Low back strengthening for the prevention and treatment of low back pain

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Abstract

CARPENTER, D.M. and B.W. NELSON. Low back strengthening for the prevention of low back pain. Med.Sci. Sports Exerc., Vol 31, No. 1, pp.18-24, 1999. Purpose: Chronic low back pain (CLBP) remains one of the most difficult and costly medical problems in the industrialized world. A review of nineteenth and twentieth century spine rehabilitation shows that back disorders were commonly treated with aggressive and specific progressive exercise (PRE). Despite a lack of scientific evidence to support their efficacy, therapeutic approaches to back rehabilitation over the past 30 yr have focused primarily upon passive care for symptom relief. Recent spine rehabilitation programs have returned to active reconditioning PRE centered around low back strengthening to restore normal musculoskeletal function. Research has shown that lumbar extension exercise using PRE significantly increases strength and decreases pain in CLBP patients. It appears that isolated lumbar extension exercise with the pelvis stabilized using specialized equipment elicits the most favorable improvements in low back strength, muscle cross-sectional area, and vertebral bone mineral density (BMD). These improvements occur with a low training volume of 1 set of 8 to 15 repetitions performed to volitional fatigue one time per week. CLBP patients participating in isolated lumbar extension PRE programs demonstrate significant reductions in pain and symptoms associated with improved muscle strength, endurance, and joint mobility. Improvements occur independent of diagnosis, are long-lasting, and appear to result in less re-utilization of the health care system than other more passive treatments. Low back strengthening shows promise for the reduction of industrial back injuries and associated costs. Key Words: RESISTANCE TRAINING, LUMBAR EXTENSION, REHABILITATION, INJURY

Spinal disorders are the most frequent cause of activity limitation among people below the age of 45 yr. The rate of physician visits caused by low back pain (LBP) is second only to cardiovascular problems among chronic disorders. Low back pain ranks fifth among the most frequent r4easons for hospitalization and third as a reason for surgical procedures (2). The natural history of LBP (pain less than 3wk duration) is that 33% of all individuals will be pain free within 1 wk regardless of the type of intervention, including none. By 3 wk time 75% will recover, and by 2 months over 90% will recover (3). Therefore, the focus of treatment for acute LBP is to rule out serious underlying conditions (tumors, infection, etc.), control symptoms, and help the patients improve activity tolerance while nature takes its course (5).

The Quebec Task Force on Spinal Disorders suggests that symptoms lasting more than 7 wk be labeled chronic (40). Epidemiological statistics indicate that chronic low back pain (LBP) patients do not enjoy the same prognosis as acute LBP patients. Chronic LBP is the number one cause of disability in the working population. The likelihood of recovery to preinjury status for CLBP patients diminishes rapidly with the passage of time (5). Patients who cannot work because of their spinal pathology and remain symptomatic beyond 1 yr have less than a 25% chance of returning to their jobs (39).

Currently, the medical community is in need of well-designed outcome studies that will better define efficacious treatments for CLBP from those that hold little therapeutic value. In the face of limited scientific data, what treatment advice for the CLBP patient is reasonable? This paper will review the literature to determine the effect of low back strengthening on the treatment of CLBP.

THE EXERCISE PARADIGM

Specific parameters to acquire and maintain cardiovascular and muscular health and fitness have been defined (1). It is generally accepted that physical conditioning is best achieved through the controlled, periodic, and quantifiable application of stress. While exercise dosage may change from patient to athlete, the principles of adaptive overload remain the same.

Few would argue the importance of exercise conditioning in cardiovascular and general orthopaedic rehabilitation. Control of pain and inflammation. Early mobilization, and specific exercise with progression of intensity remains the standard course of treatment because it has the best chance to restore normal cardiovascular and musculoskeletal function. But what about low back rehabilitation? Despite the

0195-0131/99/3101-0018$3.00/0
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Submitted for publication June 1997.
Accepted for publication May 1998.

magnitude of its medical and socioeconomic impact and the variety of disciplines that have researched and treated it, there is no consensus in the literature as to the most effective treatment for low back pathology. Further, even in the face of overwhelming evidence to support the exercise paradigm for nearly all types of physical rehabilitation, there remains considerable doubt as to the value of exercise applied to chronic low back disorders (18).

