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Evidence-Informed Management of Chronic Low Back Pain with Lumbar Strengthening and McKenzie Exercise

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ABSTRACT: There are basically two ways to change the structure in the painful spine, which include the use of strengthening exercises or repeat movements, which are guided by pain response. In this article, we take the position that strength training can only rationally be achieved by using exercise equipment that enables the knowledge of range, resistance, and number of repetitions on each exercise occasion. Without translating exercise into numbers, information that is available when using exercise equipment, progress is very difficult to define. The same is true with repeated movements, which can alter the location of pain. Such is the case with McKenzie testing, wherein centralization of the pain is the goal of the repeated movements. Adverse movements are defined those that cause peripheralization of the pain radiating into the extremities. Changing the internal status of the disc is the assumed function of repeated movements. The justification of these maneuvers is demonstrated by definable endpoints of improved function.

KEY WORDS: progressive resistance exercise, muscle isolation, progressive overload, mechanical diagnosis and therapy, repeated motion

I. INTRODUCTION

In this article, we take the position that exercise is the only noninvasive treatment that is able to change the structure in individuals who suffer from chronic back pain. However, the very diverse passive treatment methods for this common, often disabling condition are a very significant aspect of the treatment problem. The varied approaches were recently summarized in a supplement of the *Spine* journal, titled "Evidence-Informed Management of Chronic Low Back Pain without Surgery."[1] Twenty-four different interventions were profiled, with each article required to present evidence of their benefit. In the summary of this extensive review, the editors indicated that the only methodology with consistent supportive scientific evidence was exercise.

Resistance exercise and stretching with directional preference are the focus of this article, and both have good physiologic justification and a rationale of support in the literature. In an effort to gain more insight into the development of the rationale for these forms of treatment, we will devote a portion of our discussion to the history of the concepts.

II. JUSTIFICATION FOR STRENGTH TRAINING

Is muscle weakness the cause of back pain? It is unlikely; no one has ever defined atrophic muscles as painful. Does weakness of the vastus medialis cause knee pain? Of course not; there must be some underlying structural damage within the knee. The same is true for low back problems. Diminishing the effects of the structural abnormalities causing symptoms is the goal of exercise.

Back pain is extremely common. It is also clear that once back pain has occurred, approximately 90% of patients suffering from the first episode of

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acute low back pain will be asymptomatic within 3 months.[2] However, there is a very high recurrence rate of 40%–60% among those patients who are suffering from low back pain for the first time.[3]

In addition, there are morphological changes in the lumbar extensor muscles that exist in those patients suffering from low back pain.[3] This fact, of course, leads us to question whether or not muscle weakness is the cause of the first onset of back pain, which seems unlikely because there are no studies to support that concept. We completed a study of shipyard workers, in which strength testing of the lumbar spine was performed with a large group of experienced workers who did not previously have back pain.[4] We followed the study participants for 2 years, and there were 12 claims for work-related back pain. Ten of these individuals tested as average or slightly above average in isolated isometric testing over the full range of motion; only two workers were slightly below average.[4]

On the other hand, there is a discrepancy between claims of back pain in the workplace and the incidence of back pain. In another study that we conducted at a strip mine, about one third of the workers had complaints of back pain, although, at the time of the study, they were not making claims.[5] In an effort to reduce significant rates of back injury claims, a specific once-a-week training program for lumbar extensor strengthening was instituted. Only about one half of the workers volunteered for this program, but 80% of this group had some back pain in the past. These workers tested weaker than those without past back pain, and this deficit was correctable with training. The incidence of back injuries at the mine fell from 1.5 per month to a total of 1 day off during the whole next year for those workers who participated in the training. These results demonstrate that a strengthening program can be successful in reducing injuries.

A similar experience has been demonstrated with airline employees. An injury prevention program was conducted with two major airlines in the United States (airline A and airline B). Voluntary participants included ramp workers (baggage handlers), flight attendants, and pilots. The study participants exercised their isolated lumbar extensors once per week, and their low back strength increased 80%. Both airlines demonstrated similar savings. Although the data acquisition time (airline A: 20 months; airline B: 6 months) and number of workers were different (airline A: n = 622; airline B: n = 373) for these data sets, both demonstrated significant back strength gains, decreased injury rates, and cost reduction against large control groups (airline A = 2937; airline B = 2219). Participants from airline A showed a 78.5% increase in strength and those from airline B showed an 80% increase. Annualized injury rates for the exercising employees were 5.7 and 7.9 per year in airline A and airline B groups, and 179 and 256 in the control groups, respectively. The nonexercising control groups were 6.6 (airline A) and 5.5 (airline B) times more likely to be injured than the exercising workers. When the annualized cost savings (work comp direct + indirect costs) per employee per year for the exercisers versus the control group were considered, the costs per injury were $206 for airline A and $63 for airline B, contrasted with $4883 and $1223 in the nonexercising groups. These data led to a return on investment of 10/1 and 6.4/1, respectively, for airline A and airline B. In addition, when the employees were surveyed, all of them rated the program as either good or excellent.[6]

Where is the weak link? For many years, it was thought to be in the abdominal musculature. In the 1960s, Williams crystallized the common concept regarding the cause of recurrence and the appropriate focus of training.[7] His opinion was that the reversal of lumbar lordosis would yield more room in the neural foramen. Williams also suggested that abdominal strengthening would increase intra-abdominal pressure, which is necessary for torso control. Even now, a significant number of clinicians regard abdominal strengthening as the main exercise mode. Thus, the continued prescription of so-called Williams's flexion exercises is common.

