Multidisciplinary intensive treatment for chronic low back pain: a randomized, prospective study

ANE F. BENDIX, MD; TOM BENDIX, MD, DMSc; KELD VÆGTER, MD; CHRISTINE LUND, PT; LONE FRØLUND, PhD; LILLIAN HOLM, OT

BACKGROUND Americans with low back pain have been helped to return to work by multidisciplinary intensive treatment programs. Whether this treatment method will succeed in countries with a more generous social welfare system, where the incentive to return to work might be less, is not proven.

OBJECTIVES To evaluate a Danish program of functional restoration combined with behavioral support.

METHODS Patients who had experienced at least 6 months of disabling low back pain were randomly assigned to either a 3-week intensive treatment program (n = 55) or an untreated control group (n = 51).

RESULTS Of the 106 patients randomized, 94 (89%) returned for a 4-month follow-up visit. At that time, 29 (64%) of the 45 treated patients were able to work, compared with 14 of 49 (29%) in the control group. The treated patients had used fewer days of sick leave ($P < .02$), had contacted health care professionals fewer times ($P < .001$), and had lower pain and disability scores.

CONCLUSIONS Although such programs are expensive, they can reduce pension expenditures, sick leave days, health care contacts, and pain.

INDEX TERMS: LOW BACK PAIN; PATIENT CARE TEAM
CLEVE CLIN J MED 1996; 63:62–69

From the Copenhagen Back Center, National University Hospital, Copenhagen, Denmark.
Address reprint requests to A.F.B., Medical Department TTA 7521, Tagensvej 20, DK-2200 Copenhagen N.

LOW BACK PAIN is extremely common: 8% to 10% of adults experience it daily.[1] Although most cases are self-limiting, the cost of sick leave, pensions, and treatment for this group is enormous, amounting to billions of dollars each year in the United States.[2,3]

Back pain is also a major economic problem in Scandinavia. In Sweden, days of sick leave and pensions awarded because of back pain have increased 40-fold over 30 years.[4] In Denmark, back pain costs the state approximately 6 billion kronen a year in the form of pensions, sick leave, treatment, and lost earnings. In 1990, it accounted for 17% of all social pensions allocated in Denmark, compared with "only" 11% in 1980.[5]

Many factors might explain this increase, including the uncoordinated treatment efforts of far too many medical and paramedical practitioners.[6] An increasingly sedentary life style may also contribute to this trend, although to a smaller extent.[7] Pathoanatomically, people's backs do not seem to have gotten any worse during the last decades,[8] but the threshold of unacceptable pain is presumably

much lower these days. Ongoing technological development has opened many new doors in the treatment system, leading to increased patient demands and expectations.

For many years, the most frequent treatments for back pain have been short-term and passive ones such as manipulation, chiropractic, injections, heat, bed rest, and massage. At best, these treatments provide a short-term effect,[9–14] and work best for patients with acute or subacute back pain.[15] However, the value of manipulation was recently questioned by Powell et al.[16] Surgery is effective in a small minority.[17,18]

Because ordinary treatment is not sufficient in patients with chronic low back pain, several years ago a new, more active approach was tried that features intensive physical training. Results showed that one must exceed the pain threshold and "overcome oneself" in training intensity.[19–21] Not even 2 hours a week of intensive training for a month seem adequate,[19] at least not for hard-working men.[22]

However, very often, we cannot find an organic explanation for disabling low back pain.[23–25] Complaints of chronic back pain often correlate poorly with apparent pathology[18,26] or with measured physical capacities and behaviors.[27–30] This observation suggests we ought not only to focus on the physical part of the pain, but to consider the problem as a biopsychosocial complex, all parts of which need to be addressed in treatment. In the United States, Mayer et al[31] first proved that intensive multidisciplinary intervention could get patients back to work, a finding corroborated by Hazard et al[20] and—in a modified program—by Sachs et al.[32] However, modified programs in Norway and Finland failed to get people back to work.[33,34] To our knowledge, no randomized, observer-blinded study has ever been conducted to test such an intensive multidisciplinary program for this very expensive, complex problem.

