Can Spinal Surgery Be Prevented by Aggressive Strengthening Exercise? A Prospective Study of Cervical and Lumbar Patients

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ABSTRACT. Nelson BW, Carpenter DM, Dreisinger TE, Mitchell M, Kelly CE, Wegner JA. Can spinal surgery be prevented by aggressive strengthening exercise? A prospective study of cervical and lumbar patients. Arch Phys Med Rehabil 1999;80:20-5.

Objective: To determine of patients recommended for spinal surgery can avoid the surgery through an aggressive strengthening program.

Setting: A privately owned clinic, staffed by physicians and physical therapists, that provides treatment for patients with neck and/or back pain.

Methods: Over a period of 2½ years, consecutive patients referred to the clinic for evaluation and treatment were enrolled in the study of they (1) had a physician's recommendation for lumbar or cervical surgery, (2) had no medical condition preventing exercise, and (3) were willing to participate in the approximately 10-week outpatient program. Treatment consisted mainly of intensive, progressive resistance exercise of the isolated lumbar or cervical spine. Exercise was continued to failure, and patients were encouraged to work through their pain. Third-party payors in Minneapolis were surveyed for average costs. Average follow-up occurred 16 months after discharge.

Results: Forty-six of the 60 participants completed the program; 38 were available for follow-up and three required surgery after completing the program.

Discussion/Conclusion: Despite methodologic limitations, the results are intriguing. A large number of patients who had been told they needed surgery were able to avoid surgery in the short term by aggressive strengthening exercise. This study suggests the need to define precisely what constitutes "adequate conservative care."

IT IS WELL KNOWN that only a small percentage of patients account for the majority of medical and compensation costs associated with spinal disorders. The Quebec Task Force[1] reported that 7.4% of patients account for 76% of costs. In this small but expensive group, surgical patients are most common. In fact, low back disease ranks third as a reason for surgical procedures.[2] Despite many less than optimal outcomes, the number of surgical procedures continue to increase, with significantly more spine surgeries per capita performed in the United States than in any other industrial nation.[3] Driven largely by surgical and indemnity expenditures, the average cost per industrial back injury in the US is now more than $24,000.[4] We have personally seen cases with surgery that resulted in total costs of more than $500,000. It is clear that any successful cost containment strategy for spinal disorders must address surgical costs or it is unlikely to succeed.

Partly because of the limited success and expense of surgery, noninvasive treatment strategies have emerged. Saal and Saal[5,6] have published data showing that significant lumbar and cervical disc syndrome can be treated successfully with exercise and stabilization training. Mayer and associates[7,8] have had success treating long-term chronic low back pain with a multidisciplinary approach, including aggressive exercise. Manniche's group[9] studied the effects of aggressive strengthening exercises on chronic low back pain (CLBP) and showed that patients who engaged in intensive exercise did better than patients who received traditional passive modalities or less intensive exercise. Manniche[10] also found that the "dosage" of exercise was important and that CLBP patients treated with higher dosages did significantly better than similar patients at reduced dosages. Ruiz-Topinka[11] reported that Rosomoff and his group also found that patients selected for spine surgery can often avoid such surgery with an aggressive strengthening program, but Rosomoff's group has not published data to support this position. To date, no study has investigated the effects of aggressive strengthening exercises on patients who have been recommended for spinal surgery.

We recently published data detailing the outcomes of 895 CLBP patients who were treated with aggressive strengthening exercises.[12] Many of these patients were surgical candidates who were able to avoid surgery. Because of this success, many more patients have been referred with the hope that surgery can be prevented.

To document the results of these patients a prospective study was designed. This article reports results on all surgical candidates referred to our clinic and treated with an aggressive strengthening program over a 2½ year period (May 1993 to December 1995). Program participants were surveyed by telephone an average of 16 months after they completed the program to document its efficacy. In addition, three insurance companies were surveyed to determine average costs of spine surgeries.

