Effects of Home Strength Training and Stretching Versus Stretching Alone After Lumbar Disk Surgery: A Randomized Study With a 1-Year Follow-Up

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ABSTRACT. Häkkinen A, Ylinen J, Kautiainen H, Tarvainen U, Kiviranta I. Effects of home strength training and stretching versus stretching alone after lumbar disk surgery: a randomized study with a 1-year follow-up. Arch Phys Med Rehabil 2005;86:865-70.

Objective: To assess the adherence to and effects of a 12-month combined strength and stretching home exercise regimen versus stretching alone, on patient outcome after lumbar disk surgery.

Design: Randomized controlled trial.

Setting: Departments of physical medicine and rehabilitation and orthopedics at a Finnish hospital.

Participants: Patients (N=126) were randomized into either a combined strength training and stretching group (STG, n=65) or a control group (CG, n=61).

Intervention: The STG was instructed to perform strength training and both the STG and CG were instructed in the same stretching and stabilization exercises for 12 months.

Main Outcome Measures: Pain on the visual analog scale (VAS), the Oswestry and the Million disability indexes, isometric and dynamic trunk muscle strength, mobility in the lumbar spine, and straight-leg raising were measured.

Results: The trial was completed by 71% and 77% of the patients from the STG and the CG, respectively. The mean strength training frequency decreased from 1.5 to 0.6 times a week in the STG during the intervention. The mean stretching frequency decreased from 3.7 to 1.6 times a week in both groups. Median back and leg pain varied between 17 and 23 mm (VAS), and the Million and Oswestry indices varied between 14 and 23 points 2 months postoperatively. No statistically significant changes took place in these outcome measures during the 12-month follow-up in both groups. The changes in isometric trunk extension favored the STG (P=.016) during the first 2 months. However, during the whole 12-month training period, both dynamic and isometric back extension and flexion strength, as well as mobility of the spine and repetitive squat-test results, improved significantly in both groups, and no differences were found in any of the physical function parameters between the STG and CG.

Conclusions: At the 12-month follow-up, no statistically significant changes were found in the physical function, pain, or disability measures between the groups. In the STG, training adherence with regard to training frequency and intensity remained too low to lead to specific training-induced adaptations in the neuromuscular system. Progressive loading, supervision of training, and psychosocial support is needed in long-term rehabilitation programs to maintain patient motivation.

Key Words: Lumbar vertebrae; Muscles; Pain; Rehabilitation; Surgery.

LUMBAR DISK HERNIATION IS A common cause of radiating low back pain. There is evidence that pain associated with disk herniation may be induced by a combination of mechanical deformation of the nerve root and chemical irritation.[1] The primary rationale behind surgical intervention in lumbar disk herniation is to reduce pain by removing compression of the nerve root. The early results of lumbar disk surgery have shown success rates better than 90%.[2,3] When the follow-up time has been longer, varying from 1 to 11 years, 60% to 90% of operated patients have shown good or excellent results.[4-7] Differences in the inclusion criteria, criteria for surgery, and outcome measures in various studies may account for the large variation in success rates. However, in 10% to 40% of the patients, the result of disk surgery is unsatisfactory, and patients report symptoms like pain, motor deficits, and a decreased functional status.[8,9] If, despite surgery, patients still suffer from persistent symptoms, pain alleviation and active rehabilitation programs are the suggested treatment options.

Several types of postoperative rehabilitation programs have been used. These studies have been very heterogeneous with regard to the timing, duration, and intensity of interventions.[10] Studies of short-term intensive rehabilitation programs starting immediately[11,12] or 4 to 6 weeks after surgery[12-14] have shown that patients in such programs have better functional status and return faster to work than patients in mild exercise programs. However, in all these studies, the training period has been less than 3 months and, when followed over the long term, no differences between such intervention groups have been found with regard to pain, disability, or return to work. The only exception reported was in the study by Danielsen et al,[14] where good results were maintained after a 12-month follow-up. On the other hand, none of the treatments applied appeared to be harmful with regard to reherniation or reoperation.

Evidence for the efficacy of long-term training programs after lumbar disk surgery is thus lacking. Hence, in our study we compared the effectiveness of 12 months of combined strength and stretching training to conventional stretching exercises in patients after lumbar disk surgery.