TABLE 1
BASELINE VALUES FOR PATIENTS
WHO EVENTUALLY RETURNED FOR FOLLOW-UP AT 4 MONTHS

Value	Treated group (n = 45)	Control group (n = 49)	*P* value*
Median age (years)	41	40	—
Men/Women	13/32	15/34	—
No. who could work	12 (27%)	8 (16%)	.22
Median days of sick leave in 3 years	340	370	.55
Median back pain score (scale 0–10)	6.1	6.1	.9
Median leg pain score (scale 0–10)	4.1	4.6	.8
Median functional score (scale 0–30)	16.9	15.9	.8
No. of smokers	26 (58%)	27 (55%)	.79
No. who took medication for back pain	36 (80%)	36 (73%)	.39
No. who had previous back surgery	7 (16%)	9 (18%)	.8

*By Mann-Whitney test

OBJECTIVE

The aim of this study was to determine whether a 3-week, full-time, multidisciplinary program would affect the return-to-work rate, the number of days of sick leave used, the number of contacts with health care providers, pain and disability levels, and isometric back-muscle endurance in patients with chronic low back pain.

METHODS

This parallel-group study was prospective and observer-blinded. After an initial medical examination, patients were randomly assigned to a treatment group or a control group according to the minimization principle[35] (a means of achieving an even distribution according to sex, age, pain and function scores,[36] days of sick leave, and smoking status in the two groups).

Patients

The study included 106 patients referred to the Copenhagen Back Center between May 1991 and May 1992. Subjects had to be 18 to 59 years in age, read and write Danish, have had at least 6 months of disabling low back trouble, and have a threatened job situation owing to back problems (most were on sick leave or did not have a job). Most of the patients had a degenerative disease of the disk