METHODS

Patients

A total of 651 cervical or lumbar patients were referred to the program. Eight patients with contraindications to any type of aggressive strengthening exercises were excluded from the study because of medical conditions such as significant heart and/or

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lung disease or inflammatory arthritis. Of the remaining 643 patients, 62 met the inclusion criteria (each had seen one or more physicians who recommended spinal surgery). All patients were referred either by physicians familiar with our program, by friends who had been treated at our clinic, or by insurance companies. None were referred by surgeons. Two patients, after the initial evaluation, elected not to enter the program. Sixty patients began the program and 46 completed treatment (fig 1).

The average patient age was 42 years old, and the average duration of symptoms was 28 months. There were 28 men (60.9%) and 18 women (39.1%). Most patients (90%) had already tried and failed some type of exercise program. The average number of visits required to complete the program was 21 (approximately 10 weeks). According to our clinic's billing department the average total cost of the exercise rehabilitation program was $1,950. Costs included all physician evaluations, physician visits, reports, and some home exercise devices. Patients paid for the program with various insurance types (table 1).

Exercise Strengthening Program

Exercise rehabilitation and specific isometric strength testing was performed with equipment that isolates the spinal musculature, including the lumbar extensors, cervical extensors and rotators, and thoracic rotators.a This equipment's unique feature is its ability to quantify and develop spinal muscle strength through stabilization systems that isolate specific muscle groups. The efficacy of isometric testing and dynamic progressive resistance exercise (PRE) using this equipment on the healthy, asymptomatic, and chronic back pain populations has been well

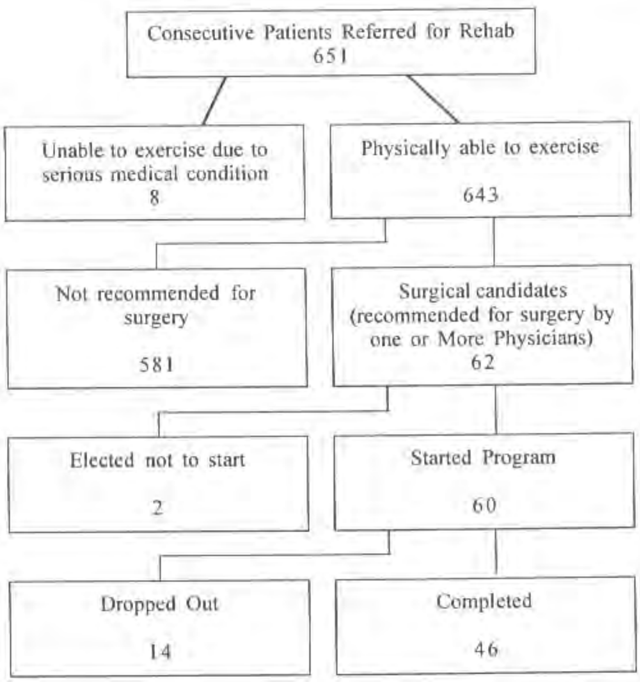

Fig 1. Patient selection flow chart and outcome. Forty-six of the 60 participants completed the program.

Table 1: Insurance Data

Type of Insurance	Participants, n (%)
Work Comp	25 (54.4)
HMO or Private	15 (32.6)
Auto	4 (8.7)
Medicaid	1 (2.2)
Medicare	1 (2.2)

documented.[12-25] Figure 2 shows the restraint system of the lumbar extension device. Figure 3 shows the restraint system used to isolate the cervical extensors. The torso and cervical rotation devices are similar but allow only isolated testing and exercise of thoracic and cervical rotation, respectively.

Patients were seen twice weekly for approximately 1 hour and were supervised by physical therapists. The mainstay of the treatment was PRE of the isolated lumbar or cervical spine, which none of the patients had performed previously. At each visit patients also performed aerobic exercise and strength training of other major muscle groups (eg, abdominals, hamstrings, glutei, trapezii, latissimus dorsi) even though more than 90% had previously tried similar exercises without success. Specific details of the training methods have been published.[12,16,20] An important point is that the training was quite vigorous and did not stop because of pain exacerbation. In such cases patients were seen by the physician, and, provided there was no clinical evidence of significant deterioration, the patient was reassured and treatment continued.

