SPINE Volume 30, Number 11, pp E293–E299

Centralization: Its Prognostic Value in Patients With Referred Symptoms and Sciatica

Lene Skytte, PT, Dip MDT,* Stephen May, MA, MCSP, Dip MDT, MSc,† and Peter Petersen, MD‡

Study Design. Prospective, comparative cohort study.

Objective. To investigate the prognostic significance of centralization in patients with subacute sciatica and referred symptoms.

Summary of Background Data. Previous studies have shown that centralization occurs commonly in the nonspecific low back population, and its occurrence is associated with a good prognosis. The phenomenon has never been evaluated in a population with sciatica and referred symptoms.

Methods. The sample pool was 104 consecutive patients referred for investigation of possible disc herniation. Of these patients, 60 were recruited into the study and underwent a standardized mechanical evaluation using repeated end-range movements, while symptom response was monitored to expose 2 groups: centralization group (CG) and noncentralization group (NCG). All patients were treated in the same way and were followed for one year. If patients did not have improvement surgery was considered. Outcomes included back and leg pain, disability, Nottingham Health Profile, and surgical outcome.

Results. There were 25 patients who were classified in the CG, 35 in the NCG, and other baseline characteristics were similar between groups. At 1, 2, and 3 months, the CG had significantly better outcomes than the NCG. At 2 months, the CG had more improvements in leg pain ($P = 0.007$), disability ($P = <0.001$), and Nottingham Health Profile ($P = 0.001$). After 1 year, disability was less in the CG ($P = 0.029$). In the CG, 3 patients underwent surgery, in the NCG, 16 ($P = 0.01$). The odds ratio for surgery in the NCG was 6.2.

Conclusion. Patients with sciatica and suspected disc herniation who have a centralization response to a mechanical evaluation will have significantly better outcomes. Patients who do not have centralization will be 6 times more likely to undergo surgery.

Key words: centralization, McKenzie, sciatica, prognosis, surgery. **Spine 2005;30:E293–E299**

Centralization is the process by which pain radiating from the spine is abolished in response to therapeutic positions or movements.[1] This happens in distal symptoms first and then proximal symptoms, and includes reduction and abolition of spinal pain. The phenomenon of centralization was first recognized by McKenzie in the 1950s and subsequently described in the literature.[2]

The phenomenon of centralization has been the subject of considerable research, and the literature on this topic has been recently systematically reviewed.[2] Fourteen studies were identified for this review,[3–16] and another study has subsequently been published.[17] The overall prevalence rate of complete or partial centralization in more 1000 patients was 70% in subacute and 52% in chronic back pain.[2] Centralization could be reliably detected during assessment; kappa values were 0.51,[10] 0.92, and 1.0,[13] 0.82, and 0.76 for graduate and student therapists,[8] and 0.7.[16] It was consistently associated with a range of good outcomes,[4,9,11–14]and conversely, failure to achieve centralization was associated with poor outcomes.[14] Thus, centralization may be a helpful symptom response to evoke during physical examination because it may expose both treatment strategies and prognostic predictors.

Previous studies investigating centralization have used a mixture of patients with spinal and referred symptoms. Patients with symptoms referred below the knee have comprised about half,[4,11] approximately 30% to 40%,[12] or approximately 20% or less of the study population.[3,5,7] No studies have specifically examined centralization in patients with sciatica and referred symptoms. Lisi[18] presented 3 case studies of patients with back pain, and signs and symptoms of sciatica. Of them, 2 had centralization and responded to conservative treatment; in one patient, no centralization occurred, and the patient underwent surgery after failure of conservative treatment. As far as these authors are aware, no published study has examined the centralization phenomenon in a patient cohort entirely with referred leg pain, including sciatica.