Despite considerable data identifying the weak link as being in the lumbar extensors, the erroneous concept of the abdominal musculature as the weak link persists.

A. Documenting the Weak Link

As radiographic techniques such as computed tomography (CT) and magnetic resonance imaging

(MRI) became available, they made it possible to create axial views of the lumbar area. It became clear that the lumbar extensors, and especially the multifidus, were atrophic associated with back pain when compared to other muscles in the torso. Alaranta et al. made this observation by using CT scanning; the more severe the back pain, the greater the atrophy observed in only the lumbar extensor muscles.[8] Parkkola et al. reported similar findings in that the lumbar extensors of patients with chronic low back pain had a greater amount of fatty infiltration as noted by MRI.[9] Mayer et al. used CT technology and showed a significant amount of atrophy in the extensors in postoperative patients.[10] Investigators have noted similar findings by investigators using electromyography (EMG) techniques. Studies have demonstrated that inhibition existed in the lumbar extensors, whereas the lumbar flexors functioned normally.[11–13] Our research has revealed similar findings. In a prospective study of a series of patients with chronic low back pain compared to healthy individuals, we found that there was considerable muscle atrophy with fatty infiltration in patients with chronic back pain.[14] This was quite specific in that other torso musculature as well as the iliopsoas showed no fatty infiltration or muscle atrophy. When tested, the individuals in this series with back pain averaged 35% below the expected normal strength during isometric testing of extension over the full range of motion. With training, muscle strength was able to return to normal; however, the inhibited surface EMG scans for the extensors showed considerable modification as the muscles strengthened. At the conclusion of treatment, the total amount of myoelectric activity was reduced for the same initial resistance with strength training, resulting in clinical improvement.

Hodges and Richardson conducted one of the most sophisticated myoelectric studies to date by using fine wire electrodes that were placed in the torso musculature under ultrasound visualization, resulting in some significant observations.[15–17] These studies highlighted that, in the case of low back, the activation of the multifidus and transversus abdominis was delayed by approximately 200 milliseconds compared to healthy individuals. Therefore, stabilization of the torso was slightly delayed when upper extremity activity was initiated. This also was true for lumbar activity such as flexion and rotation, which seem to make the trunk more vulnerable to physical stress in the case of an unguarded moment.

Hides and colleagues also made a significant observation regarding the atrophy of the multifidus muscles. The researchers used real-time ultrasound technology to study patients with first-time onset of unilateral back pain, and followed them with ultrasound measurements of the lumbar extensor musculature. The results showed that atrophy occurred rapidly, sometimes within weeks, in the multifidus on the symptomatic side. Moreover, this atrophy persisted even after there was spontaneous resolution of the symptoms.[18,19] A recent study indicates that the unilateral atrophy, which occurs only in the once-symptomatic side, persists even when it is no longer symptomatic, largely in the shorter, deeper multifidus fibers.[20]

B. The Physiologic Justification of Early Atrophy

Although the findings of unilateral atrophy on the symptomatic side may be surprising and even suspect, this is not a unique physiologic phenomenon. All clinicians are aware of the rapid atrophy of the vastus medialis soon after a knee injury. This atrophy can even be created by the painful stimuli that emerge simply from knee effusion. The atrophy is caused by the reduced neural drive to the musculature based on inhibitory processes. The specific area of atrophy cannot be caused by some disuse phenomenon, otherwise it would be much more generalized. Hodges et al. recently explored this phenomenon in an animal study, in which they used pigs to conduct a comparative study of muscle mass after three experimental conditions.[21] One condition was merely a sham incision but created no structural damage; another condition was a medial branch transection of the L3 dorsal ramus; and, finally, the last condition was an incision of the L3–4 disc with laceration of the annulus. As a result, rapid atrophy occurred at the L4 disc level of the multifidus muscles; however, no change occurred from the sham incision. The multifidus muscle has three fascicles from deep to superficial, and range in various levels of attachment to the spinal segment. With

the injury to the L3–4 disc, however, the atrophy only occurred at the L4 level, which suggests that there is a specific inhibition of the musculature. Atrophy persisted in the pigs that were examined in the study of Hodges et al. These results, of course, reflect the same observation in humans, which noted that after an acute episode of low back pain, the multifidus cross-sectional area did not resolve spontaneously and was present to the same degree when retested 4 weeks after the onset of symptoms.[22] After transection of the dorsal ramus of the L3 nerve root, the cross-sectional area was reduced over three segments rather than merely at the level of damage (L4). At present, the mechanism is unclear in terms of how some structural damage to the disc in humans creates this phenomenon; however, it is apparent that some reflex feedback to the central nervous system must be an important phenomenon that later leads to the inhibition of neuromotor activity.

In summary, it is clear from the discussion above that lumbar extensor function, specifically in the multifidus musculature, is reduced on the occasion of symptomatic back injury. Neurologic inhibitory factors are important because atrophy of the extensors occurs rapidly in individuals with symptoms of back pain.