Objective measurements included static strength at predetermined points throughout the range of motion, dynamic endurance, and range of motion in both the sagittal and rotational (transverse) planes. Dynamic endurance was defined by the amount of weight and the number of repetitions a patient could perform until volitional muscular fatigue was reached, with the following muscle groups isolated: lumbar extensors, cervical extensors, torso rotators, cervical rotators. Weight load was increased periodically to allow approximately 20 repetitions during each maximum workout. Weight trainers using Nautilus variable resistance machines commonly use this type of PRE protocol based on holding repetitions constant and increasing the weight as strength increases. Objective measurements with this equipment have previously been shown to be valid and reliable.[18,19,21-25]

Treatment was ended when one or more of the following criteria was met:

1. The patient was pain free or nearly pain free and objective functional levels were at or near normal. Pain was rated with a 10-point visual analogue scale; functional levels of isometric muscular torque, dynamic muscular endurance and isolated lumbar or cervical sagittal and rotational range of motion were measured and evaluated weekly.
2. The patient was no longer making objective gains in spinal function.
3. The patient refused to cooperate or give a good effort, are sponse to treatment that we recorded as a poor outcome.

Response to treatment was rated as excellent, good, fair, or

Table 2: Study Participants, by Diagnosis

Primary Diagnosis	Participants (n)
Degenerative disc disease (lumbar)	17
Degenrative disc diseas (cervical)	4
Lumbar disc syndrome	15
Cervical disc yndrome	9
Spondylolisthesis/spondylolysis (lumbar)	1

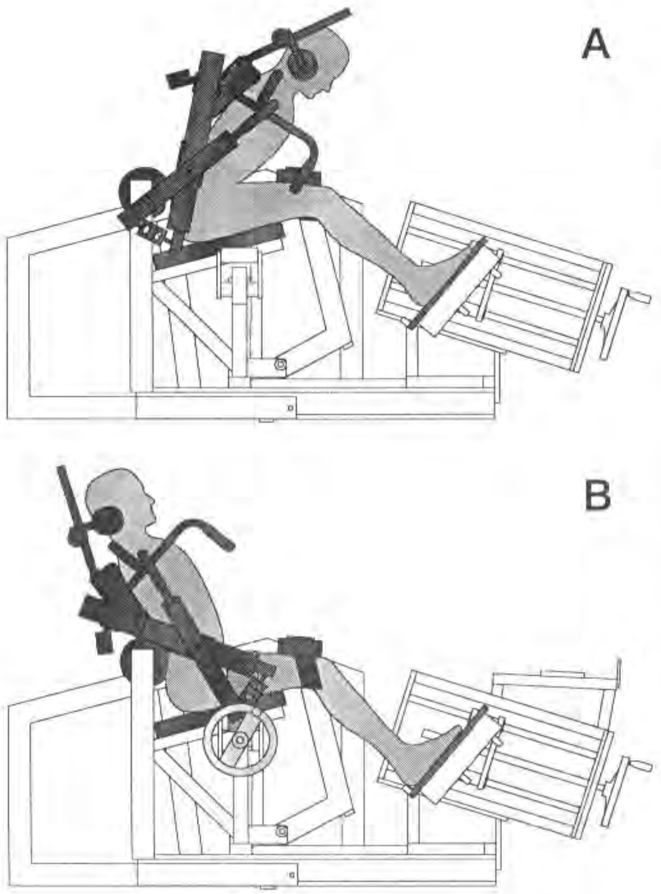

Fig 2. Lumbar extension device: (A) pelvis fixed, spine in flexion; (B) pelvis fixed, spine in extension.

> poor using a 10-point system previously described in de-tail.[12] The ratings were defined as follows: excellent, resolution or near resolution of spine and/or extremity pain, attained normal or near normal strength values; good, substantial but not complete pain relief, substantial strength gains; fair, minimal pain relief, minimal or no strength gains.