Patients with back pain with accompanying leg symptoms or sciatica have a poorer prognosis and are more disabled than those with back pain only.[19–32] Many patients who present with signs and symptoms of sciatica will respond to conservative treatment. However, for some patients, especially with more severe symptoms, surgery will provide a more rapid, early relief of symptoms.[33,34] The Cochrane review of surgery for lumbar disc prolapse concluded that there was strong evidence for the effectiveness of discectomy for patients with sciatica, as long as they were carefully selected and conservative treatment had failed.[35] Early identification of

From the *Fysioegaa Rehab Center, Egå, Denmark; †Sheffield Hallam University, Sheffield, United Kingdom; and ‡Randers County Hospital, Aarhus University, Aarhus, Denmark.
Acknowledgment date: March 10, 2004. First revision date: April 21, 2004. Acceptance date: September 28, 2004.
The manuscript submitted does not contain information about medical device(s)/drug(s).
Federal and Professional Organization funds were received in support of this work. No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subject of this manuscript.
Address correspondence and reprint requests to Mr. Stephen May, Faculty of Health and Wellbeing, Sheffield Hallam University, Cemetery Road S10 2BP, Sheffield, Yorkshire, S11 8FQ United Kingdom; E-mail: s.may@shu.ac.uk

those patients who will respond best to conservative or surgical treatment strategies is, therefore, desirable.

Unfortunately, no physical examination component used to identify a disc herniation has high diagnostic accuracy when used to identify suitable treatment.[36–39] Straight leg raising had high sensitivity (range 1.0−0.88), but low specificity (range 0.44−0.11); crossed straight leg raise had low sensitivity (range 0.44−0.23) but high specificity (range 0.95−0.86); and the sensitivity of other neurologic signs (reflexes, paresis, and impaired sensibility) varied from 0.82−0.04, while specificity ranged from 0.96−0.52.[36] The ability of any of these tests to determine whether conservative or surgical treatment is appropriate has not been shown.[40,41] Thus, when making treatment decisions, such as whether to recommend surgery, confirmatory tests are needed to select the appropriate treatment pathway. The purpose of this study was to evaluate the prognostic significance of the centralization phenomenon in patients with subacute sciatica using a prospective study design, particularly evaluating its prognostic value for determining whether surgical or conservative treatment was required.

■ Methods

Subjects. A prospective cohort study of patients with back and leg pain was conducted at the Rheumatology Department, Aarhus University Hospital, Aarhus, Denmark. Consecutive patients who met the inclusion and exclusion criteria on the days the therapist (L.S.) was in the department were entered into the study. The sample consisted of patients referred from primary care with the intention of investigation for suspected disc herniation between January 1998 and August 1998. Inclusion was based on unremitting referred symptoms in patients between 18 and 60 years old. Exclusion criteria were previous lumbar spinal operations, pregnancy, serious spinal pathology, other serious pathology, Danish was not the patient's first language, symptoms present for more than 14 weeks, and lack of consent. During the study, 114 patients were referred to the Rheumatology Department when the therapist was present and met the inclusion criteria. Fifty-four patients were excluded because of symptom duration more than 14 weeks (24), previous back pain surgery (17), coexisting serious pathology (4), cauda equina syndrome (2), pregnancy (1), language (2), and refusal to participate (4). The study was approved by the ethics committee of Aarhus County, Denmark.

Baseline Data. Baseline data that were gathered included the Nottingham Health Profile (NHP)[42] and Low Back Pain Rating Scale (LBPRS).[43] Demographic details were collected by self-report and included age, work and leisure activity, gender, previous episodes of back pain and sciatica, marital status, duration of current episode, sick leave for current episode, medication use, cause of onset, smoking and drinking habits, exposure to vibration, litigation status, and satisfaction with and beliefs about returning to work. Patients were also classified according to the Quebec Task Force (QTF) categories regarding the referral of symptoms.[44] This classifies symptoms as: QTF 1, back pain only; QTF 2, back and thigh pain; QTF 3, pain below the knee; and QTF 4, pain below the knee with positive neurologic signs (*i.e.*, focal muscle weakness, asymmetry of reflexes, or local sensory loss in one dermatome). The QTF system actually has more categories that represent results from imaging investigations (QTF 5−7), responses to treatment (QTF 8−10), and serious spinal pathology (QTF 11). The modified QTF classification system used here was deemed appropriate for this early stage of the investigation and treatment cycle when these patients were being categorized.[28]

Examination Procedures. Patients were then given a mechanical evaluation,[1] which included multiple direction repeated end-range lumbar spinal movements. The mechanical evaluation, which averaged 30 minutes, was conducted by a therapist (L.S.) with a diploma in mechanical diagnosis and therapy, the highest level in the McKenzie educational program. The therapist was blinded to all medical notes and imaging studies. After the mechanical evaluation, patients were classified as either "centralizers" or "noncentralizers," according to preestablished criteria.