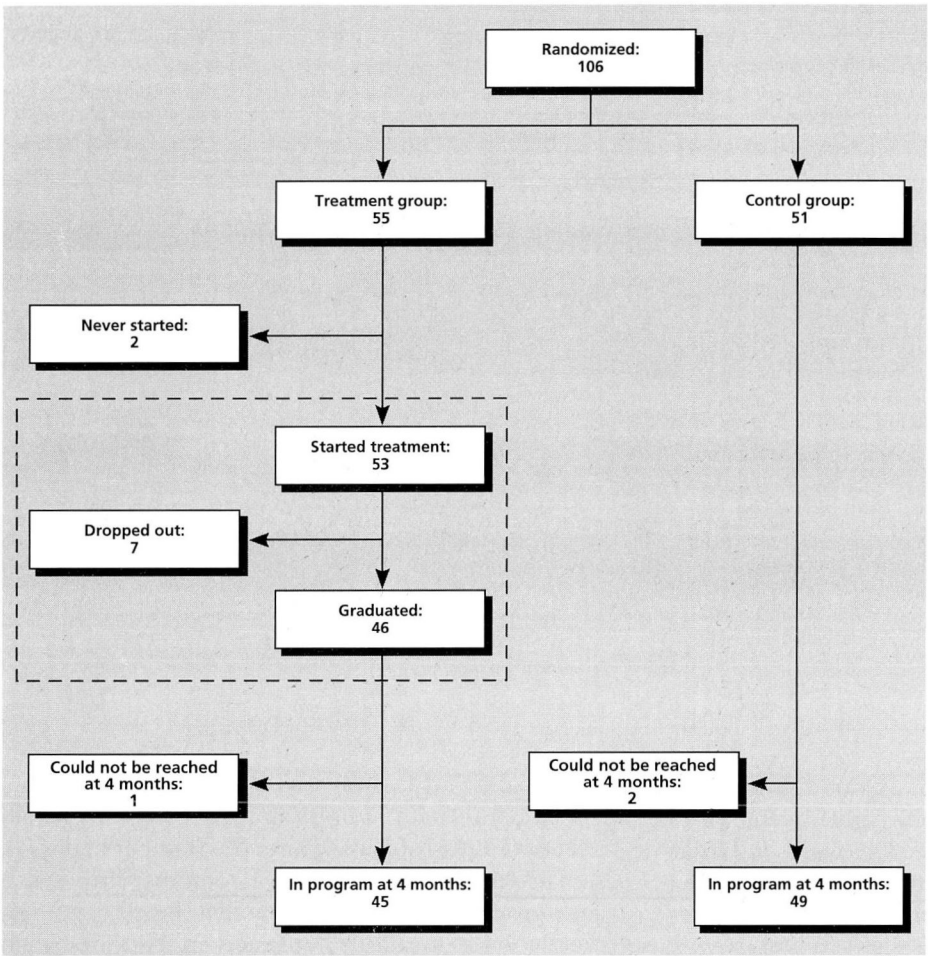

FIGURE 1. Patient flow from randomization until the 4-month follow-up examination.

or facet or both. Twelve patients (11%) had predominantly diskogenic back pain, characterized mainly by pain on forward bending or sitting and also by disk narrowing. Four of these patients had dark disks on magnetic resonance imaging at one level or more. None had undergone diskography. Several other patients also had such symptoms, but only as a part of a mixed clinical picture.

Another eight patients (8%) had facet joint symptoms as a predominant feature. Facet disease was diagnosed by extension pattern: back pain when raising from a forward-bending posture, pain on hyperextension in the standing posture, and a positive springing test (pain on manual hyperextension of each spinal segment), in combination with contralateral back pain on rotation and corresponding radiographic features. Eighteen patients (17%) had undergone disk surgery, and three had more than one operation. One patient had grade-1 spondylolisthesis, but without demonstrated instability on flexion and extension radiography.

Sciatica accounted for 29 (27%) of the patients, in most of whom the cause was probably an earlier herniation. However, only some of these patients had undergone myelography, computed tomography, or magnetic resonance imaging to confirm the herniation. The other patients had a wide variety of muscular or ligamental pain or sacroiliac joint symptoms. Moreover, many patients demonstrated one or more nonorganic signs, but we always considered such psychological aspects as supplemental to an organic problem.

Patients with any of the following were excluded: current disk herniation (which might be amenable to surgery or bed rest), other surgically remediable lesions, inflammatory disease of the back, pregnancy, cancer, or clinically relevant osteoporosis with or without fractures. People receiving social pensions were also excluded.

At baseline (*Table 1*), 12 (27%) of the 45 patients in the treatment group who eventually finished the program and returned for the 4-month follow-up were able to work (nine were working full-time, two were in school, and one was laid off). In the control group, eight of the 49 patients who returned for the 4-month follow-up had been able to work at baseline (five were working full-time, one was in school, and two were laid off). There were no significant differences between the two groups upon entering the project.

Figure 1 illustrates the flow of patients through the project. Two patients never started the treatment: one had a disk herniation while waiting, and one never appeared. Seven patients dropped out of

the program: one was strongly addicted to morphine, one could not accept the restrictions on smoking (which was only allowed outdoors), one felt the program was too difficult, one was found to have a neurologic disease, and three had increased back pain they could not accept. All the dropouts were on sick leave when they entered the program and did not differ from the graduates in any of the measured characteristics.

The project was blinded in that the physician who saw the patients for the initial examination and the 4-month follow-up did not know which group each patient was in. The same physician saw all the patients in both groups throughout the study. The blinding was broken in about 10% of the cases, equally distributed between the two groups, when patients disclosed this information during the follow-up examination.

