assistant and not the primary researchers. Your surgeon and his staff will have no access to your answers.*

Will you be paid to take part in this study and are there any costs involved?

- *No you will not be paid to take part in the study.*
- *You will receive a \$25 gift certificate for your time.*
- *There will be no costs involved for you, if you do take part. You may be asked to schedule a one-time physical therapy visit prior to the operation to receive the educational session. **You will not be charged for the one-time physical therapy visit.***

Is there anything else that you should know or do?

- *You can contact the Committee for Human Research, Stellenbosch University, Cape Town, South Africa, at 011-2721-938 9207 if you have any concerns or complaints that have not been adequately addressed by the researchers.*
- *You will receive a copy of this information and consent form for your own records.*

Declaration by participant

By signing below, I agree to take part in a research study entitled pre-operative education for patients undergoing spinal surgery for lumbar radiculopathy.

I declare that:

- I have read or had read to me this information and consent form and it is written in a language with which I am fluent and comfortable.
- I have had a chance to ask questions and all my questions have been adequately answered.
- I understand that taking part in this study is **voluntary** and I have not been pressurized to take part.
- I may choose to leave the study at any time and will not be penalized or prejudiced in any way.
- I may be asked to leave the study before it has finished, if the study doctor or researcher feels it is in my best interests, or if I do not follow the study plan, as agreed to.

Signed at (*place*) on (*date*) 2011.

.....
Signature of participant

.....
Signature of witness

Declaration by investigator

I (*name*) declare that:

- I explained the information in this document to
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did/did not use a translator. (*If a translator is used then the translator must sign the declaration below.*)

Signed at (*place*) on (*date*) 2011.

.....
Signature of investigator

.....
Signature of witness

Appendix 10

Demographics sheet

Demographic information

Thank you for your participation in this study. Please provide the most appropriate answer to each question. Please complete ALL questions. There is no right or wrong answer. All information will be handled in confidence and no personal data will be collected.

1. What is your age? _____ years _____ months

2. What is your gender? _____ male _____ female

3. What is your ethnic background?

- African-American
- Hispanic
- White, non-Hispanic
- Asian
- Other: Please specify: _____

3. What is your educational background?

- Post-graduate education (Masters, doctorate, etc.)
- Graduate (Bachelors)
- High school
- Other. Please specify: _____

4. Which of the following describes your income best?

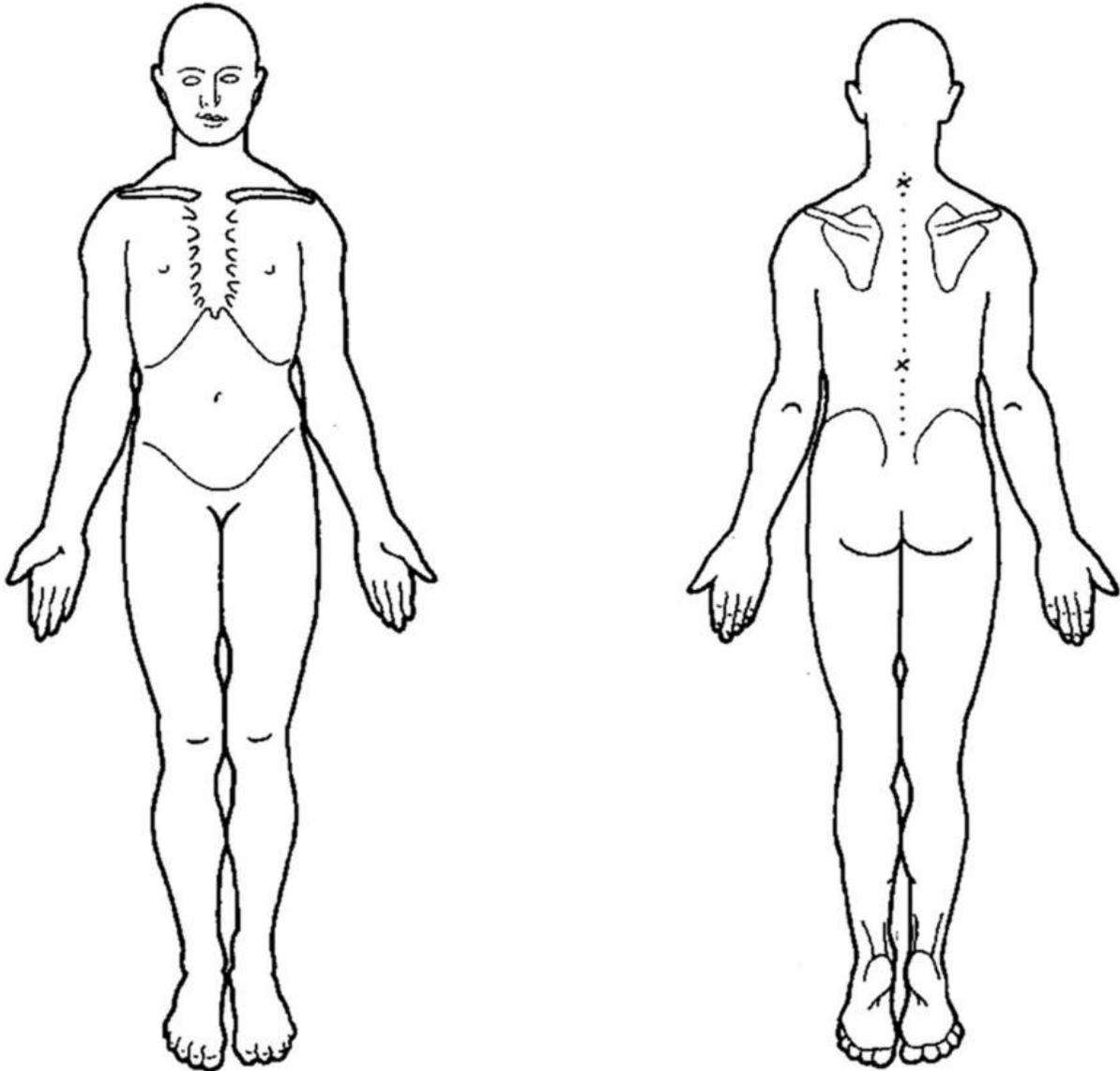
- Less than \$10 000 per year
- Between \$10 000 and \$50 000 per year
- Between \$50 000 and \$100 000 per year
- More than \$100 000 per year