Multiple studies have described multifidus function as a deficiency in chronic low back pain by multiple studies. This deficiency is particularly notable in the abdominal flexors, which remain normal.[23] An important aspect of multifidus function is the more rapid fatigability of this muscle.[12] In a unique study using specialized MRI analysis, Flicker et al. demonstrated that the multifidus fatigued more rapidly than any other torso musculature, which was true in both normal healthy persons as well as patients with chronic back pain.[24]

III. SHORT HISTORY OF THE DEVELOPMENT OF THERAPEUTIC SPINAL EXERCISE

Therapeutic exercise, in general, is a rather recent form of therapy in medical care. The medical applications of exercise likely began with the Central Institute of Gymnastics in Stockholm, established in 1813 by Per Henrik Ling. Ling was appointed as a fencing master at the University of Uppsala in 1805 and developed a series of exercises originating from the craft of fencing. He then elaborated a system of gymnastics exercises and maneuvers divided into various categories such as pedagogical and medical, military, and aesthetic. The Royal Gymnastics Central Institute was established in 1813 by a grant from the Swedish government. Over time, Ling made claims of being able to cure diseases, such as arthritis and scoliosis, and to hasten delivery in obstetrical care, by using exercise. Ling was elected a member of the Swedish General Medical Association in 1831.[25]

Gustav Zander, a Swedish physician, was a student who was initially in the Ling curriculum and was impressed by the concepts. Ling had coined the terms *eccentric* and *concentric* exercise and had developed a protocol of progressive resistance exercises. However, the progressive exercises were performed against the manual, hands-on resistance methods that were used by therapists; thus, the amount of exercises was variable, based on the fatigue of the therapist. In an effort to be more consistent and offer a more specific method of muscle group-isolated strengthening, Zander developed what he called *medical mechanical therapy system*. Eventually, Zander went on to create 40 different pieces of equipment that allowed variable resistance exercises based on a series of weights, levels, and gears.[26]

Although the medical community did not initially accept the claims of potential medical benefits from these new techniques, demonstration of their efficacy was documented by the fact that Ling was elected to the Swedish General Medical Association in 1831. Zander opened up the Medical Mechanical Institute in 1857, and he was elected to the Swedish Institute 10 years later. Zander's equipment spread around the world and, by the turn of the century, there were 200 facilities in locations ranging from Australia to New York City. The system faded, however, as hospitals emerged with their insistence on sterility and with the therapeutic philosophy of proper hygiene, appropriate nutrition, and prolonged rest. As late as the 1930s, women delivering babies in the hospital tended to stay for a week to 10 days. Therapeutic exercise was not considered of medical interest. The concept of rest as applied to back pain persisted until the 1990s. Bedrest and traction were certainly the main themes of the

training programs. For many of the older physicians today, these concepts remain.

It took perhaps a war to rediscover the benefits of progressive resistance exercise, as developed by Zander and Ling. Dr. Thomas DeLorme transferred the concepts he had learned as a world-class weightlifter to the treatment of injured joints. At the beginning of World War II, before the importance of rehabilitation systems emerged in the medical community, troops who required knee surgery for a torn meniscus while in training were discharged with what was then assumed to be a permanently injured joint. DeLorme, however, documented that progressive resistance exercise to the knee and other joints by using weights and progressive repetition could restore normal function.[27] The injured or postsurgical troops did not have to be discharged. However, after World War II, the concepts of rehabilitation by using progressive exercises slowly faded in favor of electronic systems including ultrasound, massage, heat, cold, and so forth. Incidentally, the concepts of Ling and Zander were completely unknown to DeLorme. He first became aware of Zander equipment when, as an orthopedic surgeon at Harvard with an interest in rehabilitation, he was approached by an administrator about what he should do with the dusty, unused equipment (Zander's) in the basement of Massachusetts General Hospital.

The value of muscle isolation, progressive overload, and documentation of progress by using exercise equipment were once again discovered, this time for sports, by Arthur Jones. Jones invented Nautilus equipment.[28] The fact that he published all of his findings and experiences in *Iron Man* magazine indicated that the earlier interest in this exercise system was focused at the health enthusiast, and not to the medical context community. Jones, too, was completely unaware of Zander and Ling, and only became aware of their work in conversations with Dr. DeLorme. Because the concepts of lumbar extensor deficiency were gradually emerging, the value of isolation and progressive resistance exercise related to low back deficiencies became apparent. On the basis of these findings, Jones proceeded to develop MedX equipment for the specific application as therapeutic exercise to the spine (Fig. 1). This equipment was developed in the academic environment of the University of Florida. Thus, specific protocols based on extensive human testing were developed.[29]

The next section of this review focuses on the clinical application of strength training.

IV. THE FUTURE OF THERAPEUTIC STRENGTH TRAINING FOR LOW BACK PAIN

The impact of therapeutic strength training for low back pain is quite minimal, as documented in a recent review of nonoperative care for chronic low back pain, in which there were 24 chapters written by various experts in this field, but only one focused on lumbar extensor training.[30] This minor visibility in the broad array of back treatments demonstrates a current and perhaps future application for treatment. This is despite the fact that one of the few solid scientific observations concerning back pain is the recognized delay in activation of the multifidus in individuals with back pain compared to those without back pain. This delay was associated with a delay of the transversus abdominis.[16] Other authors have also noted the atrophy of the multifidus,[31] and therefore it seems quite reasonable that strengthening of this musculature would be appropriate. Atrophy was observed in patients who had complaints of persistent back pain with an unknown cause.

Of course, in chronic back pain, there are no pathognomonic signs for this problem on physical examination and even on standard imaging studies. Radiographs and MRI and CT scans do not define the back pain problem.[32] Defining back pain is extremely difficult because of the lack of pathognomonic findings during a regular physical examination. For that reason, we focus on the McKenzie rationale later in this article, which discriminates different types of back pain and their associated treatment.

Back pain has led to an abundant use of diagnostic and therapeutic procedures.[32] For example, there was a 543% increase in facet injections from 1997 to 2006 in Medicare beneficiaries. There was also a 518% increase in discography and a 159% increase in epidural procedures. Because of the limited scientific basis for these procedures, there is a 14-fold difference in the application of these procedures across the United States.