Classification. Following the mechanical evaluation, patients were classified by the following criteria according to the therapist's judgment:
Centralization Group (CG):

1. The most distal pain referred from the spine was abolished in response to the mechanical evaluation.
2. The change in pain location remained afterwards when the patient returned to the neutral position.

Noncentralization Group (NCG):

1. No changes in location occurred during mechanical evaluation, or
2. Location of pain changed to a more distal location during mechanical evaluation.

Treatment. Treatment followed a routine structure (Figure 1) that was unaffected by the study, and all staff were blinded as to the patient's CG or NCG classification. The therapist who conducted the mechanical evaluation was not involved in the subsequent treatment. Decisions were made according to clinical presentation at both initial medical assessment and at a follow-up medical assessment at 2 weeks (Figure 1). Thus, initially, those patients with neurologic deficit were advised bed rest, those without were advised light mobilization. At review, those patients who had no improvement were sent for further investigations, while those with improvement were discharged, as long as improvement continued. If a disc herniation was found on imaging studies at the appropriate level with the clinical presentation, surgery was advised; if not, the patient was discharged back to his/her primary care physician with advice for "watchful waiting."

Outcome Measures. The NHP[42] is a generic health measure with 6 sections relating to energy, pain, emotional reactions, sleep, social isolation, and physical mobility. There are a total of 38 items to which the patients provide a dichotomous response, with higher scores representing poorer general health. The total was given in percentage terms.

The LBPRS[43] consists of pain, perceived disability, physical impairment, and medication intake measures. This scale was designed to monitor the outcome of clinical trials of low back treatment, it can be used as a postal questionnaire, and has been validated and shown to be reliable.[43] The modified scale for postal questionnaires was used, which omits measures of

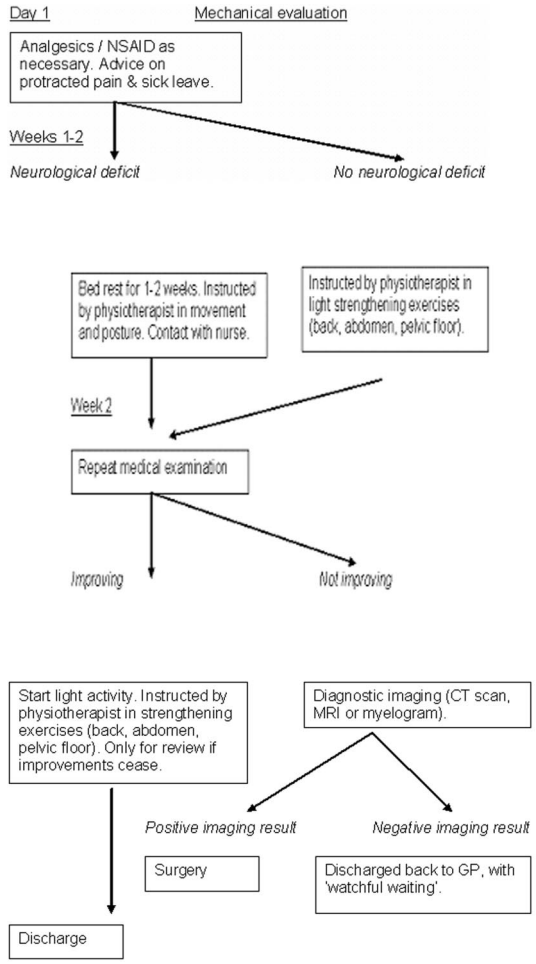

Figure 1. Flow diagram of treatment study. CT = computerized tomography; GP = general practitioner; MRI = magnetic resonance imaging.

physical impairment. For symptoms, the scale includes back and leg pain (each 0−10 points) at the moment, the worst back and leg pain (each 0−10 points) during the last 2 weeks, and the average back and leg pain (each 0−10 points) during the last 2 weeks. The possible total and the worst pain thus being 30 each for back and leg pain. Disability is measured by the patient's response to 15 questions about his/her ability to perform different tasks: "yes" (0 points), "can be trouble" (1 point), or "no" (2 points). In total, 0−30 points, with the highest score representing higher disability; this was transferred into percentage scores. Medication usage was recorded and scored 0−10, as follows: 0 = no medication during a week; 2 = nonsteroidal anti-inflammatory drugs or simple analgesics up to 4 times a week; 4 = nonsteroidal anti-inflammatory drugs or simple analgesics more than 4 times a week; 8 = opioid analgesic up to 4 times a week; and 10 = opioid analgesic more than 4 times a week.