EARLY LESSONS IN SPINE REHABILITATION

Like many aspects of muscle strengthening, some of the first recordings of low back exercise have a Western European origin. Interestingly, strengthening exercises were initially used for physical therapy rather than general conditioning. In the early nineteenth century, the Swede Ling developed a program of exercises aimed at physical restoration of injured patients (17). The program, which became known as remedial or Swedish gymnastics, included exercises for trunk flexion and extension. Unique to Ling's program was the concept of exercising an isolated muscle group against a resistive force. Ling also believed that a patient's exertion level (and resistive force) should be increased gradually as healing occurs. Resistive force for each exercising muscle was provided manually by the physiotherapist, which proved demanding and difficult to quantify, particularly as the therapist fatigued over the course of a day.

From 1857 to 1920, a Swedish physician named Zander advanced the theories of Ling by developing a system of strengthening exercises that utilized mechanical devices that Zander himself designed and built (19). Zander's application of mechanics to exercise was based upon the premise that, by controlling and standardizing resistive forces, muscle exertion could be better quantified. Machines also relieved the therapist from having to manually provide resistance. Through the use of restraint mechanisms and weighted lever arms, Ling's principles of muscle isolation and progressive resistance were inherent in Zander's designs. Zander's concepts and innovations led many fellow physicians to develop exercise programs that emphasized back strengthening.

Despite early advances, the amount and type of exercise prescribed for muscle strengthening remained a subjective and discretionary judgment of the physician or physical therapist. This situation changed in the 1940s when DeLorme and Watkins (8) introduced their system of progressive resistance exercise (PRE). DeLorme and Watkins' system of PRE was the first to quantify objectively muscle strengthening by controlling exercise intensity (% repetition maximum), volume (sets and repetitions), and frequency. Principles of PRE called for specific and periodic overload of isolated muscles through the use of barbell and weighted cable-pulley type exercises. Specific low back resistance exercises were developed to treat chronic psychosomatic back pain, muscle atrophy consequent to spinal fusion, degenerative joint disease, low back strains, and even poliomyelitis. Particular care was given to ensure isolation of the lumbar extensor muscles by preventing concurrent hip extension. The goal of such exercise was to return the patient to a normal level of physical functioning. To that end, DeLorme and Watkins noted a gradual resolution of symptoms associated with back pain as exercise weight loads and trunk muscle strength increased.

In 1958, Flint (10) published a study, which demonstrates the effectiveness of high intensity PRE for the treatment of CLBP. Nineteen subjects suffering from back pain were evaluated for one repetiti0on maximum (IRM) strength before and after a 12-wk exercise program. The program consisted of 10-RM trunk flexion (two sets) and extension (one set) progressive resistance exercises performed three times per week. To provide specific exercise for the low back, a specialized slant table was used that allowed subjects to extend their trunks backward from a flexed position with the lower body secured. Resistance was provided by weights attached to a cable-pulley system and connected to a vest harness worn by the subjects. A control group of 27 subjects free from back pain were tested and exercised in the same manner to allow for strength comparisons. Both the patient and control groups demonstrated similar and significant improvements in trunk flexion and extension strength from the training program. Of the back pain patients, 58% reported a complete resolution of back pain, 31% reported partial relief, and 11 % experienced no relief.

What lessons did 100 yr of back strengthening provide? The need for muscle overload is most dominant. Whether it be in the form of barbells or machines, mechanical overload has formed the basis of most programs, presumably because of its ability to quantify effort. Progression of exercise intensity through adjustable resistance also proved a consistent theme. Additionally, nearly all historical recordings of strengthening devices and programs recognized the need to stabilize the lower extremities in an effort to isolate and exercise the low back musculature. Finally, these principles were developed to affect low back function, including muscle strength, endurance, and joint mobility. A review of "modern" spine care over the past 30 yr shows that these early concepts were abandoned in favor of passive modalities that predominantly treat symptoms.