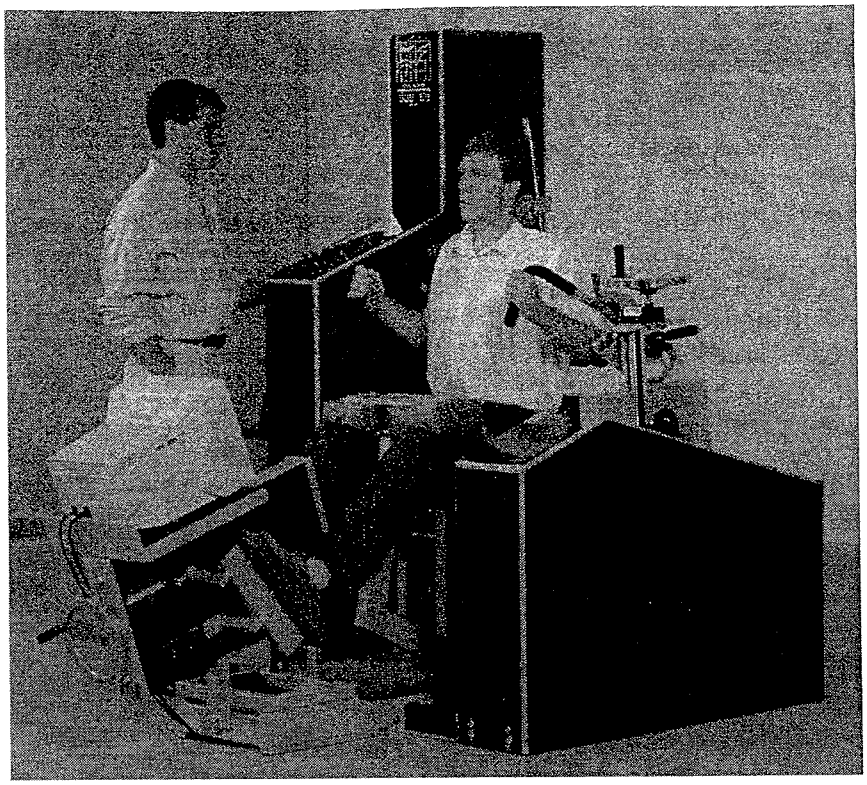


FIGURE 1. A testing device for measurement of strength and range of motion of the lumbar spine. (Reproduced with permission from MEDX LIMITED, Ocala, FL.)

Nonetheless, there is rationale for strength training, which was well identified in a recent article by Mayer et al. published in *The Spine Journal*.[30] The American College of Sports Medicine notes that there are guidelines for strength training that are focused on frequency, intensity, volume, duration, and mode.[33]

A. Current Justification for Strength Training Rationale

Strength training should have the opportunity for overload.[34] Science has demonstrated that intensity must be increased to produce strength training. However, progressive overload should be gradual in intensity and volume, particularly in treating patients with chronic low back pain. Also, the strength training should be specific to isolate the weak link; in the case of chronic back pain, the weak link is the lumbar extensors. It therefore is necessary to use a specific piece of equipment to create the specificity and gradual overload.[30] It is extremely difficult to create a gradual increase in overload and specific muscle strengthening by using calisthenics or floor exercises.

Exercises should be continued if they are necessary from a therapeutic standpoint. Atrophy of unused tissues occurs physiologically. Nonetheless, once strengthening has been achieved, strength training can be reduced to at least once per month.[34]

If the exercise is specific, it can be carried out in one set twice per week to achieve ultimate improvement.[14,33] With the use of specific equipment, high intensity and short duration of exercise are possible. To obtain the most significant effect, each repetition of a particular exercise should be performed in slow, controlled fashion through the full range of motion.[35] These exercises should not be performed at a rapid rate on multiple occasions. Ideally, a single set with 15–20 repetitions is as effective as any other method of strength training.[29] Hypertrophy and more-efficient bioelectric activity of the lumbar extensors have been documented after performing a single set of exercises twice per week. However, to achieve the maximum benefit, the exercise program must be carried

out for 10–12 weeks when it is performed twice per week. Functional gains will be made earlier in the program, but the ultimate benefit will not be reached until there is a plateau, essentially at 2½ to 3 months.[34]

Although the extension dynamometer is not necessary to achieve appropriate isolation and specificity of function, similar levels of specific training can be achieved with the Roman chair.[36] The Roman chair has a disadvantage of engaging the hip extensors, which can substitute for the deficient lumbar extensors. Nonetheless, it is a low-tech option and can be used in most fitness facilities or even in a home program.

The point of these programs is that the universal weak link in persistent back pain is the lumbar extensors.[37] The theme for these treatment programs is that, in chronic low back pain, lumbar extensors are weak, highly fatigable, atrophied, and demonstrate excessive fatty infiltration.[38] To achieve the best results in recovery of these weak links, isolation and progressive overlay of the lumbar extensors is necessary. The better isolated the musculature is, the more efficient the strength training is.

There is literature to support the benefits of progressive isolated strength training of the lumbar extensors. In an article by Manniche et al.,[39] high-intensity exercise demonstrated a significant improvement in low back pain and reduced disability. In another article by Risch et al.,[40] individuals with low back pain were treated in a specific strength training program as described above. Treatment was delayed for the group of control participants and upon testing of their strength and psychological function, it was determined that the delayed group had significant defects. However, when participants in the delayed group were placed on the strength training program, they had resolution of their psychological strength problems. Even after surgery, strength training has benefits in range, strength, and return to function, as compared to no strength training.[41] In a randomized, controlled trial by Kankaanpaa et al.,[42] twice-per-week strength training for 12 weeks compared to no intervention resulted in improved pain intensity and disability rating. The 3- and 12-month improvements for each outcome were significantly greater for the strength training group.