For this study, however, the most important measure of treatment efficacy was whether the patient underwent surgery.

After discharge all patients were instructed in a very specific home maintenance program that incorporated the principles of progressive resistance training. Cervical patients were given home exercise devices,c included in the price of the program, and, in addition, the lumbar patients were strongly advised to purchase a 45ø back extension unit, approximately $165, from a local vendor in order to maintain lumbar strength. Patients were given permission to be vigorous. They were taught that "hurt does not necessarily mean harm." Instruction for self-treatment of exacerbations was provided. Education emphasized natural history, imaging abnormalities seen in the general population, body mechanics, herniated disc reabsorption, and so forth.

Cost Data

Studies on spinal treatment often lack cost data. Consequently, the expense associated with spine surgery is often obscured. To highlight the economic impact, we requested appropriate data from local third-party payers based on 14 Current Procedural Terminology (CPT) codes representative of the most common spinal surgeries. Insurance companies are able to process information based on CPT codes from computer databanks, which allows access to large numbers of cases. Costs were broken down into medical costs (physician fees, hospitalization, drugs, postoperative therapy), indemnity (lost wages paid), and permanency costs (lump sum paid to worker's compensation patients after spine surgery to compensate for the injury). The sums were then averaged.

Follow-Up

A vigorous attempt was made to contact by telephone all patients, including those who quit before the program completion and those seen only for the initial evaluation. Follow-up was completed an average of 16.2 months (range, 12 to 30 mo, SD 5.2 mo) after the patient was last seen at the clinic. Of the original 46 surgical candidates completing the program, 38 (82.6%) were located for follow-up. Each patient was asked the following questions: Since you completed the program have you had surgery or your spine? If yes, what type of surgery did you have?

Statistics

Statistics were compiled using SPSS/Windows.e Student's t test was used to analyze strength increases within the group before and after treatment.

RESULTS

Objective dynamic endurance increased significantly among the 46 surgical candidates completing the program. Table 3 and 4 show beginning and ending weights that were lifted to volitional muscle fatigue for each muscle group. All strength gains were statistically significant ($p < .001$) and ranged from 62% to 134%. At follow-up, the clinical outcome was "excellent" in 17 subjects (44%), "good" in 14 (36.8%), "fair" in 4 subjects (10.5%), and "poor" in 3 subjects (7.9%).

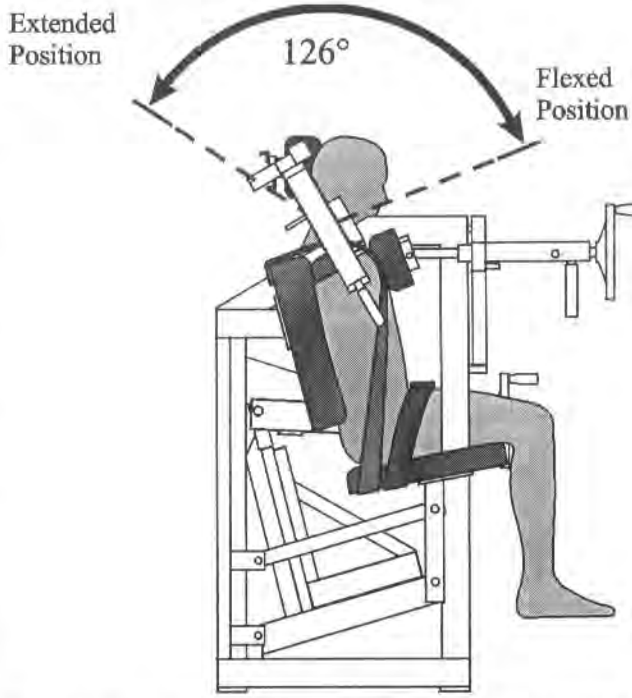

Fig 3. Cervical extension device, with torso fixed and neck neutral.