Outcomes were measured by postal questionnaires at 1, 2, 3, 6, and 12 months after the initial evaluation. Changes in NHP and LBPRS (back pain, leg pain, and perceived functional disability), as well as days off from work, medication use, and the need for surgery were compared between centralizers and noncentralizers.

Statistical Analysis. Outcome data were analyzed by the repeated measurement of analysis of variance using SAS software (version 8e, Proc Mixed, SAS Institute, Cary, NC). The CG and NCG were compared regarding changes over time for 4 variables: NHP, disability on the LBPRS, back pain, and leg pain. The repeated measurement of analysis of variance was used to detect differences in improvement over time between the 2 groups during the conservative treatment regime. To ensure that the assumptions required by repeated measurement analysis were fulfilled, the data (x) were transformed by 1n (x + 10). The variance-covariance matrix was chosen to be unstructured because assumptions about equal variance at different times, and/or equal covariance or correlations between times were not justified. Statistical significance was set at 0.05. Because the data were skewed, median figure, with 95% confidence intervals, was used as the measure of central tendency. All the patients were included in the analysis as long as they had not undergone surgery; from the time of surgery, no further data from these patients were included because they were no longer in the conservative treatment regime. The Fisher exact test was used to determine differences in surgery rates between the groups.

■ Results

Sixty patients were included in the study; mean age was 44 years, 58% were men, 82% were working, and 60% were on sick leave. The mean length of symptom duration was 55 days, 93% of patients had pain below the knee, and 70% had neurologic signs or symptoms (Table 1).

According to the initial mechanical evaluation, 25 (42%) patients were classified as "centralizers" and 35 (58%) as "noncentralizers." The 2 groups did not differ significantly on any of the baseline measurements (Table 1). Follow-up data were obtained at 1, 2, 3, 6, and 12 months as 90%, 88%, 93%, 95%, and 92%, respectively.

There were significant differences between the CG and NCG for NHP, disability, and leg and back pain at various times, especially during the first few months. The differences between the groups were most evident in the 2 measures of disability, which showed significant differences at 1, 2, and 3 months, and also at 12 months in the disability component of LBPRS (Figure 2, Table 2). Differences in leg pain were significant at 2 and 3 months (Figure 3, Table 2), and differences in back pain were significant only at 3 months. The most marked difference in disability was at 2 months: CG 20%, NCG 42% ($P < 0.001$); the most marked difference in leg pain was at 3 months: CG 5.2, NCG 10.9 ($P = 0.005$).

Three (12%) patients from the CG and 16 (46%) from the NCG underwent surgery during the follow-up ($P = 0.01$). The odds ratio for surgery in the NCG was 6.2. The sensitivity of the NCG for predicting surgery was 0.84, specificity 0.54, positive predictive value 0.48, and negative predictive value 0.88. No significant differences were seen in medication usage or days on sick leave. After one year, one (4%) patient from the CG and 5 (14%) from the NCG were still out of work because of back or leg pain according to the patient's report, but this was not significant.

Table 1. Patient Characteristics at Initial Evaluation

Characteristics	No. of All Patients (mean ± SD)	No. of Centralizers (mean ± SD)	No. of Noncentralizers (mean ± SD)
Total number	60	25	35
Age (yrs)	44 (±11)	43 (±11)	45 (±11)
Females/males	25/35	11/14	14/21
Body mass index	25 (±4)	24 (±3)	26 (±5)
Married or cohabiting	45	20	25
Employed	49	20	29
Unemployed	5	3	2
Retired	6	2	4
QTF group 2/3/4	4/14/42	2/9/14	2/5/28
Patients with previous LBP	47	19	28
Patients with previous sciatica	22	11	11
Smoking: Yes/no	28/32	11/14	17/17
Sick leave because of LBP	36	14	22
Days on sick leave	21 (±22)	21 (±25)	21 (±20)
Symptom duration (days)	55 (±23)	53 (±25)	57 (±22)
Initial Scores			
LBP (0–30)	15 (±7)	15 (±6)	14 (±8)
Leg pain (0–30)	15 (±6)	14 (±6)	16 (±6)
Disability (%)	50 (±20)	45 (±21)	54 (±19)
NHP (%)	32 (±16)	29 (±17)	35 (±15)
Medication (0–10)	3 (±2.5)	2.4 (±2)	3.4 (±2.7)

LBP = low back pain.