Treatment

Our program was a modification of the functional restoration programs described earlier by Mayer[31] and Hazard.[20] The concept is described in detail elsewhere.[37] On the first day, the patients underwent various tests. Physical tests included dynamic and isometric endurance, lifting capacity, walking and running 400 meters, and standing and sitting tolerance. The psychological tests included the Millon Behavioral Health Inventory, the Million Pain Analog Scale, the Symptom Check List 90-R, the Therapeutic Alexithymia Scale (TAS), and the Vanderbilt Coping Questionnaire. A structured psychological interview was also carried out the first day.

Each patient participated for 39 hours per week for 3 successive weeks. The daily schedule is shown in *Table 2*. The aerobics class included training in cardiovascular fitness, muscular endurance, coordination, and stretching. This was followed by progressive strength and endurance training for all major muscle groups, using air-moderated machines and other training equipment. Occupational therapy consisted of simulated work situations, including lifting, pulling, pushing, sitting and standing workplaces, garden work, and kitchen work. Biofeedback was used in some of the sitting work situations.

The psychological treatment had a behavioral approach; patients were urged to take greater responsibility for coping with pain, set realistic personal goals, change the negative sensation of pain into a more positive way of living, and give themselves credit for their achievements. It included daily group therapy and relaxation and an average of one individual counseling session per week.

TABLE 2
PROGRAM SCHEDULE

Time	Activity
08:00–09:00	Aerobics
09:00–10:00	Weight training
10:00–11:30	Work simulation, work hardening
11:30–12:00	Lunch
12:00–12:30	Relaxation
12:30–01:30	Psychological group
01:30–02:00	Stretching
02:00–03:00	Theoretical class
03:00–04:00	Recreation

In the daily stretching classes, patients worked on all major muscle groups. Classes in spinal anatomy and pathology addressed each patient's condition and the topics of sexuality, pain, hobbies, nutrition, and medication. In a 3-hour job-analysis course, patients learned how to write an application and resumé, find out about job possibilities, and evaluate advertisements in light of their own abilities and skills. Recreation consisted of different games and physical training, such as ball games, walking, running, and swimming.

All training was carried out in groups of seven patients. Every Monday, two or three new patients started the program, and every Friday two or three patients "graduated." This group structure is essential, as the program is especially difficult during the first week. Patients in their third week inspire the "first-weekers" to endure and encourage them to continue. This also gives the "third-weekers" a responsibility and authority in relation to the beginners, which in turn increases self-confidence.

After graduating, patients underwent a follow-up program of 6 hours of psychological, physical, and ergonomic training, as described above, once a week for 3 weeks.

The control group

Patients randomized to the control group after the medical examination were not treated by us. They could go anywhere else for treatment, and as such they represent the "spontaneous" progress of patients with chronic back pain in Denmark.

TABLE 3
RESULTS AT 4-MONTH FOLLOW-UP

Value	Treated group (n = 45)			Control group (n = 49)			*P* value
	Median	IQR*	Range	Median	IQR	Range	
Contacts with health-care system	1.6	0.4–3.9	0–26	5.3	1.8–11.5	0–40	< .001
Days of sick leave	10	0–122	0–123	122	24.5–122	0–122	.02
Back pain (scale 0–10)	5.7	2.3–7.8	0–10	6.9	4.8–7.8	1–10	.05
Leg pain (scale 0–10)	3.5	0.3–7.0	0–10	5.4	3.0–7.3	0–10	.17
Function (maximum score 30)	12.1	7.2–16.8	0–23	16.8	13.1–20.1	7–25	< .001
Isometric back-muscle endurance (seconds)	38.0	16.0–88.0	0–260	13.0	2.8–33.0	0–112	< .001

*Interquartile range

Statistical methods

The baseline and 4-month values were compared in separate analyses using Mann-Whitney tests. Because more patients in the treated group were able to work at baseline, an additional Fisher-Irwin test was done for this parameter. The level of significance was defined as 5%.

RESULTS

The results are based on data collected at a follow-up examination at 4 months (the first Monday after 122 days after graduation). Each patient in the control group was matched at randomization with one in the treated group, so that the interval between the initial medical examination and the 4-month examination was identical.