Table 3: Extensor Muscle Strength Gains

	Starting Weight Load	Ending Weight Load	Norma Weight Load	Weight Load Increase
Lumbar extensors muscles (ft lbs)				
Men	79.4 ± 12.2	136.0 ± 21.2	150	72%*
Women	49.4 ±7.8	88.0 ± 12.7	80	87%*
Cervical rotator muscles (in lbs)				
Men	207.0 ± 55.5	334.0 ± 58.2	342	61%*
Women	110.6 ± 22.5	182.2 ± 33.1	187	65%*

Value are reported as averages ± SD. Weight adjusted for patient to fail after approximately 20 repetitions.
Abbreviations: ft lbs, foot pounds; in lbs, inch pounds.
* Statistically significant ($p < .001$)

Of the original surgical candidates completing the program we located 38 (82.6%). Only three of the 38 patients needed surgery in the follow-up period; two had lumbar laminectomies and one had a lumbar fusion. None of the cervical patients underwent surgery in the follow-up period.

Cost Analysis

To obtain representative costs we surveyed third-party payers in Minneapolis/St. Paul on 14 CPT codes representative of typical spine surgeries (table 5). Study participants were identified if their case file included one of these codes. Table 6 showed the average costs associated with the various types of surgeries. In comparison, the average cost of the aggressive strengthening program was $1,950.

DISCUSSION

The debate about spinal surgery continues in the United States. Critics claim overutilization; supporters claim otherwise. There is no dispute about how costly spinal surgery can be. This study raised several interesting questions. Can we do a better job of defining who needs surgery? Who should first try exercise? What part should an aggressive strengthening program play in treatment plans? What constitutes adequate "conservative care?"

Limitations of the Method

Despite the methodologic shortcomings of this study, the results are still intriguing. First, the patients were not randomized because as a referral, private practice clinic, we could not do so practically.

Table 4: Rotator Muscle Strength Gains

	Starting Weight Load	Ending Weight Load	Norma Weight Load	Weight Load Increase
Lumbar extensors muscles (ft lbs)				
Men	44.9 ± 6.7	72.0 ± 12.9	80	60%*
Women	22.3 ± 5.0	43.5 ± 8.8	43	95%*
Cervical rotator muscles (in lbs)				
Men	54.7 ± 9.8	102.3 ± 15.6	115	87%*
Women	30.1 ± 6.9	70.5 ± 13.3	67	134%*

Value are reported as averages ± SD. Weight adjusted for patient to fail after approximately 20 repetitions.
Abbreviations: ft lbs, foot pounds; in lbs, inch pounds.
* Statistically significant ($p < .001$)

Table 5: CPT Codes for Spine Surgeries

CPT Code	Description
22548	Cervical fusion, anterior, C1-C2, with bone graft
22554	Cervical fusion, anterior, single level, below C2, with bone graft
22558	Lumbar fusion, anterior, single level, with bone graft
22585	Cervical or lumbar fusion as above, each addition level
22590	Cervical fusion, posterior, occiput to C2, with bone graft, + or - internal fixation
22600	Cervical fusion, posterior, below C2, with bone graft, + or - internal fixation
22625	Lumbar fusion, posterior/posterolateral, one level, with graft, + or - internal fixation
22630	Lumbar fusion, posterior interbody, one level, with graft, + or - internal fixation
22650	Lumbar fusion as above, each additional level
63001	Cervical laminectomy, no diskectomy, posterior, one or two levels
63015	Cervical laminectomy, no diskectomy, posterior, more than two levels
63020	Cervical laminectomy, with diskectomy, posterior, one level
63030	Lumbar laminectomy, with diskectomy, posterior, one level
63035	Lumbar laminectomy, with diskectomy, posterior, each additional level

It also might be argued that the patients in this study were more motivated to avoid surgery. This may be true, but how many patients, having seen a surgeon who recommends surgery, are aware that such an alternative exists? Many patients might decide to postpone surgery of they knew the success rate of an alternative program.

The study lacked a control group - a major shortcoming. This report is submitted to stimulate discussion and provide the rationale for future randomized, controlled trials assessing aggressive exercise as an alternative.