■ Discussion

Previous studies have shown the prognostic value of the centralization phenomenon in acute and chronic nonspecific low back pain.[2] Previous studies have also shown the prognostic importance of mechanical and symptom responses for predicting if patients with sciatica will respond to conservative treatment.[40,41,45,] In those studies, roughly half the study samples had centralization and recovery of range of movement in response to mechanical evaluation. Most patients who had such a response went on to respond to conservative treatment. Conversely, those patients who did not have this response to a mechanical evaluation were much more likely to require surgery.

In the present study, a series of patients referred for investigation of suspected disc herniation were given a mechanical evaluation to determine how many had centralization. All patients were then given a standard conservative care package, regardless of centralization categorization, of "watchful waiting," involving rest followed by progressive activation. Failure to improve at any point led to further investigation before consideration for surgery. If patients were operated on, they were excluded from further data collection points because they were no longer under conservative treatment. During the subsequent year, there were several outcomes that were significantly better in the CG. In particular, disability and leg pain improved more quickly in this group. There was a significant difference in the rate of surgery between the groups with patients in the NCG 6 times more likely to require surgery.

The results show that centralization has prognostic importance in the population with sciatica for identifying a subgroup who will get better more quickly. Equally, the lack of centralization identified a group that resolved more slowly and were much more likely to need surgical intervention. Therefore, this phenomenon is an important examination finding that can be used to help determine if patients will require surgery when presenting with sciatica. Noncentralization had an acceptable sensitivity (0.84) but poor specificity 0.54. High levels of sensitivity are clinically important because a negative result, in this case centralization, effectively excludes the outcome,[46] in this case surgery. Similarly, the positive predictive value of noncentralization was poor (0.48), but the negative predictive value was high (0.88). In other words, centralization is a very good predictor of a nonsurgical outcome. Other potential prognostic factors, such as gender, straight leg raise, neurologic signs and symptoms, and smoking, were not significantly different between the groups. As in previous studies,[40,41] the response to mechanical evaluation was a better predictor of outcome than traditional orthopedic signs.

Psychologic factors have consistently been identified by previous studies as the most important factors explaining chronic low back pain and disability in nonspecific spine pain,[47,48] and important predictors of chronicity in patients with lumbar disc.[49] In the present

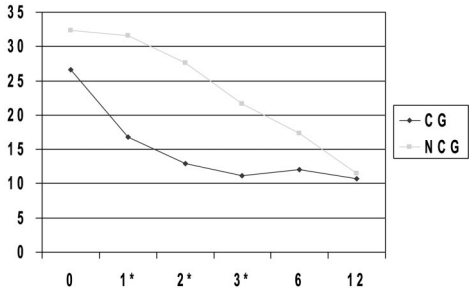

Figure 2. Median scores NHP in the CG and NCG at baseline, and 1, 2, 3, 6, and 12 months.

Table 2. Median Score (95% CI) for the CG and NCG

	Initial Baseline	1 Month	2 Months	3 Months	6 Months	12 Months
CG						
Disability (%)	43.2 (36.3,51.2)	32.3* (24,42.7)	20.2* (14.6,27)	20.1* (13.9,28.1)	18.1 (12.2,25.6)	15.5* (10.4,21.8)
Leg pain (0–30)	13.3 (11,16)	9.7 (7,12.8)	5.9* (3.7,8.4)	5.2* (3,7.8)	5.8 (3.6,8.4)	4.9 (2.6,7.7)
NCG						
Disability (%)	51.4 (44.7,58.9)	47.4* (37.7,59)	42.4* (33.2,53.6)	36.1* (27,47.5)	25.9 (18.4,35.5)	26.3* (19,35.5)
Leg pain (0–30)	14.9 (12.7,17.2)	13.1 (10.4,16.2)	11* (8.3,14.2)	10.9* (8,14.3)	6.6 (4.2,9.3)	6.9 (4.2,10.1)
P Values†						
Disability	0.118	0.037	<0.001	0.011	0.144	0.029
Leg pain	0.373	0.104	0.007	0.005	0.666	0.313

Note: All values are median (95% CI).
* Significant differences ($P < 0.05$).
† Differences between the CG and NCG at each point in time.

study, these issues were monitored with the NHP, which includes dimensions of energy level, sleep, social isolation, and emotional reaction. None of these factors were significantly different at baseline between the groups and, thus, were not helpful for predicting outcome. However, the NHP does not provide a comprehensive or structured analysis of psychologic factors. The NCG initially had more patients with category QTF 4, previous low back pain, and sick leave, and higher disability and NHP scores, but none of these differences were significant. So, initial differences between the groups are unlikely to be the explanation for the differences in outcome.