Progressive strength training has been shown to have significant potential in reducing the need for spine surgery. In a study by Nelson et al.[43] of a group of 38 patients who had been recommended to have elective spine surgery, only 3 patients required surgery after a progressive exercise program.

A significant problem in treating persistent back pain is the inability to measure baseline and results. As the discussion above indicates, strength training performed on equipment can have a specific measurement of deficit improvement. On the other hand, individuals are more concerned with function. There are many functional questionnaires available to patient populations. However, in common practice today, less than 50% of therapy facilities use any form of outcome measure such as the standard questionnaires.[44] This is likely one of the reasons why so many methods of care for persistent back pain have been advocated. Because of the lacking of any methodology in measurement, it is difficult for a scientifically based treatment system to be identified. For this reason, strength training, with its reasonable rationale and specific measurement capacity, seems to be quite an appropriate system of treatment to advocate for persistent back pain.

Unfortunately, the rationale and evidence described above have not become persuasive to either the medical profession or to patients. In a recent study in North Carolina, Carey et al. noted that there is a substantial underuse of therapeutic exercise and structured rehabilitation, whereas there is an overuse of muscle relaxants and imaging studies and physical modalities.[45]

V. MECHANICAL DIAGNOSIS AND THERAPY: THE MCKENZIE METHOD

Although we have discussed the value of strengthening exercises in the spine, mechanical management of spinal pain has also been shown to demonstrate successful management and a reduction in symptoms. Mechanical management in this context refers to a two-fold process. First, a provocative assessment permits clinicians to divide patients into the subgroups of mechanical responders and mechanical nonresponders. A mechanical responder is one who has intermittent symptoms. Intermit-

tent symptoms suggest that there are positions that cause symptoms to get better or worse. It is these patients for whom movement patterns may be discovered that are able to increase or decrease symptoms. When a movement pattern is discovered that reduces the patient's symptoms, it is termed the "directional preference"—meaning that a preferred direction of movement has been found to make the patient's symptoms consistently better. This provides important compatibility to strength training in that a reduction of symptoms makes strengthening easier to accomplish. The value of mechanical assessment and directed treatment are discussed in the following section of this article.

A. Mechanical, Nonspecific Low Back Pain

Mechanical, nonspecific low back pain is one of the most ubiquitous presenting symptoms for health care professionals, second only to that of the common cold. One of the reasons that low back pain remains difficult to treat is that there is no consistently accepted method of assessment that directs treatment. Each clinician follows the methods in which he or she was trained, very few of which have a common thread. This is best reflected by the educator Maslow, who said, "I suppose it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail."[46]

In general, health care practitioners assess, diagnose via exotic and expensive testing, and treat back pain in legions of ways, depending on their training. Primary care physicians often treat with anti-inflammatory medications, and some specialists treat with injections and exotic medications ranging from the fairly benign to the potentially dangerous, whereas physical therapists have a broad variety of manual approaches depending on the school of thought in which they have trained. Many of these providers also have different vocabularies and mechanical diagnoses that they use to describe their treatments.

Herein lies the problem in the world of back pain management and, in particular for this discussion, physical therapy. Like other health care providers, physical therapy treatment of spinal pain has many different approaches. Manual therapy gurus are many and each have their own sense of how spinal pain should be treated. Although treatments and rationales for these methods abound, they often have little in common from a clinical standpoint. Because much of this treatment relies on the therapist's intuition, years of experience, and belief in their specific approach, there is little common ground among purveyors of treatment. In addition, each has a vocabulary for describing the importance of the way they treat, which makes communication regarding the different methods difficult. Furthermore, there are lengthy courses that teach therapists how to "feel" pathology in muscle and other spinal anatomical areas in order for successful treatment to occur; for example, it could be a bilateral muscle imbalance, misalignment of the vertebrae of facets, some proprioceptive imbalance in the lower extremities, or tightness of connective tissue in some critical area. The lack of common thought is pervasive and, for each different approach, an almost evangelical zeal exists in their promotion and defense. There are, however, at least two striking commonalities in the manual therapy treatment of back pain. First, there is little or no objective measurement involved in the assessment and treatment, which is a problem because without measurement, one cannot assess patient improvement or, at the very least, link improvement to treatment beyond some unknown psychosocial phenomenon or natural history. Second, manual therapy approaches do not have as much evidence published in the scientific literature to support their methods. In some ways, manual therapy could be described as charismatic treatment in the sense of unmeasured laying on of the hands.

B. Mechanical Diagnosis: Subgrouping Patients

Once manual assessment is performed, treatments become surprisingly generic. Most medical treatments flow from the ADTO model (i.e., assess—diagnose—treat—outcome) as previously described, where the assessment informs the diagnosis and treatment.[47] There seems to be little linking of assessment to mechanical diagnosis, hence treatment in manual therapy. It is almost as if the treatment and outcome are distinctly separate from the assessment and diagnosis process. Making matters more difficult are the plethora

of manual diagnoses, most of which do not have any relationship to an approximated pathology. Even more interesting is that the generic standard programs that are typically given to patients most frequently involve palliative activities on the basis of time exposure. That is to say, hot/cold packs are applied for certain periods of time. TENS (transcutaneous electrical nerve stimulation) units or electrical stimulation are applied for certain periods of time. Stretches are assigned, performed, and held for certain periods of time. Some of these treatments are intended to increase blood flow or diminish pain, whereas others are intended to create adaptive changes in connective tissue. Most of these treatments are subjectively applied at best, or passed on through some unsubstantiated theory at worst. Few activities are performed on the basis of physiology or mechanical responses of soft tissue, and success is almost always reported by the patient's reflected feelings. This fairly amorphous approach has been labeled as the standard of care for nonspecific back pain.