Return to work

One of the major goals of the project was to prepare patients physically and psychologically to go back to work. "Workability" was defined as having a job, being in school, or seeking work.

At the 4-month follow-up, 29 (64%) of the 45 treated patients were able to work, compared with 12 (27%) at baseline; in the control group, 14 (28%) of the 49 patients were able to work at the time of the 4-month follow-up, compared with 8 (16%) at baseline. The difference between the two groups was significant ($P < .001$); the differences in the before and after values in the two groups were also significant ($P < .001$ by Fisher-Irwin test). Of the 29 patients able to work in the treated group, 17 had full-time jobs, seven were unemployed but seeking work, and five were in school. Of the patients in the treated group who could not work, six were receiving social pensions and the rest were still on sick leave. In the control group, 10 of the 14 patients able to work were working full-time, three were unemployed but seeking work, and one was in school. Eight persons in this group were receiving social pensions and the rest were on sick leave.

Health care, sick leave

The treated group contacted family doctors, specialists, physical therapists, chiropractors, or hospitals significantly fewer times than the control group did. They also used significantly fewer days of sick leave (*Table 3*).

Pain and function

Patients used a scale of 0 (no pain) to 10 (worst possible pain) to rate pain in the back and in the legs. After 4 months, the treated group had significantly less back pain than the controls, but they had no difference in leg pain (*Table 3*).

We assessed function with 15 questions about how much the back problem interfered with activities of daily living.[36] The possible answers were 0 ("no problem"), 1 ("might be a problem"), or 2 ("is a problem"). Thus, the maximum total score was 30. This test indicated that the treated patients were doing significantly better than the control patients (*Table 3*).

Isometric back-muscle endurance

We measured isometric back-muscle endurance with a test previously evaluated by Biering-Sørensen.[38] Patients were asked to assume the position shown in *Figure 2* and to hold it as long as possible, up to a maximum of 4 minutes and 30 seconds (the record in our program was 4 minutes and 20 sec-

onds). Four months after treatment, the treated group did significantly better in this test than the control group (*Table 3*).

Dropouts

Of the two patients who never started the treatment program and the seven who dropped out, only two could be contacted after 4 months. Therefore, these patients are not included in this analysis.

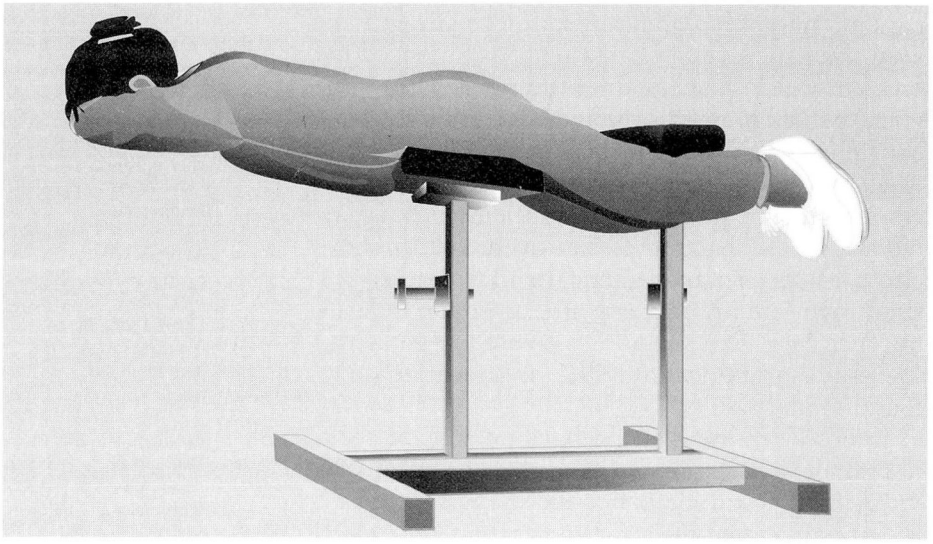

FIGURE 2. The Biering-Sørensen test for endurance of the back muscles.