PASSIVE VERSUS ACTIVE TREATMENT

Despite the number of conservative care treatments available to the CLBP patient, few have met the challenge of vigorous scientific investigation. Chronic LBP treatments that have become standard, even in the absence of scientific data which supports their efficacy, include bed rest, passive modality therapy (i.e., ultrasound, electrical stimulation, diathermy, massage, traction manipulation enzyme injections, hot packs, cold packs, etc.), medications, stretching, back schools, and pain clinics (32). A common denominator among these treatments is that, because they are passive in nature, they do not elicit healing through positive physiological adaptation. While they may serve to relieve acute pain, the continued application of passive therapies beyond

6 wk from a soft tissue injury adds an unnecessary layer of treatment costs and is of little proven value in the management of CLBP.

Because of their association of physical activity with increased pain, CLBP patients often avoid using backs (25). Their decreased joint mobilization is associated with the wasting of trunk musculature, a decrease in muscular strength/endurance and cardiovascular fitness, stiffness of ligaments and joints, reduced metabolic activity, and an increased susceptibility to sprains, strains, and muscle spasms. These deleterious effects of muscle/joint disuse provoke symptoms, causing greater avoidance of activity. This cyclical pattern of pain/avoidance of activity/ deconditioning/more pain, referred to as the "Deconditioning Syndrome," is a defining characteristic of the CLBP patient (22). A number of studies have shown that CLBP patients have significantly lower trunk strength when compared with healthy controls (25, 30, 38). In addition, weak trunk musculature has been found to be an important risk factor for low back problems (6). Likewise, individuals with greater levels of muscular strength and endurance and cardiovascular fitness will have fewer spinal problems (6, 22, 30). Mobilization of the spine has also been shown to reverse biochemical changes caused by injury, which may help to alleviate LBP (26). Currently, there is general consensus in the literature which supports the need for active reconditioning exercise in the treatment of CLBP (5). Unfortunately, there is little agreement as to which exercise regimens are most effective at producing optimal therapeutic outcomes.

The fact that many CLBP patients have participated at one time or another in exercise programs without significant symptom relief may lead some clinicians to question the value of this treatment choice. However, it is important to acknowledge the difference between movement and meaningful exercise. Athletes do not become better conditioned by simply lying on the floor and moving their joints and limbs. Conditioning occurs only through the controlled application of progressive and intensive overload. In this sense, CLBP patients are no different than athletes. William's flexion and McKenzie extension calisthenics movement for the spine are commonly prescribed for LBP, but lack the necessary requirements that facilitate adaptive responses in deconditioned tissue (27). For example, increases in external resistive load to the muscles are limited by the constraints of body segment weight. Such movements fail to provide a meaningful level of muscular resistance throughout a full range of joint movement. Perhaps of greater importance relative to low back rehabilitation, calisthenics-type floor exercises do not isolate the low back muscles because the pelvis is free to move.

PELVIC STABILIZATION AND ISOLATED LUMBAR FUNCTION

Pollock et al. (34) have discussed factors that influence the accurate assessment of low back (lumbar extension) strength in detail. Pelvic stabilization is among the key requirements for accurate measurement and training of the