This "one-size-fits-all" approach has been the hallmark of back pain treatment. As a result, the literature has been equivocal regarding the efficacy of one treatment over another.[48] As previously noted in this article, the one approach that seems to consistently work for patients is exercise, but which form of exercise is best? How does one determine which exercises are most valuable in their armamentarium for mechanical nonspecific back pain?

One of the foundations of medicine is the differential diagnosis. For example, a patient arrives at his or her doctor's office with a complaint of nonspecific chest pain. How does the physician determine the course of treatment? It could be:

- intercostal chondritis from a lifting strain or other inflammatory source
- anterior wall chest pain related to muscle
- esophagitis from acid reflux, or
- myocardial pain from an ischemic change in the heart

Diagnosing the source of the pain would lead to the appropriate treatment pathway. In effect, the source of the pain would become more clear with a good history and possibly some provocative testing. The differential diagnosis is a method of subgrouping the patient. Once the subgroup has been identified (e.g., esophagitis), the appropriate treatment (i.e., antacids) would be applied.

A standard, reproducible assessment then, leading to a mechanical differential diagnosis, might be the place to start in the case of a patient who presents with nonspecific back pain. A standard evaluation would help health care providers to identify categories (i.e., subgroups) of back pain in the patients they see. For example, in the patient who presents with nonspecific intermittent back pain, are there specific movements that make their symptoms better or worse? If a directional preference were to be discovered (i.e., a repeated movement pattern relieving symptoms), treatment based on that movement preference would enhance the patient's potential for recovery. The question is: How does one subgroup patients with back pain?

The idea of subgrouping in spinal patients began to find its way into the clinical arena several decades ago.[49] As is often the case with discoveries, its presence made a slow and arduous journey into the world of spinal care. It began with an observation, which led to trial and error, which led to an assessment methodology. This methodology, directly informed by patient response to provocative movements, led to the development of a reproducible clinical evaluation. Tracking patient responses over a long period of time led to an understanding that a large percentage of patients with back and neck pain could be predictably and successfully treated. This approach to spinal pain has been called mechanical diagnosis and therapy (MDT) or, in more recognizable terms, the McKenzie method.

C. A Brief History of Mechanical Diagnosis and Therapy

To appreciate this method, it may be helpful to see how categorizing and subgrouping patients came to be understood. Like most discoveries, it was a chance event in the furthest place from the study of back pain. It began in 1956 in a small clinic in Wellington, New Zealand, in the hands of a physiotherapist named Robin McKenzie. Like therapists before and after him, he used many different approaches to the management of patients

with back pain. In that day, treatments ranged from galvanic stimulation to Williams flexion exercises,[7] as previously described. McKenzie's experience and results, like therapists before and after him, were singularly unsuccessful in the consistent treatment of patients with back pain. If there was a method that actually helped, it was either serendipitous or the tincture of time combined with benevolent neglect.

As is often the case with discovery, it was an accidental observation that began a clinical dialogue that continues to enlighten the treatment of back pain to this day.

While treating a patient with a knee problem, McKenzie had elevated his treatment table to an upward angle so that the patient could sit up while being treated. In a busy practice, often attention is not paid to everything in the course of the daily clinical flow. And so, by chance, the next patient to be sent to this treatment room was one with low back pain. McKenzie told him to go in, lie down, and he would be back in a few minutes. When McKenzie entered the treatment area, he was alarmed to note the patient was laying face down on the table with his back in an extreme arched position, and had been there for about 10 minutes! As McKenzie fumbled for the appropriate words, the patient exclaimed it was the best his back pain had felt in a considerably long time. Not only was this confusing, but it flew in the face of everything that McKenzie had been taught. This event created a curiosity, one that would irrevocably change both his life and the treatment of back pain.

Over the course of subsequent years, McKenzie experimented with variations of this early experience, treated many patients, and organized his thoughts. Initially, he tried extending all of his patients and found that this method did produce consistent results. Through trial and error, he discovered many patients' symptoms were made better or worse depending upon specific movement patterns that were produced during physical examination. Gradually, a standardized assessment of provocative movements emerged. This assessment revealed that patients with back pain could be classified into different categories. The key to the discovery of a directional preference in patients was repeated end-range movement. A single flexion or extension motion would reveal little, but repeated flexion or extension (both in standing and lying) movements, provided a clear directional preference with a number of patients. Exercises that were adapted by the directional preference found during the assessment proved to afford much better results in McKenzie's patients.

D. A Mechanical Differential Diagnosis

While experimenting, McKenzie also discovered that some back pain got better simply by correcting poor posture, others got better by challenging shortened connective tissue, and some did not respond to any movements. From these observations, he developed a system of assessment, leading to a level of predictable success as yet unknown in the management of back pain. This codification of a repeatable and consistent assessment that was meant to inform treatment became known as the McKenzie method. This codification was separated into three basic syndromes: postural, dysfunction. and derangement.[50]

Postural syndrome. Postural pain typically comes from prolonged static postures or positions that can affect joint surfaces, muscles, and tendons, leading to discomfort and pain. The pain is generally local and reproduced when the patient slouches for extended periods of time at end-range positions. Repeated movements during assessment do not affect symptoms. The hallmark of postural syndrome is that the pain is intermittent and simple corrections in seated or standing posture relieve symptoms immediately.