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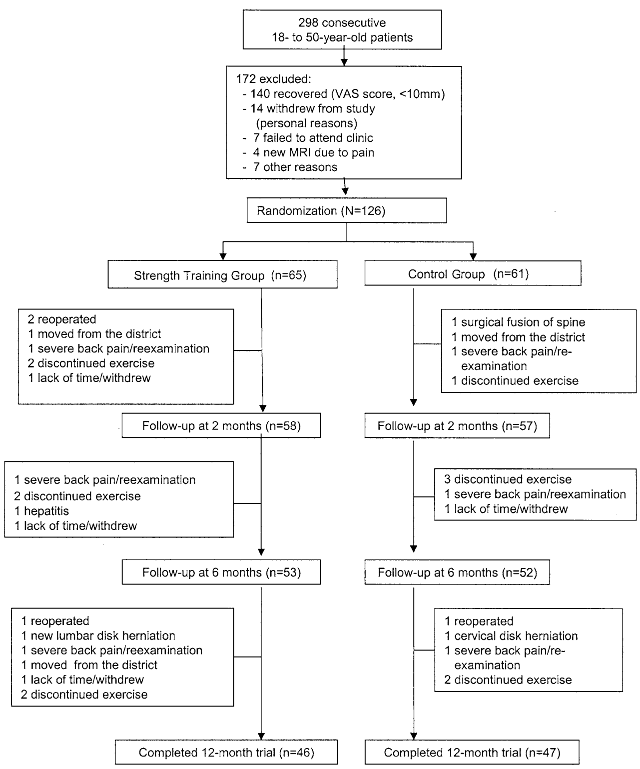

Fig 1. Patient flow during the study. Abbreviation: MRI, magnetic resonance imaging.

METHODS

Participants

Two hundred ninety-eight consecutive patients, who had their first lumbar disk surgery because of a lumbar disk prolapse, were treated in the Department of Orthopaedics, Jyväskylä Central Hospital. Of this total, 140 patients were pain free (visual analog scale [VAS] score, <10mm) 2 months postoperatively and were excluded, according to the exclusion criteria, as asymptomatic subjects. The remaining 158 patients were asked to volunteer for the postoperative rehabilitation study (fig 1). The indication for surgery was unbearable back pain because of prolapsed disk, with or without muscle weakness, which radiated down to the lower extremity and was not relieved by conservative treatment. The diagnosis of lumbar disk herniation was based on preoperative clinical status, detected spinal nerve root compression in magnetic resonance imaging (MRI) or computed tomography, and it was finally confirmed during surgery. The patients were operated on using the open mini approach described by Wood and Hanley in 1991.[15]

Of the 158 symptomatic patients who were referred to the outpatient clinic 2 months postoperatively for the baseline clinical examination, tests, and training instructions, 32 were excluded because either they did not meet the criteria or they withdrew: 7 patients did not attend the baseline checkup, 14 attended the clinic but withdrew from the study because of lack of time or for other personal reasons, 4 were waiting diagnostic MRI in the treatment of severe back and leg pain, and 7 patients were excluded (1 had been reoperated on, 1 had spondylodesis of the lumbar spine, 1 had had a gastrointestinal tract operation, 1 was pregnant, 1 had Parkinson's disease, 1 had moved away from the district, 1 had switched to a private clinic). Finally, 126 patients were randomly assigned either to the strength training group (STG) (n=65) or to the control group (CG) (n=61). The demographics and results of the clinical examination at the baseline are presented in tables 1 and 2.

Outcome Measurements

Before surgery, in the department of orthopedics, subjects were asked to complete a questionnaire that combined items on the duration and intensity of back and leg pain. The postoperative outcome was assessed before the intervention began and at 2- and 14-month follow-ups. Back and leg pain were assessed with the VAS (range, 0–100mm).[16] The degree of functional impairment was assessed with the Oswestry Low Back Pain Disability Questionnaire, which is divided into 10 sections designed to assess limitations on various activities of daily living.[17] Million's disability index, which consists of 15 subjective variables reflecting the severity of back pain, circumstances exacerbating symptoms, and the impact of these problems on lifestyle, was scored on the VAS.[18] The mean of these scores is used as a subjective outcome index. In addition, the patients were asked about their leisure time physical activities per week (in minutes).