The clinical results (excellent, good, fair, or poor) were not determined by a blinded observer and can be questioned. Our experience, however, demonstrates that this rating system is a simple and accurate measure of treatment outcome in a busy private clinic as well as a good predictor of short-term treatment efficacy.12 Additionally, this report is not primarily concerned with clinical results. The essence of this study is whether or not the patient had surgery in the 16-month period after discharge, a result that is definitive and not subjected to any bias.

A critical reader might question if the clinical results were long-lasting. Perhaps patients were avoiding surgery but were miserable in doing so. Although we do not report here on whether the subjective improvement was lasting, we have done so previously in a similar CLBP population with good or excellent results from an aggressive strengthening program.12 In that group of

Table 6: Average Surgical Cost Data by Type of Surgery

Type of Surgery	Medical	Indemnity	Permanence	Total Cost
Lumbar laminectomy	$30,300	$35,900	$16,,414*	$ 82,614
Lumbar fusion	$62,300	90,300	16,132*	$168,732
Cervical laminectomy	$20,750	$21,800	$17,754*	$ 60,304
Cervical fusion	$43,100	$53,900	$15,480*	$112,480

* Estimate of amount paid over the life of the claim.

patients, 94% maintained their improvement with a home program at 1-year follow-up. This suggests that not only can surgical candidates avoid surgery, they can improve subjectively and maintain their improvement with a home strengthening program. Manniche[9,10] reported similar lasting improvement from intensive exercise and rehabilitation, provided that patients continued with their exercises, findings similar to those reported by our own group[12] and those of Risch and colleagues,[20] who published a randomized comparative study using the same protocols.

Finally, not all patients completed the strengthening program (77% completion) and not all who completed it were available for follow-up (82.6%). As was found in our previous study of exercise and chronic low back pain,12 most of the patients who dropped out of the program did so early on, completing an average of only seven visits. In comparison, patients who finished the present program completed and average of 21 visits. Early attrition is unfortunate because patients undergoing aggressive strengthening exercises often do not begin to feel better until 3 or 4 weeks into the program.[9,10,26,27] Also, some patients are unwilling to devote the time and energy required for aggressive strengthening exercises and elect passive care and/or surgery instead.

Nevertheless, we believe that the study is valuable because it shows that a large number of surgical candidates at a private practice clinic can avoid surgery over an extended period. Further, there were no significant complications or negative consequences associated with delaying surgery while patients participated in an aggressive strengthening program. Occasional exacerbations occurred, but these were self limited and did not prevent rehabilitation from continuing.

The Need for Muscle Isolation and Exercise Intensity

One key factor in the treatment protocol is that the strengthening program was specific and intense. "Specific" was defines as exercise with the pelvis (for lumbar injuries) or upper torso (for cervical injuries) immobilized to isolate the lumbar and cervical musculature, respectively. "Intensive" was defines as muscular exercise against dynamic resistance to volitional failure, ie, exercise performed on a strength training device through a full range of motion. The exercise activity was continued for as many repetitions as possible, as long as the patient could maintain the range of motion demonstrated during the first repetition.

Few disagree with the position that patients with chronic spine pain should fail an adequate trial of nonoperative care prior to surgery. But what is an adequate trial on conservative care? How should it be defined? The patients in this study had already tried some conservative care, and most had tried several different treatments. More than 90% had tried a previous exercise program. Why, then, did the majority of these patients have better outcomes with an aggressive strengthening program?

We believe there are several reasons. First, most of the surgical candidates talked about their "degenerative disc" or "ruptured disc" or "spinal stenosis" or "spondylolisthesis," etc. Reinforced through extensive exposure within the health care system, they saw themselves as damaged goods. Few understood that literally millions of people have the same radiologic diagnoses with few or no symptoms.

Surgical candidates are often considered more "fragile" than nonsurgical patients and are more often guided toward inactivity to protect the spine. Many have been told to remain inactive based on MRI scans. They develop a keen sense of fear when it comes to spinal motion. Spinal pain patients become expert at substituting pelvic or thoracic movement for lumbar or cervical motion, respectively.[8] In this way they protect the injured body part from meaningful exercise.