During the long-term, noncentralization was helpful for predicting whether patients underwent surgery, but other long-term outcomes showed few differences between the groups at either 6 or 12 months. Werneke and Hart [14] did find centralization/noncentralization predictive of a range of outcomes at 12 months, including pain intensity, return to work, disability, and further health care usage. Excepting one measure of disability at 12 months, none of these variables were significantly different at 6 or 12 months in this study. However, there was a trend toward less pain in the CG, and failure to achieve significant results may have resulted from a smaller sample size. Furthermore, those patients who underwent surgery, probably with higher levels of pain and disability, were excluded from further data collection after the failure of conservative treatment, which probably had the effect of reducing differences between the groups. The sample in that study[14] was acute, nonspecific back pain that was treated in a more individualized manner based on directional preference for movement, which may explain the different outcomes. Different operational definitions and outcome measures may have contributed toward differences.

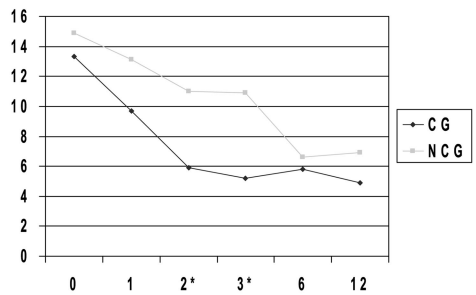

Figure 3. Median scores leg pain in the CG and NCG at baseline, and 1, 2, 3, 6, and 12 months.

The limitations of this study include a rather small sample and a rather high number of exclusions from the potential sample pool. However, most exclusions (76%) were related to 2 issues: symptom duration more than 14 weeks and previous lumbar spine surgery. The issue of duration and surgery identifies a particular group to whom these results may be generalized. It may be inappropriate to generalize these results to those patients with chronic sciatica without further research. Equally, it is unclear from this study if these same responses are found in those patients who have a previous history of surgery. The focus of this study was on the value of centralization; a multivariate test model should be used to compare this prognostic value with other known prognostic factors.

In normal practice following a mechanical evaluation during which a positive response is generated, the patient would be treated with those movements for which they had a directional preference.[1,5] In this study, patients were treated with a nonspecific strategy of unproven efficacy that may have had the effect of producing less distinct results between the groups. However, the study design blinded the treating staff to the groups, which excludes clinician bias as a source of the treatment effect. Future research is needed to ascertain if treatment using directional preference exercises and procedures is the most effective, especially during the long-term.

■ Conclusions

In a sample of patients with subacute sciatica or referred symptoms, nearly half had a centralization response. Those patients who had centralization at the initial evaluation had less disability and less pain up to 3 months later. At 6 and 12 months, there were smaller differences between the groups. However, patients in the NCG were at much higher risk for requiring surgery during that year. Although this was a small patient population, the

prognostic importance of centralization, shown in earlier studies with nonspecific back pain, in this study is extended to those with referred symptoms and neurology. The study further shows the prognostic importance of this clinical phenomenon. An appropriate mechanical evaluation should be included in the routine treatment of these patients. Additional research using appropriate study design is required to define the optimum conservative treatment of this patient group.

■ Key Points

- Patients with subacute sciatica or referred symptoms when exposed to a mechanical evaluation have centralization or noncentralization responses.
- Centralization commonly occurred in this group.
- Patients with centralization have better outcomes up to 3 months later regarding disability and leg pain.
- Patients with centralization are 6 times less likely to require surgical intervention compared to the NCG.
- Previous research has shown that initial centralization suggests a good prognosis in nonspecific back pain populations; this research shows the same interpretation in a specific back pain population.

Acknowledgments

The authors thank Ulrik Tarp, MD, Søren Holst, MD, Berit Schøittz-Christensen, MD, Ms. Kirsten Krogsdal, Lisbet Gerdes, RN, and Lene Andersen, PT, Department of Rheumatology, Aarhus University Hospital, for their help and practical support during the study.