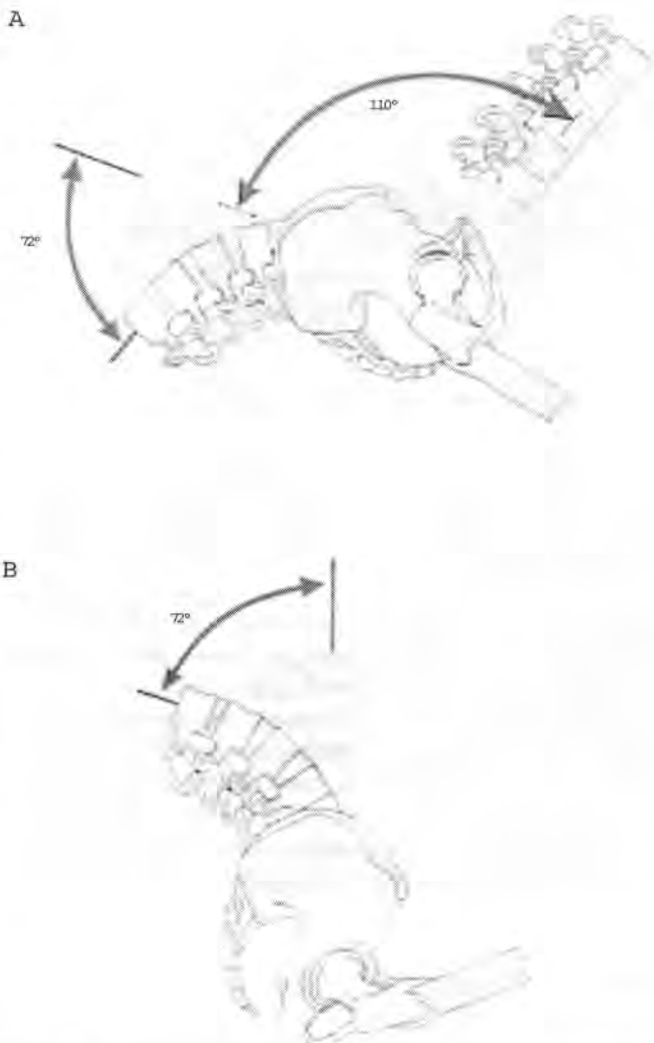

Figure 1–A) Compound movement usually involved in trunk extension. Contraction of the gluteal and hamstring muscles produces 110° of pelvic rotation about the femurs. Simultaneousl contraction of the lumbar extensor muscles produces 72° of lumbar vertebral movement. B) Isolated lumbar function with the pelvis immobilized.

lumbar extensor muscles. Figure 1A shows the relationship between pelvic and lumbar movement. Contraction of the hip extensor muscles is responsible for pelvic rotation, through approximately 110°. Throughout this movement, the lumbar vertebrae maintain their relative position to one another. When the pelvis is immobilized, the lumbar vertebrae extend as the low back muscles contract and move the lumbar spine through 72° (Fig. 1B). Other investigators have documented the need for pelvic stabilization during dynamometry measurements of lumbar extension strength (12, 31, 38).

Recent advances in the design of exercise equipment have improved the efficiency and effectiveness of resistance training. Although there are a number of commercially available devices purported to exercise the low back, few actually affect the lumbar extensor muscles because of their inability to fixate the pelvis. Graves et al. (14) compared the effects of intensive training with various back machines

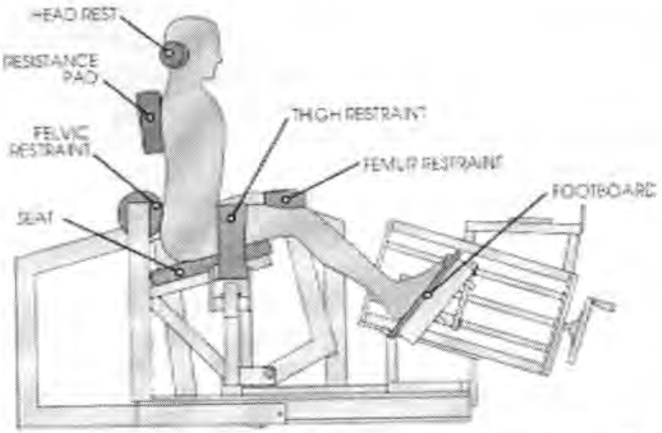

Figure 2–Restraint system of the lumbar extension machine used to isolate the lumbar extensor msucles for progressive resistance exercise. With the femur and thigh restraint tightened, the pelvis is immobilized, thereby preventing hip extension (gluteals and hamstrings) from influencing the exercise.

on the development of isolated extension strength. The study showed that exercise performed on a lumbar extension machines that isolates the lumbar muscles by pelvic stabilization resulted in a dramatic increase in low back strength, while training on low back machines that did not stabilize the pelvis yielded no improvement. The lumbar extension machine (MedX Corp., Ocala, FL) is unique in its ability to isolate the lumbar muscles by stabilizing the pelvis with specially designed restraints (Fig. 2).