Substitution protects the lumbar or cervical spine from normal movement, Without motion the disc deteriorates, disc pH decreases, joints stiffen, ligaments shorten, bone density decreases, and muscles become deconditioned.[26,27] Recent evidence[28] suggests that a damaged disc becomes more acidic and that reduced pH is a mediator of spinal pain. The adult disc is an avascular structure that depends on diffusion for its nutrition. Diffusion is facilitated by a pumping action through spinal motion. Lack of motion, however, hinders diffusion. In the aggressive strengthening program in this study, patients were not allowed to substitute. The cervical and/or lumbar spine was isolated in such a way that substitution was impossible. Exercise therefore facilitated fluid exchange in the disk, which may account for the subjective improvement even though most patients (90%) had tried and failed other strengthening programs that did not provide isolated, intensive exercise. Graves and associates[29] showed that attempts to strengthen the lumbar spine using traditional exercise equipment are completely ineffective. These and similar devices are capable of strengthening the pelvic extensors but not the lumbar extensors. The data from Graves and from our study suggest that to be effective, exercise must both isolate and intensely work the target muscles and joints.

Another essential component of the rehabilitation program used in this study is exercise. Patients were directed to perform PRE to volitional muscle fatigue within 20 repetitions. Weight loads were increased periodically to maintain exercise intensity. Rather than using pain as a barometer to guide physical activity, patients were educated and encouraged and ultimately became self motivated to exercise beyond their pain threshold. For most patients, symptoms dissipated as functional status improved. For example, surgical candidates increased the amount of weight lifted to volitional muscle fatigue by 72% to 87 % for the lumbar extensors and 60% to 95% for the thoracic rotators. Eighty percent of these patients reported a good or excellent response to treatment. These findings are consistent with those of previous studies[9,10,12,16,20,30] that used intensive exercise to improve spinal musculoskeletal function in CLBP patients. Further, aggressive exercise complies with recent guidelines for spine rehabilitation that emphasize treatment directed toward improved activity tolerance rather than toward symptom relief.[1,12,31] Visual feedback of improving performance, provided by specific lumbar or cervical testing, encourages patients to continue exercising even in the face of initial discomfort. As patients improve spinal function, pain and fear decrease while confidence and ability to perform activities of daily living increase.

Surgical Costs

This study documents the high costs of surgery. The higher the cost, the more attractive nonsurgical alternatives become. The average cost of the exercise rehabilitation program in this study was $1,950. In contrast, an average worker's compensation lumbar fusion costs $168,000, 86 times more expensive.

Additionally, the cost data implicitly assume that surgically treated patients have a successful outcome. Considering the minimum 15% failure rate estimated for spinal surgery,[32] the predicted surgical costs presented in the current study are likely underestimated. Whether the results are representative of all or most surgical candidates is not known, but the obvious morbidity and cost benefits suggest further study is warranted.

CONCLUSION

Although this study has methodologic limitations, it nonetheless represents actual practice in a private clinic. Because of the sheer volume, most spinal patients will necessarily be treated in private clinics, and practical, yet efficacious, treatment strategies must be developed with cost containment in mind.

The significance of this study is that many patients were spared surgery during the study period even though surgery had been recommended. The findings show that a percentage of spinal patients can avoid surgery by completing an aggressive strengthening program and that even patients recommended for spinal surgery can tolerate intensive, specific exercise. Also, this study documents the amount of physical treatment each patient received, thus enabling comparisons with other types of physical treatment programs. Moreover, these findings suggest that substantial cost savings are possible by first attempting aggressive strengthening exercises. To be effective, such exercises must be specific and intensive. In the absence of deteriorating physical condition, patients should be encouraged to exercise beyond their initial pain to achieve the functional improvements, symptom relief, and cost savings this program can offer. Finally, the spinal treatment community needs a consensus definition of "adequate conservative care." At present it is defined however a physician wishes it to be defined.

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Suppliers

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