References

1. McKenzie RA. *The Lumbar Spine. Mechanical Diagnosis and Therapy*. Waikanae, New Zealand: Spinal Publications; 1981.
2. Aina A, May S, Clare H. The centralisation phenomenon of spinal symptoms –A systematic review. *Man Ther* 2004;9:134–43.
3. Delitto A, Cibulka MT, Erhard RE, et al. Evidence for use of an extension-mobilisation category in acute low back syndrome: A prescriptive validation pilot study. *Phys Ther* 1993;73:216–28.
4. Donelson R, Silva G, Murphy K. Centralization phenomenon. Its usefulness in evaluating and treating referred pain. *Spine* 1990;15:211–3.
5. Donelson R, Grant W, Kamps C, et al. Pain response to sagittal end-range spinal motion. A prospective, randomized, multicentered trial. *Spine* 1991; 16:S206–12.
6. Donelson R, Aprill C, Medcalf R, et al. A prospective study of centralization of lumbar and referred pain. A predictor of symptomatic discs and annular competence. *Spine* 1997;22:1115–22.
7. Erhard RE, Delitto A, Cibulka MT. Relative effectiveness of an extension program and a combined program of manipulation and flexion and extension exercises in patients with acute low back syndrome. *Phys Ther* 1994; 74:1093–100.
8. Fritz JM, Delitto A, Vignovic M, et al. Interrater reliability of judgments of the centralization phenomenon and status change during movement testing in patients with low back pain. *Arch Phys Med Rehabil* 2000;81:57–61.
9. Karas R, McIntosh G, Hall H, et al. The relationship between nonorganic signs and centralization of symptoms in the prediction of return to work for patients with low back pain. *Phys Ther* 1997;77:354–60.
10. Kilby J, Stigant M, Roberts A. The reliability of back pain assessment by physiotherapists, using a "McKenzie algorithm." *Physiotherapy* 1990;76: 579–83.
11. Long AL. The centralization phenomenon. Its usefulness as a predictor of outcome in conservative treatment of chronic low back pain (a pilot study). *Spine* 1995;20:2513–21.
12. Sufka A, Hauger B, Trenary M, et al. Centralisation of low back pain and perceived functional outcome. *J Orthop Sports Phys Ther* 1998;27:205–12.
13. Werneke M, Hart DL, Cook D. A descriptive study of the centralization phenomenon. *Spine* 1999;24:676–83.
14. Werneke M, Hart DL. Centralization phenomenon as a prognostic factor for chronic low back pain and disability. *Spine* 2001;26:758–65.
15. Williams MM, Hawley JA, McKenzie RA, et al. A comparison of the effects of two sitting postures on back and referred pain. *Spine* 1991;16:1185–91.
16. Kilpikoski S, Airaksinen O, Kankaanpaa M, et al. Interexaminer reliability of low back pain assessment using the McKenzie method. *Spine* 2002;27:E207–14.
17. Werneke M, Hart DL. Discriminant validity and relative precision for classifying patients with non-specific neck and back pain by anatomic pain patterns. *Spine* 2003;28:161–6.
18. Lisi AJ. The centralization phenomenon in chiropractic spinal manipulation of discogenic low back pain and sciatica. *J Manipulative Physiol Ther* 2001; 24:596–602.
19. Andersson GBJ, Svensson HO, Oden A. The intensity of work recovery in low back pain. *Spine* 1983;8:880–4.
20. Ben Debba M, Torgerson WS, Long DM. A validated, practical classification procedure for many persistent low back pain patients. *Pain* 2000;87:89–97.
21. Carey TS, Garrett JM, Jackman AM. Beyond the good prognosis. Examination of an inception cohort of patients with chronic low back pain. *Spine* 2000;25:115–20.
22. Chavannes AW, Gubbels J, Post D, et al. Acute low back pain: Patients' perceptions of pain four weeks after initial diagnosis and treatment in general practice. *J R Coll Gen Pract* 1986;36:271–3.
23. Cherkin DC, Deyo RA, Street JH, et al. Predicting poor outcomes for back pain seen in primary care using patients' own criteria. *Spine* 1996;21:2900–7.
24. Goertz MN. Prognostic indicators for acute low-back pain. *Spine* 1990;15: 1307–10.
25. Hagen KB, Thune O. Work incapacity from low back pain in the general population. *Spine* 1998;23:2091–5.
26. Lanier DC, Stockton P. Clinical predictors of outcomes of acute episodes of low back pain. *J Fam Pract* 1988;27:483–9.
27. Leclaire R, Blier F, Fortin L, et al. A cross-sectional study comparing the Oswestry and Roland-Morris functional disability scales in two populations of patients with low back pain of different levels of severity. *Spine* 1997;22:68–71.
28. Loisel P, Vachon B, Lemaire J et al. Discriminative and predictive validity assessment of the Quebec Task Force classification. *Spine* 2002;27:851–7.
29. Muller CF, Monrad T, Biering-Sorensen F, et al. The influence of previous low back trouble, general health, and working conditions on future sick-listing because of low back trouble. *Spine* 1999;24:1562–70.
30. Selim AJ, Ren XS, Fincke G, et al. The importance of radiating leg pain in assessing health outcomes among patients with low back pain. *Spine* 1998; 23:470–4.
31. Smedley J, Inskip H, Cooper C, et al. Natural history of low back pain. A longitudinal study in nurses. *Spine* 1998;23:2422–6.
32. Thomas E, Silman AJ, Croft PR, et al. Predicting who develops chronic low back pain in primary care: A prospective study. *BMJ* 1999;318:1662–7.
33. Atlas SJ, Deyo RA, Keller RB, et al. The Maine Lumbar Spine Study, Part II. 1-year outcomes of surgical and nonsurgical management of sciatica. *Spine* 1996;21:1777–86.
34. Postacchini F. Results of surgery compared with conservative management for lumbar disc herniations. *Spine* 1996;21:1383–7.
35. Gibson JNA, Grant IC, Waddell G. The Cochrane review of surgery for lumbar disc prolapse and degenerative lumbar spondylosis. *Spine* 1999;24: 1820–32.
36. Van den Hoogen HMM, Koes BW, van Eijk JTM, et al. On the accuracy of history, physical examination, and erythrocyte sedimentation rate in diagnosing low back pain in general practice. A criteria-based review of the literature. *Spine* 1995;20:318–27.
37. Andersson GBJ, Deyo RA. History and physical examination with herniated lumbar discs. *Spine* 1996;21:24S.
38. Deville WLJM, ven der Windt DAWM, Dzaferagic A, et al. The test of Lasegue. Systematic review of the accuracy in diagnosing herniated discs. *Spine* 2000;25:1140–7.
39. Deyo RA, Rainville J, Kent DL. What can the history and physical examination tell us about low back pain? *JAMA* 1992;268:760–5.
40. Alexander H, Jones AM, Rosenbaum DH. Nonoperative management of herniated nucleus pulposus: Patient selection by the extension sign. Long-term follow-up. *Orthop Rev* 1992;21:181–8.
41. Kopp JR, Alexander AH, Turocy RH, et al. The use of lumbar extension in the evaluation and treatment of patients with acute herniated nucleus pulposus. A preliminary report. *Clin Orthop Relat Res* 1986;202:211–8.