DISCUSSION

Because the Scandinavian countries have a social system characterized by economic security in case of sickness or inability to work, one might hypothesize that our patients with back pain have less motivation to return to work than American patients do. In Denmark, some people may find being on social pension attractive, especially if they have low-paying jobs, as they can receive more money from a pension than from working. However, this study indicates that a functional restoration program for patients with chronic low back pain, designed and modified after programs developed and tested in the United States, can also be effective in a Scandinavian country. The program's effectiveness might be due to its influence on personal attitudes rather than to economic aspects. Unlike the US studies,[20,31] in which the control groups consisted of patients whose insurance would not pay for the special intervention, our study was randomized and had no potentially confounding financial aspect.

Previous Scandinavian studies that tested modified functional restoration programs did not show an effect on the return-to-work rate. Different circumstances may account for this. In the study from Norway,[33] the training lasted from 3 to 5 hours per day, which is less than in our study and the US studies. In addition, it consisted of passive treatment, whereas our functional restoration program stressed activity. Another key difference is self-responsibility: the patient should be responsible for his or her own situation, which is hard to combine with a passive treatment approach. Moreover, the Norwegian program did not have a clinical psychologist connected with it, although the patients could consult a psychiatric nurse if they wished. In our experience, many patients with chronic back problems do not appreciate the psychosocial aspects of the problem until they have started treatment. Presumably, some of the patients in the Norwegian study did not consult the psychiatric nurse at all. Also, there might be a difference between goal-related, daily pain management supervised by clinical psychologists and occasional consultations with a psychiatric nurse.

A very important concept in the original functional restoration programs is that of the multidisciplinary team. A team approach tells patients that physical disorders are not the sole cause of pain, and that they must change their attitudes and behavior. In the Finnish study,[34] the goal was not to get people back to work, but solely to improve their physical capacity. Therefore, the program did not include sessions with rehabilitation specialists. The authors state that their results might have been different if their goals had been different. Gatchel et al[39] emphasize the importance of the multidisciplinary approach and philosophy.

Pain reduction was not a major goal of our program. Such a goal would have been unrealistic, since these patients had longstanding pain, and the possibility of reducing or eliminating it would have been extremely small. However, after treatment, our patients did tend to have less leg pain and had significantly less back pain. In this kind of training,

patients must keep going in spite of pain and exceed the pain level. Most patients experienced increased muscle pain in the beginning of the program, but for most this resolved quickly in spite of continued training. The fear of re-injury diminished at the same time. Patients often avoid physical activity for fear of injuring themselves again, but with experience, they can overcome this psychological barrier and change their attitude. In our study, pain did not increase after training, indicating that back pain should not be used to guide the intensity of training. Rainville,[21] in a separate study, found similar results.

Intensive training and behavioral support seem to promote a better "back life." It may be possible to increase isometric endurance and strength, at least if the training continues for more than 6 weeks.[40] Most of our patients continued some kind of training during the 4 months after graduation, but at a less intensive level. However, psychological changes are also very important in managing pain in the long run, as also stated by Cooke et al.[40] Patients learn how to cope with pain and to function in spite of it, instead of letting the pain dominate their lives. This builds self-confidence, which may endure even if the intensity of training decreases.

Intensive, multidisciplinary treatment is expensive (approximately $5000 per patient), and should only be used for people with disabling back pain. On the other hand, back pain is also very expensive for society in terms of sick leave, pensions, and health care. Another study from the Copenhagen Back Center found less-intensive training programs ineffective.[41] These featured 2-hour outpatient sessions of active physical and psychological training twice a week for 6 weeks, and cost approximately $500 per patient.

In conclusion, this short-term follow-up study shows that patients with chronic low back pain can be helped. Only long-term follow-up, lasting 12 or 24 months, will show if these results continue, as has been the case in the United States. If so, the program will save money and, above all, improve the patients' quality of life.