Dysfunction syndrome. It became clear to McKenzie that some patients had limited end-range motion, meaning that connective tissue had gone through some sort of adaptive shortening, scarring, or adherence that caused discomfort or pain. Patients with this syndrome may have chronic or intermittent symptoms but, in all cases, its hallmark is loss of motion and pain at the end-range of movement. When the patient moves away from the pain, it subsides and reveals itself as an "on-off" phenomenon during assessment. Treatment for this syndrome takes time because it requires tissue remodeling—meaning a plastic change (permanent adaptation) in connective tissue (tendon or ligament). In order for a plastic change to occur, end-range stretching must occur

and it takes time for remodeling to take place. This syndrome is not a common finding, but it occurs frequently enough that it has been observed and defined.

Derangement syndrome. This is the most common clinical presentation of patients with low back pain. The hallmark of this syndrome is symptom sensitivity to provocative movements. Repeated flexion-extension exercises on assessment cause symptoms to become more central or more peripheral—meaning that, in the case of the low back, repeated flexion or extension causes the symptoms to move. It is not uncommon for a patient to experience a rapid reduction of his or her symptoms immediately during the assessment. That is to say, if the pain were in the right calf, it might move more centrally into the right buttock. When symptoms become more central, the patient's directional preference has been found and treatment is informed by this preference. Any central movement of symptoms is key to understanding the derangement syndrome.

Nonresponders. As important as it was to find suitably treatable patients, it was equally valuable to discover patients for whom mechanical exercise would not work. These patients were referred to as nonresponders and were quickly moved to some treatment other than MDT.

It is a common mistake to think of the MDT method as a series of exercises. Indeed, there are no MDT exercises, per se. As demonstrated above, there is an assessment and that assessment drives the treatment. Without the assessment, there are simply generic exercises. Studies conducted by therapists who were either not trained or minimally trained in the McKenzie method have effectively demonstrated that indicated extension exercises were better than flexion exercises, but that neither one of them were particularly meaningful in the treatment of acute back pain. In these studies, assessment did not drive the exercises. In one study, patients presenting with nonspecific back pain were randomly assigned to one of three groups: (1) bed rest, (2) mobilization exercises (extension and side bending), and (3) usual life activities as tolerated (the control group). The results were equivocal related to the extension and side-bending exercises.[51] In another one of these studies, patients with nonspecific low back pain were randomly assigned to three groups: (1) McKenzie physical therapy, (2) chiropractic manipulation, and (3) an educational booklet. Although there was a trend toward the McKenzie exercises being more effective, all three groups showed improvement with no significant differences when followed over 2 years.[52] It is no surprise, therefore, that the results were equivocal. Assessment is the key.

E. McKenzie Exercises

Once movement patterns are found that make the patient's symptoms better, exercises are given that support the reduction of patient symptoms. The discovery of directional preference seems simple and straightforward, but it had escaped the attention of the spine-care community and was the first clinical insight to standardizing an approach to the management of low back pain.

Although other manual approaches to the management of low back pain provide a vague view of causation, the MDT method confronts the disc head on. Although the model does not require a pathoanatomic diagnosis and explanation for causation, it does focus on the disc as the pain generator. McKenzie[49] published his methodology in a text in the early 1980s and hypothesized that repeated movements, particularly in the derangement syndrome, caused migration of the nucleus of the disc. When the patient's symptoms moved more centrally, he suggested that the nucleus moved away from the posterior elements of the disc, leading to a relief of pressure and therefore symptoms. A reduction of or increase in symptoms with repeated motions, the method contended, suggested that there was migration of nuclear material in the disc that may aggravate or relieve symptoms. Clinical experience seemed to suggest this, but there was little evidence at the time. As is often the case with keen observation and hypothesizing, discoveries stand or fail the test of time.

F. Standardized Training: A Key to Success

In the 1980s, McKenzie understood the importance of educating the physical therapy world to his discovery.[49] This led to an educational initiative

and ultimately to an institute dedicated to teaching the assessment and treatment to physical therapy professionals. Eventually, for the spine, it became a four-part education program, which consisted of courses for the lumbar and cervical spine in addition to two further-advanced problem-solving courses. This series of structured training modules was intended both to teach the assessment in a standardized method and to ensure a certain quality of training that would permit similar results to be found among trained health care professionals.

It is beyond the scope of this article to provide a comprehensive review of the MDT method, which has been done by previous authors.[53,54] However, it is interesting to note how this insight of nuclear movement with repeated motion has played out in the scientific and clinical literature.

G. Brief Clinical Review

Although the MDT method was standardized and taught to interested physiotherapists, it was not clearly described in the scientific literature until 1990 when Donelson et al. showed that directional preference was an observable and quantifiable phenomenon.[55] Donelson and colleagues' work was a retrospective chart review of 87 patients presenting to an orthopedic practice. All of the patients had been evaluated by using the MDT assessment, and the authors, on initial evaluation, looked for patients with the presence or absence of centralizing symptoms. In Donelson's study, 87% of patients showed signs of centralization, suggesting that directional preference was identifiable in clinical practice. Outcomes included a return to normal activity, pain relief, and patient satisfaction. The authors concluded that assessment and treatment of patients by using the MDT method was a good predictor of successful outcomes, as described. The following year, Donelson et al. performed a prospective study that examined the effects of flexion and extension exercises on patients with low back pain. The majority of patients showed a centralization response to extension exercises (39%), whereas 8% demonstrated a centralization response to flexion exercises. Although this was an exercise study, it suggested that patients do not demonstrate a directional preference with a "one-size-fits-all" exercise approach.[56]