All the tests of physical function were performed only during the postoperative follow-up because severe pain prevented objective measures before surgery. The endurance strength of the selected muscle groups was measured by calculating the repetition maximum up to a maximum of 100 repetitions.[19] In the repetitive sit-up test for the trunk flexors, each subject lay in the supine position with the knees flexed at 90° and the feet held by a belt on the test bench. The subject raised the upper body and touched the kneecaps with his/her wrist. In the repetitive arch-up test for the trunk extensors, each subject lay in a prone position with the arms along the side, inguinal region at the edge of the test bench, the upper trunk flexed downward at 45°, and the feet held in the ankle region. The subject brought the upper trunk up to the horizontal position and back down again. The endurance strength of the lower extremities was assessed by the number of squats and the endurance of the upper arms by the alternate single-arm dumbbell press (women with 5-kg weights, men with 10-kg weights). The rate of 22 repetitions per minute was controlled with a metronome in all the muscle endurance tests.

Maximal isometric forces of the trunk flexors and extensors were measured using a strain-gauge dynamometer,[20] and the results were analyzed with an Isopack computer program.[a] The subject stood with the hips fixed at the level of the anterior superior iliac spine. The strap was tightened just below the armpit and horizontally connected to the dynamometer through a steel chain. The best result from 3 attempts was taken for the final analysis.

The Schober test was used to measure lumbar flexion.[21] Straight-leg raising (SLR) was determined with a goniometer, and the result was recorded as positive if the symptoms appeared less than 60°.

Participants gave written informed consent after the study protocol was explained to them. The ethics committee of Jyväskylä Central Hospital approved the study design.

Interventions

All subjects received instructions and written information about the exercises to be practiced at home and were taught to keep an exercise diary throughout the 1-year follow-up. The same physiotherapist instructed all participants individually at

Table 1: Demographics and Classification of 126 Lumbar Disk Surgery Patients Randomized Into Either the STG or the CG

Variables	STG (n=65)	CG (n=61)
Male/female (n)	36/29	35/26
Mean age ± SD (y)	39±7	39±8
Mean body mass index ± SD (kg/m²)	26±3	26±4
Active smokers (n)	22	20
Median duration of back pain (IQR) (mo)	12 (5–24)	12 (5–48)
Median duration of leg pain (IQR) (mo)	5 (0–12)	8 (3–19)
Median back pain before operation (VAS), (IQR)	58 (43–74)	58 (44–80)
Median leg pain before operation (VAS), (IQR)	71 (50–86)	76 (53–92)
Laseque (SLR <60°)		
Right side	8	10
Left side	16	13
Both sides	10	8
Location of the prolapse		
Right	20	27
Left	40	29
Central	5	5
Level of herniated disk		
L1–2	2	0
L2–3	1	0
L3–4	0	3
L4–5	34	28
L5–S1	27	30
L4–5 and L5–S1	1	0

Abbreviations: IQR, interquartile range; SD, standard deviation; SLR, straight-leg raising.

the department of rehabilitation. The tests of physical function were performed in the exercise laboratory by a second experienced physiotherapist blinded to the patient's group assignment.

Strength training. The patients in the STG were instructed to perform the home strength training program for 12 months. Each exercise was practiced under supervision for 1 session. The strength exercises were done using body weight or individually adjusted dumbbells (8–12 repetitions) for resistance and included the following exercises: bilateral leg press or stepping on the bench, hip extension, knee flexion, toe rise, abdominal crunch, and leg lifts while lying on the back; back hyperextension in the prone position; upper back and shoulder exercises with push-ups or bench press; front alternate rise; and rowing. Subjects were instructed to perform 2 series per exercise twice a week. Compliance with the exercise programs was checked at the 2- and 6-month follow-up visits.

Stretching and stabilization exercises. Both the STG and the CG received instructions to stretch 3 times a week. The stretching exercises included active SLR; trunk flexion in the supine position by pulling the flexed leg toward the chest; passive extension of the lumbar spine while prone by pressing the upper body upward; and stretching of quadriceps, iliopsoas, gluteus medius, and maximus muscles while lying supine. For each stretching exercise, 3 repetitions for 30 seconds was recommended. Isometric, rhythmic muscle contractions of the transversus abdominis muscle while leaning against the wall was also to be done to increase the stabilization of the lumbar spine. Instructions were given to perform these exercises daily, with 5 to 10 repetitions. In addition, all patients were encouraged to perform aerobic training 2 to 3 times a week and to return to their normal daily physical activities. The patients were also encouraged to contact the staff by phone whenever needed, and the diaries were used as feedback about the regularity of training.