ACKNOWLEDGMENT

The study was supported by the Danish Rheumatism Association, Nycomed-DAK, AP Møller og Hustrus Fond, Pensam, Assurandørsocietetet, Meyer's Foundation, Minister Erna Hamilton's Foundation, Direktør Ib Henriksen's Foundation, The Research Foundation of the Copenhagen University, Hafnia Foundation, Peter Ryholt's Foundation, Ingrid Munkholm's Foundation, Danish Society for Manual Medicine, Lily Benthine Lund's Foundation, and others.

REFERENCES

1. **Biering-Sørensen F.** Physical measurements as risk indicators for low-back trouble over a one-year period. Spine 1984; **9:**106–119.
2. **Federspiel CF, Guy D, Kane D, Spengler D.** Expenditures for nonspecific back injuries in the workplace. J Occup Med 1989; **31:**919–224.
3. **Spengler DM, Bigos SJ, Martin NA, et al.** Back injuries in industry: a retrospective study. I. Overview and cost analysis. Spine 1986; **11:**241–245.
4. **Nachemson A.** Back pain—a community problem [in Swedish]. The Swedish Council on Technology Assessment in Health Care, SBU Conference, Stockholm, 1990.
5. A statistical review about rehabilitation and pension decisions [in Danish]. The Danish Social Ministry. Copenhagen, 1991.
6. **Waddell G.** A new clinical model for the treatment of low back pain. Spine 1987; **12:**632–644.
7. **Riihimäki H, Sakari T, Videman T, Hänninen K.** Low-back pain and occupation. Spine 1989; **14:**204–209.
8. **Biering-Sørensen F, Bendix T, Jørgensen K, Manniche C, Nielsen H.** Physical activity, fitness and back pain. In: Bouchard C, Shephard R, Stephens T, et al, editors. Physical fitness and health: International Proceedings and Consensus Statement. Champaign, Windsor, Leeds, Kingswood, Auckland: Humanic Kinetis Publishers, 1994:737–748.
9. **Haldeman S.** Spinal manipulative therapy: a status report. Clin Orthop 1983; **79:**62–70.
10. **Gibson T, Grahame R, Harkness J, Woo P, Blagrave P, Hills R.** Controlled comparison of soft-wave diathermy treatment with osteopathic treatment in nonspecific low back pain. Lancet 1985: 1:1258–1261.
11. **Hadler N, Curtis P, Gillings D, Stinnett S.** A benefit of spinal manipulation as adjunctive therapy for acute low-back pain: a stratified controlled trial. Spine 1987; **12:**703–706.
12. **Deyo RA.** Conservative therapy for low back pain: distinguishing useful from useless therapy. JAMA 1983; **250:**1057–1062.
13. **Spitzer WO, LeBlanc FF, Dupuis M.** Scientific approach to the assessment and management of activity-related spinal disorders. Spine 1987; **12:**S1–S5.
14. **Koes B, Bouter L, Beckerman H, van der Heiden G, Knipschild P.** Physiotherapy exercises and back pain: a blinded review. Br Med J 1991; **302:**1572–1576.
15. **Blomberg S.** A pragmatic approach to low-back pain including manual therapy and steroid injections. Uppsala, Sweden: Acta Universitatis Uppsaliensis; 1993. Thesis.
16. **Powell FC, Hanigan WC, Olivero WC.** A risk/benefit analysis of spinal manipulation therapy for relief of lumbar or cervical pain. Neurosurgery 1993; **33:**73–78.
17. **Frymoyer JW.** Back pain and sciatica. N Engl J Med 1988; **318:**291–300.
18. **Haldeman S.** Presidential address, North American Spine Society: failure of the pathology model to predict back pain. Spine 1990; **15:**718–724.
19. **Mannicke C, Lundberg E, Christensen I, Bentzen L, Hesselsøe G.** Intensive dynamic back exercises for chronic low back pain: a clinical trial. Pain 1991; **47:**53–63.
20. **Hazard R, Fenwick J, Kalisch S, et al.** Functional restoration with behavioral support. A one-year prospective study of patients with chronic low-back pain. Spine 1989; **14:**157–161.
21. **Rainville J, Ahern DK, Phalen L, Childs LA, Sutherland R.** The association of pain with physical activities in chronic low back pain. Spine 1992; **17:**1060–1064.
22. **Hansen FR, Bendix T, Skov P, et al.** Intensive, dynamic back muscle exercises, conventional physical therapy or placebo-controlled treatment of low back pain: a randomized, observer-blind trial. Spine 1993; **18:**98–108.