6. What is the reason for your surgery? (Only choose one)

- Pain
- Numbness and/or pins and needles in the leg
- Decreased function and mobility
- Failed treatment
- Other: Please specify: _____

7. How long have you had the above symptoms (in question 6)?

8. In the body chart below, colour in the area where you experience your symptoms



9. Pain Rating

On a scale of zero to ten (0 – 10) with zero indicating no pain and ten indicating the worst pain you have ever experienced, please rate your pain at this time: _____

Date your surgery is scheduled for: _____

Contact information

Your contact information will be kept in a secure file and only be seen by a research assistant who will periodically remind you to complete your surveys after the operation. Your answers will not be shared with your surgeon or his staff. The collection of your personal data is only to make sure we can contact you about the surveys after surgery; therefore we will only ask for limited information.

First Name: _____

Last Name: _____

Phone number: _____

Alternate phone number: _____

E-mail address: _____

Mailing address (for your gift card and post-surgery surveys)

Appendix 11

Physician referral example for one time therapy visit for preoperative NE program

Script for 1 time physiotherapy visit preoperatively



Dear patient

You are scheduled to undergo spinal surgery for leg pain in the next few weeks. At Kansas City Neurosurgery we aim to provide the highest quality of care for our patients. It is our policy that patients who are scheduled for spinal surgery for leg pain attend a 1-time educational session at a physical therapy office before the operation. Please call the number below and get scheduled for an appointment as soon as possible. **YOU WILL NOT BE CHARGED FOR THE ONE-TIME PHYSICAL THERAPY VISIT.** The therapist listed below is part of a research project evaluating the education material provided to patients before undergoing spinal surgery for leg pain. If you have any questions – please feel free to contact us.

Kansas City Neurosurgery

Adriaan Louw (816) 225-8710



Preoperative education for lumbar surgery

1 visit


Stephen L. Reintjes, M.D.

Appendix 12

Preoperative NE tool questionnaire

PNET Questionnaire

Questions		True	False
1	The purpose of the PNET is to discourage patients to undergo surgery		
2	Remaining unsure about having surgery may result in a poorer surgical outcome		
3	The nervous system is usually calmed down by the process prior to the upcoming surgery such as seeing doctors, therapists and having tests.		
4	From an physiological and mechanical perspective, nerves locally need three things to perform at their best: space, movement and blood		
5	Surgery aims to open the spaces around the sensitive nerves and pain should thus be gone after surgery		
6	Hospital experiences after surgery such as hospital procedures, anaesthesia, different people and recovery is likely to increase nerve sensitivity a little		
7	Once the nervous system is “woken up” very little can be done to calm the nerves down		
8	By understanding more about their pain, and how pain works, increased patient knowledge can “calm the nervous system down.”		
9	Increased blood and oxygen around nerves increase sensitivity		
10	A wet brain describes a situation where the brain produces adequate amounts of chemicals able to calm the nervous system down in lieu of injury or surgery.		
11	Increased nerve sensitivity after surgery is abnormal and should alarm you something is wrong		
12	Periods of increased pain (“Flare up”) after surgery during progressive increased activity are common		
13	The depth of surgical incision and the number of tissues cut in lumbar surgery determines the level of pain		
14	Learning to cope with stress promotes recovery from lumbar surgery		
15	Increased pain indicates new tissue damage or the spread of existing damage		
16	Emotional stress can cause pain the absence of tissue damage		