Statistical Analysis

Clinical outcome variables were analyzed by using the intention-to-treat principle. The results are expressed by means and standard deviations (SDs) and by medians and interquartile ranges (IQRs). Statistical comparison between the groups was done by analysis of covariance or median regression analysis (least-absolute value model), where appropriate. The Hodges-Lehmann estimate of median difference, with a 95% confidence interval (CI), was used to study differences between the groups in the clinical outcome variables. The normality of the

Table 2: Disability and Pain Ratings of Subjects at the Baseline and Changes at the Follow-Up

	Baseline (2mo after surgery)		Change to Endpoint (after 12mo of training)		
Variables	STG Median (IQR)	CG Median (IQR)	STG Median (95% CI†)	CG Median (95% CI†)	P*
Back pain (VAS)	23 (12–30)	17 (8–31)	−4 (−11 to 5)	−1 (−7 to 9)	.98
Leg pain (VAS)	17 (8–31)	17 (8–25)	−2 (−7 to 7)	−2 (−7 to 3)	.36
Million index	23 (13–39)	18 (10–27)	−3 (−8 to 2)	−2 (−6 to 2)	.63
Oswestry index	18 (12–23)	14 (8–22)	−3 (−6 to 1)	−2 (−5 to 1)	.80

*Baseline adjusted median regression analysis.
†Hodges-Lehmann estimates of median difference.

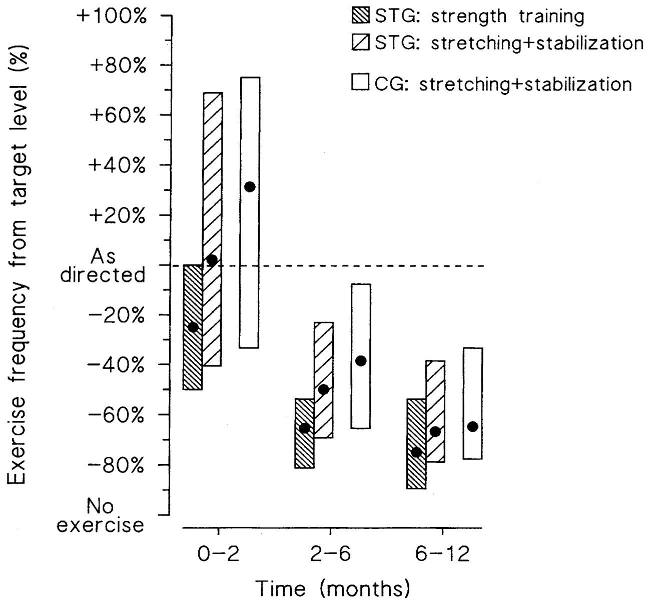

Fig 2. Exercise frequencies against target levels. In the STG, the frequencies of strength training and stretching are presented separately. Legend: Circles show medians; boxes show IQRs.

variables was evaluated by the Shapiro-Wilk test. Pearson correlation coefficients were calculated to assess the relationships between the variables.

RESULTS

Forty-six patients (71%) from the STG and 47 (77%) from the CG attended the 12-month checkup. The reasons for dropout are presented in figure 1.

According to the training diaries, the mean strength training frequencies ± SD were 1.5±0.8, 0.8±0.6, and 0.6±0.5 times a week, and stretching frequencies were 3.4±2.0, 2.3±1.5, and 1.6±1.5 times a week, for 1 to 2 months, 3 to 6 months, and 7 to 12 months in the STG, respectively. In the CG, the corresponding stretching frequencies per week were 3.7±1.9, 2.3±1.5, and 1.6±1.5. Figure 2 shows the exercise frequency compared with target levels (strength training target was 2 times a week, stretching target was 3 times a week). The strength training frequency during the first 2 months was associated with the training frequencies up to 6 months (r=.57; 95% CI, .38–.72) and 12 months (r=.42; 95% CI, .20–.60). In the stretching exercises, the corresponding correlations up to 6 and 12 months were r equal to .67 (95% CI, .50–.79) and r equal to .49 (95% CI, .27–.66).

All the patients suffered from severe back and leg pain before surgery (see table 1). At the time of randomization 2 months after the operation, median back and leg pain had decreased by 61% to 78% (P<.001) from the preoperative level. No differences were detected in the disability indexes or in back and leg pain between the groups (see table 2). Furthermore, these outcome measures remained unchanged during the 1-year follow-up in both groups. Considerable or complete relief from both back and leg pain (VAS score, <10mm) was obtained by 24 patients in the STG and by 20 patients in the CG. At the baseline, 44 patients used analgesics occasionally and 6 used them daily in the STG; in the CG, 36 used them occasionally and 6 used them daily. After 12 months, the numbers of occasional or daily users of analgesics were 21 and 5 in the STG and 24 and 2 in the CG, respectively. The training frequencies were not associated with the amount of back and leg pain.