42. Hunt SM, McEwen J, McKenna SP. Measuring health status: A new tool for clinicians and epidemiologists. *J R Coll Gen Pract* 1985;35:185–8.
43. Manniche C, Asmussen K, Lauritsen B, et al. Low back pain rating scale. Validation of a tool for assessment of low back pain. *Pain* 1994;57:317–26.
44. Spitzer WO, LeBlanc FE, Dupuis M, et al. Scientific approach to the activity assessment and management of activity-related spinal disorders. *Spine* 1987; 12:S1–55.
45. Brotz D, Kuker W, Maschke E, et al. A prospective trial of mechanical physiotherapy for lumbar disk prolapse. *J Neurol* 2003;250:746–9.
46. Sackett DL, Richardson WS, Rosenberg W, et al. *Evidence-Based Medicine. How to Practice & Teach EBM*. New York, NY: Churchill Livingstone; 1997.
47. Burton AK, Tillotson KM, Main CJ, et al. Psychosocial predictors of outcome in acute and subchronic low back trouble. *Spine* 1995;20:722–8.
48. Gatchel RJ, Polatin PB, Mayer TG. The dominant role of psychosocial risk factors in the development of chronic low back pain disability. *Spine* 1995; 20:2702–9.
49. Hasenbring M, Marienfeld G, Kuhlendahl D, et al. Risk factors of chronicity in lumbar disc patients. *Spine* 1994;19:2759–65.