LUMBAR EXTENSION EXERCISE PRESCRIPTION

Pollock et al. (35) have shown that the lumbar extensor muscles have an unusually large potential for strength improvement when isolated through pelvic stabilization and exercised with a low training volume. Fifteen healthy, asymptomatic subjects trained on a lumbar extension machine one time per week for 10 wk. Training consisted of one set of 6 to 15 repetitions of lumbar extension exercise to muscle fatigue. A control group performed no training. The exercise group showed a significant and dramatic increase in lumbar extension strength when compared with the control group, which showed no change (Fig. 3). The magnitude of strength gained by the training group (42% at full flexion to 102% at full extension) indicates that the lumbar muscles were initially very weak and have a large potential for improvement

To determine the effect of training frequency on the development of lumbar extension strength, Graves et al. (13) randomized 72 healthy, asymptomatic subjects into groups that trained every other week, once per week, twice per week, three times per week, or a control group that did not train. Training consisted of one set of isolated dynamic lumbar extension exercise to fatigue with the pelvis stabilized over a 12-wk period. The results showed that all training groups significantly increased in lumbar extension strength when compared with controls; however, there was no difference among the groups with respect to the magnitude of strength gained. These data indicate that a lumbar extension training frequency as low as one time per week is as effective as two or three weekly training sessions. The lumbar extension muscles appear to be unique in this regard, with other muscle groups needing greater frequencies of training (9). Further research is needed to determine the mechanisms that cause training frequency differences among various muscle groups.

In addition the improvements in strength, training of the isolated lumbar extensor muscles has been shown to significantly increase lumbar vertebrae BMD and erector spinae cross-sectional area (CSA). Pollock et al. (33) randomized a group of elderly subjects (60 – 82 yr of age) into a training group (N = 17) that performed one set of 10-15 lumbar extensions to muscle fatigue one time per week and a control group (N = 6 that did no low back exercise. Before and after the 6-month study period, subjects were assessed for lumbar extension strength and lumbar BMD (L2, L3, lateral perspective). The results indicated a significant improvement in both lumbar strength and BMD in the training group, while the control group showed no change. To determine the effect of isolated lumbar extension exercise performed one time per week on erector spinae CSA, Foster et al. (11) studied a group of 9 male subjects over a 6-month training period. Magnetic resonance imaging (MRI) was used to measure right and left erector spinae CSA before and after the training program. Subjects performed one set of 8 to 12 lumbar extensions to muscle fatigue one time per week. The results showed significant increases in lumbar extension strength and right and left side erector spinae CSA.

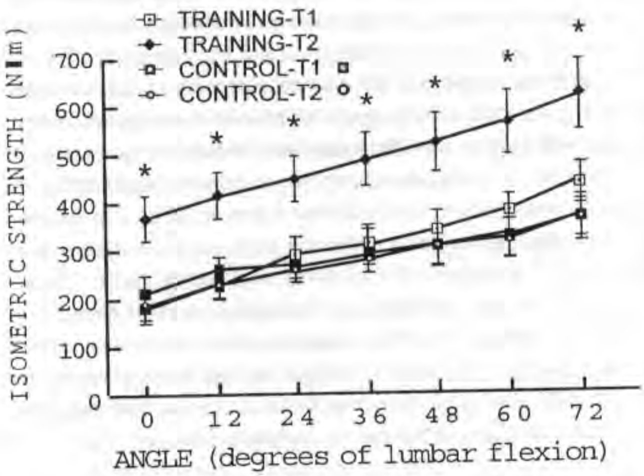

Figure 3–Torque measurements for lumbar extension isometric strength of the control and training groups. T1 and T2 represent measurements before and after the 10-wk study period. Training consisted of one set of 6 to 15 repetitions to muscle fatigue one time per week. Values are means and ± SEM in newtom-meters. Graph is from reference 35. Pollock, M., S. Leggett, J. Graves, A. Jones, M. Fulton, and J. Cirulli. Effect of resistance training on lumbar extension strength. Am. J. Sports Med. 17:624-629, 1989.