Preoperatively, 34 STG cases and 31 CG cases had a positive SLR result (see table 1). At the time of randomization, the corresponding numbers were 15 patients in the STG and 14 in the CG, and at the 1-year follow-up, 4 and 3 patients, respectively.

Both the isometric and endurance strength measurements and the mobility of the spine were comparable between the groups at the baseline (table 3). The mean increases in the isometric trunk extension and flexion forces were 118N (31%) (P<.001) and 49N (12%) (P=.002) during the first 2 months of training in the STG. In the CG, the corresponding changes were 49N (11%) (P=.002) and 20N (5%) (not significant). The mean number of repetitions in the trunk extension endurance test increased from 25 repetitions to 41 repetitions (39%) and in trunk flexion from 16 repetitions to 28 repetitions (43%) in the STG. In the CG, the mean changes were from 32 repetitions to 41 repetitions (22%) and from 21 repetitions to 29 repetitions (28%). Because of the high individual variation in the strength results, only the changes in isometric trunk extension during the first 2 months was statistically significant between the groups (P=.016). After the first 2 months, the changes in both isometric and endurance back extension and flexion force values were minor. Repetitive squat and lumbar flexion mobility improved significantly in both groups, whereas the results

Table 3: Muscle Strength and Mobility of Subjects at the Baseline and Changes at the Follow-Up

Variables	Baseline (2mo after surgery) STG Mean ± SD	Baseline (2mo after surgery) CG Mean ± SD	Change to Endpoint (after 12mo of training) STG Mean (95% CI)	Change to Endpoint (after 12mo of training) CG Mean (95% CI)	P*
Isometric strength (N)					
Trunk flexion	395 ± 188	434 ± 168	88 (51–124)	49 (18–81)	.20
Trunk extension	385 ± 197	454 ± 197	140 (92–188)	95 (59–130)	.35
Endurance strength (no. of repetitions)					
Trunk flexion	17 ± 15	21 ± 14	16 (6–25)	7 (2–11)	.25
Trunk extension	25 ± 24	31 ± 22	13 (7–18)	6 (1–12)	.31
Squat	31 ± 22	34 ± 22	7 (4–10)	6 (3–10)	.73
Alternate single-arm dumbbell press	20 ± 9	24 ± 15	2 (−0 to 3)	1 (−1 to 3)	.90
Mobility					
Flexion (Schober test in cm)	4.0 ± 1.4	4.0 ± 1.3	0.7 (10.3–1.1)	0.6 (0.2–0.9)	.75

*Analysis of covariance. Baseline value as covariate.

for the alternate single dumbbell press remained unchanged. At the 12-month checkup, no between-group differences were found in any of the physical function parameters.

Nine patients (14%) from the STG and 8 (13%) from the CG were on sick leave during the 12 month follow-up. The respective median duration of sick leave in the groups was 34 (IQR, 10–180) days and 33 (IQR, 16–59) days. According to the questionnaires, the median amount of leisure time used for physical activities during the 12-month follow-up was 241 (IQR, 106–469) minutes per week in the STG and 271 (IQR, 121–451) minutes in the CG.

DISCUSSION

Patients in the combined strength training and stretching group showed slightly greater improvement in isometric and endurance trunk muscle strength than the stretching group during the first 2 months of the training intervention. However, at the 12-month follow-up, the changes in the trunk muscle strength and spine mobility measures were statistically significant in both groups, and there was no difference in the level of improvement between the 2 interventions. Pain and subjectively perceived disability remained relatively constant during the 1-year follow-up in both groups.

Other studies have reported atrophy of type II muscle fibers and alterations in the connective tissue of multifidus muscles in lumbar disk herniation patients.[22-24] Three months after lumbar disk surgery, decreased lumbar spine mobility, lifting capacity, and trunk muscle strength have been reported in disk surgery patients compared with a normative population.[25] In addition to decreased maximal strength, the explosive force production capacity of the trunk muscles[26] and the balance between trunk extension and flexion strength[25,26] have also been shown to be disturbed, which indicates a postoperative deficit in physical function. Decreased strength levels have been reported even 1 year after surgery.[27] Because of the limited amount of knowledge available, it has not been possible to estimate the rate of natural postoperative recovery of trunk muscle strength. In the present study, the median duration of preoperative back pain was about 1 year and that of leg pain about half a year. Both the STG and CG in our study increased their trunk muscle strength from the levels measured 2 months postoperatively. Because there were no changes in back and leg pain values during the follow-up, pain cannot account for the changes in strength levels.