23. **Hadler N.** Regional back pain. N Engl J Med 1986; **315:**1090–1092.
24. **White AA.** Synopsis: Workshop on idiopathic low back pain. Spine 1982; **7:**141–149.
25. **Wiesel SW, Feffer HL, Borenstein DG.** Evaluation of low back pain of unknown etiology. Spine 1988; **13:**679–680.
26. **Bigos SJ, Spengler DM, Martin NA, et al.** Back injuries in industry: a retrospective study. III. Employee-related factors. Spine 1986; **11:**252–256.
27. **Fordyce W, McMahon R, Rainwater G, et al.** Pain complaint-exercise performance relationship in chronic pain. Pain 1981; **10:**311–321.
28. **Mellin G, Hurri H, Harkapaa K, Jarvikoski A.** A controlled study on the outcome of inpatient and outpatient treatment of low back pain. Part II. Effects on physical measurements three months after treatment. Scand J Rehabil Med 1989; **21:**91–95.
29. **Romano JM, Syrjala KL, Levy RL, et al.** Overt pain behaviors: relationship to patient functioning and treatment outcome. Behavior Therapy 1988; **19:**191–201.
30. **Waddell G, Main CJ.** Assessment of severity in low-back disorders. Spine 1984; **9:**204–208.
31. **Mayer TG, Gatchel RJ, Mayer H, et al.** A prospective two-year study of functional restoration in industrial low back injury: an objective assessment procedure. JAMA 1987; **258:**1763–1767.
32. **Sachs BL, David JF, Olimpio D, Scala AD, Lacroix M.** Spinal rehabilitation by work tolerance based on objective physical capacity. Spine 1990; **15:**1325–1332.
33. **Oland G, Tveiten G.** A trial of modern rehabilitation for chronic low-back pain and disability. Spine 1991; **16:**457–459.
34. **Estlander AM, Mellin G, Vanharanta H, Hupli M.** Effects and follow-up of a multimodel treatment program including intensive physical training for low back pain patients. Scand J Rehabil Med 1991; **23:**97–102.
35. **Taves DR.** Minimization: a new method of assigning patients to treatment and control groups. Clin Pharmacol Ther 1974; **15:**443–453.
36. **Manniche C, Asmussen K, Lauritsen B, Vinterberg H, Kreiner S, Jordan A.** Low back pain rating scale. Validation of a tool for assessment of low back pain. Pain 1994; **57:**317–326.
37. **Gatchel RJ, Mayer TG.** Functional restoration for spinal disorders: the sports medicine approach. Malvern, Pa: Lea & Febiger, 1988.
38. **Biering-Sørensen F.** Physical measurements as risk indicators for low-back trouble over a one-year period. Spine 1984; **9:**106–119.
39. **Gatchel R, Mayer TG, Hazard RG, Rainville J, Mooney V.** Functional restoration [editorial]. Spine 1992; **17:**988–995.
40. **Cooke C, Menard MR, Beach GN, Locke SR, Hirsch GH.** Serial lumbar dynamometry in low back pain. Spine 1992; **17:**653–662.
41. **Bendix AF, Bendix T, Ostenfeld S, Bush E, Andersen A.** Active treatment programs for patients with chronic low back pain—a prospective, randomized, observer-blinded study. Eur Spine J 1995; **4:**148–152.