LUMBAR EXTENSION EXERCISE REHABILITATION PROGRAM

Contemporary rehabilitation programs have addressed deconditioning and disability in CLBP patients using a "functional restoration," sports medicine approach to industrial back injury (22). Functional restoration programs are multidiscipline and typically include a combination of short-term, intensive medical, psychological, physical, and occupational therapy. A number of studies have shown that CLBP patients can benefit from these programs by a reduction of LBP and the need for less additional health care following treatment (16, 23, 24). Functional improvements have included improved trunk strength and mobility and resulted in a greater lifting capacity.

Manniche (20) studied the effects of PRE on 105 CLBP patients randomized into three groups. A usual care group received hot packs, massage, and mild flexion exercises two times per week for 4 wk. A high intensity exercise group performed 50 sets each of hip extensions, back extensions, and pull downs three times per week for 4 wk, then two times per week for an additional 8 wk. A low intensity exercise group used the same regimen as the high intensity group, but performed 20 sets of each exercise. The high intensity group improved significantly in endurance (prone trunk hang) and back mobility, while reducing pain, disability, and physical impairment. The usual care and low intensity exercise groups showed little or no change. A subsequent study confirmed that intensive exercise performed at least one time per week over a 1-yr follow-up period can maintain improved symptomatology (21). Unfortunately, many studies investigating the effects of exercise on CLBP contain numerous methodological shortcomings (18), and/or did not isolate the lumbar muscles, thus making it difficult to determine the role of specific low back exercise in the treatment of LBP. In addition, specific prescriptions that delineate resistive exercise intensity and frequency (dosage) were not adequately reported.

Recent data have shown that CLBP patients demonstrate positive therapeutic outcomes from a specific dosage of isolated lumbar extension exercise with the pelvis stabilized. Patients also reported a significant reduction in LBP and improvements in functional status. In a randomized, controlled experiment, Risch et al. (37) examined the effects of isolated lumbar extensor exercise in 54 patients suffering from CLBP for an average of 8 yr. Patients were randomly assigned to a 10-wk exercise program or a wait-list control group. Treatment consisted of 8 – 12 repetitions of isolated lumbar extension exercise to fatigue two times per week for the first 4 wk and one time per week for the remaining 6 wk. Results indicated a significant full range-of-motion increase in isometric lumbar extension strength for the treatment group and a significant reduction in reported pain compared with controls who showed no change. Treated patients also reported less physical and psychological dysfunction.

Nelson et al. (30) tested the long-term efficacy of aggressive, isolated lumbar extension exercise in a nonrandomized, controlled study of 895 consecutive patients suffering from CLBP for an average of 26 months. A total of 627 patients completed the program, while 107 patients were evaluated and recommended for inclusion into the program but for various reasons did not enroll and served as a control group. One hundred sixty-one patients initiated treatment but for various reasons dropped out for completion. The treatment consisted of PRE to muscle fatigue for the isolated lumbar extensor and torso rotation muscles over an average of 18 visits (approximately 8-10 wk). Treated patients significantly improved in isometric lumbar extension strength and ROM, and dynamic lumbar extension and torso rotation strength. Patients in the treatment group also showed substantial improvements in LBP, leg pain, and ability to perform daily activities. Those patients that showed greatest improvements in symptomatology also demonstrated the largest increases in lumbar extension strength. At 1 yr follow-up, patients in the treatment group had maintained their improvements in symptomatology and had less utilization of the health care system compared with the controls. Thus, aggressive strengthening of the isolated lumbar extension muscles for the treatment of CLBP in this study resulted in significant improvements in measurable low back function and lasting reduction in symptomatology with less use of the health care system. Interestingly, patients in the treatment group were able to achieve these improvements despite the fact that they had, on the average, tried six conservative treatment modalities and seen three health care providers before entering the program.