During the first 2 months, the strength training frequency in the STG, according to the training diaries, was greater than 70% from the target level. During this period, the increases in both isometric and endurance trunk muscle strength favored the STG, but only the increases in isometric trunk extension strength were significantly higher in the STG than in the CG. For the checkup visits at 6 and 12 months, the median strength training frequencies were less than 50% of the target 2 times a week in the STG. The adherence rate for the stretching and stabilizing exercises was at the target frequency of 3 times a week in both groups for the first 2 months, but after that they fell to 50% to 60% of the target for the next 4 months and to 30% for the last 6 months. Furthermore, the training adherence during the first 2 months of follow-up reflected rather well the later adherence of the participants. Thus, trainers who are not able or motivated to perform self-directing exercises in the early phase of rehabilitation may need more intensive support or more supervised training.

After the first 2 months' follow-up, the changes in all the trunk muscle strength parameters were minor in both groups and remained essentially at the 2-month level throughout the remaining 10 months. Thus, there were no significant between-group differences after the 1-year follow-up. In our study, body weight and dumbbells were used for resistance with a constant number of repetitions and always 2 sets per exercise. This suggests that, after the initial 2-month period, the amount and frequency of strength training stimuli remained too low and the stimuli too monotonous, with an overall absence of the progressiveness required to lead to further increases in force output. Kjellby-Wendt and Styf[11] used strengthening exercises at home and reported compliance rates of 75% to 96% for the strengthening exercises and 86% to 90% for the range-of-motion exercises during the 12-week follow-up. Danielsen et al[14] applied supervised intensive exercises in the training group and mild stretching and relaxing exercises at home in the control group for 8 weeks, starting 4 weeks postoperatively. The adherence was not reported for the home exercises but motivation was maintained via a checkup with a physiotherapist every second week. In other musculoskeletal diseases, adherence to the training regimen has been reported to vary between 39% and 75% in long-term follow-ups.[28-30] Thus, our training frequencies were comparable to those of other long-term studies, and it is evident that more patient support is needed if exercise frequency is to be maintained at a high level in long-term follow-up.

Awareness of the importance of long-term, low-cost rehabilitation programs has emerged. Unfortunately, little is known about the effectiveness, optimal timing, and duration of postoperative treatments. For treatments that start 4 to 6 weeks postsurgery, intensive exercise programs have been shown to be more effective in improving functional status and in leading to a faster return to work than mild exercise programs in short-term follow-ups, whereas in longer-term follow-ups the differences have disappeared.[10] According to the review by Ostelo et al,[10] the duration of rehabilitation programs has varied from 1 week to 3 months, and the rest of the follow-up has taken place during the posttraining period. In our study, patients were encouraged to exercise for the whole 12-month follow-up time, and after initial instructions patients' motivation to keep up the strength training or stretching at home was maintained by the scheduled follow-up visits at 2 and 6 months and by the training diaries. Although there was a slight difference in the objective muscle strength parameters during the first 2 months of training, there were no between-group differences after 12 months in any outcome measures used. Furthermore, the number of patients with a positive SLR result showed a similar decrease in both groups, and no differences were found in the number of patients on sick leave or in the length of sick leave. In some studies, the effectiveness of a supervised exercise program has been compared with home exercises. Johannsen et al[31] reported no difference between supervised training and home training starting 4 to 6 weeks postoperatively by using the same strengthening exercises and training intensities in both groups for 3 months after lumbar disk surgery. Danielsen[14] reported that the supervised intensive program reduced pain and increased participation in daily activities better than mild relaxing home training, but no differences were found between the groups after 12 months. In our study, the pain values at the 12-month checkup were at the same level as those reported earlier by Danielsen[14] after 12-month follow-up and by Johanssen[31] after 6 months. Patients may feel satisfied with their improved condition, even with residual mild pain, and may not have the motivation to continue with long-term training at the advised frequency.

CONCLUSIONS

The patients in the STG showed slightly greater improvements in trunk muscle strength than did those in the CG after the first 2 months of training. However, after 12 months of training, the overall outcome measured by physical function, pain, and disability, and by length of sick leaves, was comparable between the groups. Both the training frequency and intensity in this long-term follow-up were possibly too low to lead to the specific training-induced adaptations in the neuromuscular system. In the future, more intensive supervision of progressive training and psychosocial support is recommended for long-term rehabilitation programs, to maintain patients' motivation.

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