LOW BACK INJURY PREVENTION

A variety of programs have attempted to reduce the incidents of industrial low back injuries, including workplace evaluation and design, pre-employment screening, occupational strength testing, workplace simulation, vocational intervention, and management/worker education and training (36). Despite these efforts, worker's compensation costs related to back disorders continue to escalate (29). A limiting factor of ergonomic training and education programs is that they are primarily designed to protect the worker while on the job. How is the worker protected from back injury the remaining two-thirds of the time away from the job? One possible solution is to improve the structural and functional capacity of the lumbar spine through a low back exercise program. Load-bearing dynamic exercise has a beneficial effect on the properties of bone, ligament, tendon, and muscle (41). As discussed earlier, isolated low back strengthening programs have been shown to elicit positive bone and muscle adaptations in the lumbar spine (11, 33). Since workers with low levels of muscular strength suffer a higher incidence of back injury (7), it is reasonable to expect that strengthening the low back architecture may reduce the risk of back injury both at and away from the workplace. Several studies have investigated the relationship between worker physical fitness levels and back injury (4, 6), but the findings are equivocal and have centered mainly on cardiovascular conditioning.

Gundewall et al. (15) published a controlled, randomized study to determine whether a program designed to improve back strength, endurance, and coordination would effect the occurrence of low back pain among nurses and nurse's aides in a geriatric hospital. Sixty-nine subjects were randomized into a training group (N = 28) or a control group (N = 32) that did not exercise. Training consisted of calisthenics-type back extension exercises that used body weight, elastic bands, or hand-held weights as resistance. Exercise sessions occurred during working hours and averaged six per month over a 13-month period. Intensity of the exercise was increased periodically through individual training sessions with a physiotherapist. Subjects in the training group showed a significant increase in back muscle strength. One subject was absent from work 28 d in the training group compared with 12 subjects absent from work for a total of 155 d in the control group. Back pain complaints and intensity of pain decreased significantly in the training group. Unfortunately, since subjects in the training group performed a variety of back exercises designed to affect different aspects of neuromuscular function, the results cannot be attributed solely to improvements in muscle strength.

A recent study has demonstrated the positive effects of an industrial spine injury prevention program in a Montana coal strip mine utilizing a specific program of isolated low back muscle strengthening (28). A group of employees performed lumbar extension exercise to muscle fatigue one time per week for 20 wk and were compared to a nonexercising group. Exercise was performed during working hours on a lumbar extension machine, which isolates the low back muscle by preventing pelvic movement (Fig. 2). There was a 54 to 104% increase in low back strength in the exercise group. The incidence of back injuries in this group was 0.52 injuries per 200,000 employee hoursversus the industry average of 1.09 back injuries per 200,000 employee hours. The average incidence of injury for the previous 9 yr at the coal mine was 2.94 injuries per 200,000 employee hours. The injury incidence in the workers not exercising was 2.55 injuries for 200,000 employee hours. The average workers' compensation liability dropped from $14,430 per month to $380 per month over the study period. The significant increase in strength associated with the exercise group correlated with the greatly reduced incidence of back injury claims.

SUMMARY

Chronic LBP us a difficult and costly problem to address. Nineteenth century spine rehabilitation programs emphasized intensive, progressive resistance exercise to restore a weak, deconditioned musculoskeletal system to normal levels of function. This treatment approach remained popular well into the twentieth century until the emergence of passive modalities, which redirected patient care toward symptom relief. Unfortunately, passive care does not address underlying dysfunction and fosters an ongoing, costly reliance upon the health care system. Research over the past 10 yr suggests that CLBP is best managed by specific, progressive, and intensive lumbar extension reconditioning exercise with the pelvis stabilized. Isolated lumbar extension resistance training significantly improves lumbar muscle strength, CSA, and BMD with a minimal training volume of one set of 8 to 15 repetitions performed to muscle fatigue one time per week. Chronic LBP patients who participate in a low back strengthening program can expect significant improvements in muscular strength, endurance, and joint mobility, as well as relief of pain and symptoms. Additional randomized, controlled studies should help to delineate further the role of isolated lumbar extension exercise for the treatment of CLBP and to test its efficacy against other methods of care. Specific low back strengthening shows promise for decreasing industrial back injuries and reducing associated worker's compensation costs.

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