An early cadaver study suggested that there was nuclear migration with repeated motion,[57] but the number of subjects was very small and the study was poorly designed. In more recent years, however, Alexander and others have shown significant anterior and posterior nuclear movement through static loading of the lumbar spine in either the flexed or extended positions.[58] MRI scans were performed on 11 healthy volunteers in a variety of positions (i.e., standing, sitting, supine, and prone extension). This method differed from other MRI studies in that the patients were functionally loaded in several of the measured positions. None of the patients had back symptoms or a history of having had treatment for back pain. The participants held their positions for approximately 10 minutes per scan in an upright MRI machine that could image in the supine, erect, and seated positions. The authors demonstrated that the greatest sagittal migration of the disc nucleus was at the L4-L5 and L5-S1 levels. They further suggested that their results were in alignment with the ". . . theoretical model of posterior migration, leading to disc bulging and ultimately pathology . . ."[58] It was noted that prone extension induced less posterior migration than the sitting positions, suggesting that standing or sitting extension may be preferable for better nuclear movement. However, it should be noted that these participants were held in static positions, whereas the MDT method is based upon repeated motion.[58]

Although the previous study[58] showed nuclear migration, it was done under static conditions. By using a cervical porcine cadaver model, Scannell and McGill demonstrated a reduction of the cervical nucleus through repeated movements in the cervical spine.[59] The authors noted that the porcine cervical spine resembles the human lumbar spine, allowing for some comparative thought. The specimens were frozen immediately postmortem and then thawed just prior to the experiment. The work by Scannell and McGill is not the first study to show repeated movements to influence nuclear movement,[59] but it is the best-designed study with resultant migration. The specimens were repeatedly flexed under axial compression. Four specimens were exposed to sagittal flexion only, whereas 14 were subjected to combined sagittal and lateral flexion

loads, leading to disc prolapse. Five of the discs failed and 11 prolapsed. Once prolapse had been accomplished, those that had prolapsed were exposed immediately to repeated extensions or a combination of extension and lateral flexion. The specimens that had only moderate disc height loss all responded by centralizing (n = 5). Six of the 11 specimens had severe disc height loss and did not respond. The data demonstrated a 45% response rate and a 55% nonresponse rate. The discs that demonstrated centralization of the nuclear material did so with opposite movements (same plane) to those that had caused the prolapse in the first place. The cadaver specimens were controlled for diet, exercise level, and age, but obviously did not appear with the same comorbidities of the chronic spine patient. Nonetheless, Scannell and McGill's study demonstrated that nuclear positioning can be influenced by repeated motion. As is the case with patients presenting clinically, not all nuclei moved as a result of repeated motion—meaning that some patients respond and others are nonresponders.

The strongest clinical suggestion for the data of Scannell and McGill appeared earlier in the literature. It had been assumed that for there to be nuclear migration, the annulus would need to be competent. Patients who did not respond with a directional preference were theorized to have an incompetent annulus. Donelson et al. tested this hypothesis by subjecting 63 patients with low back pain to repeated movements using a discogram to determine the integrity of the annular wall.[60] All of the patients underwent a McKenzie repeated end-range motion evaluation in both the loaded (standing) and unloaded (lying down) positions. Patients were classified as (1) centralizers, meaning that symptoms moved more centrally; (2) peripheralizers, meaning that symptoms moved more peripherally; and (3) nonresponders, meaning that there was no change in symptoms. Immediately following the evaluation, the patients underwent a lumbar discogram to determine integrity of the annular wall. Thirty-one of the patients (49%) centralized, 25% peripheralized, and the remainder experienced no change. Ninety-one percent of the patients who demonstrated centralizing symptoms had intact annuli, suggesting that the centralization phenomenon requires an intact annulus. This study further suggested that an MDT mechanical evaluation was as successful in indicating an intact annulus as the provocative discogram.[60]

These studies substantiated the observational theory of nuclear migration put forth by McKenzie in the early 1980s, from both the scientific and clinical standpoints.

The other major thrust of the MDT thought process was whether the method could be taught with reproducible results. In other words, would training in the method produce consistent results between trained therapists across patient populations? Furthermore, would how well therapists were trained in the method make a difference? Finally, if patients were determined to have a directional preference by using the assessment process, what would happen if they were given exercises that were contraindicated—meaning, if their directional preference was repeated extension exercise, what would happen if repeated flexion exercises were prescribed? As is often the case in health care, what works in one facility in the hands of one provider, does not always translate into the same result in the hands of another provider in a different facility. To address this issue, the MDT method requires 98 hours of postgraduate training, followed by both written and practical examinations. Passage of these examinations is necessary to be credentialed in this method.

A number of studies have been performed to determine inter-rater reliability for subgrouping patients with back pain.[61–65] Riddle and Rothstein examined intertester reliability in patients with low back pain by therapists who were trained in the McKenzie method.[63] The study authors were interested in looking at the effects of McKenzie training on the ability of therapists to provide consistent classifications. Therapists were given written descriptions of the McKenzie method and classification criteria. Three hundred sixty-three patients were evaluated by 49 physical therapists in eight clinics. The therapists agreed on only 39% of patient classifications. One of the limitations of Riddle and Rothstein's study is that only 16 of the therapists had attended one postgraduate McKenzie training course, whereas the remaining 33 therapists relied on the written descriptions of the method. Only the outcome was reported with no comment on the consistency of assessment, making the case that inconsistently trained therapists produce inconsistent results. On

the other hand, Clare et al.[66] performed a study with 50 MDT credentialed therapists in different locations to see whether they would consistently be able to classify patients solely on the basis of a completed assessment form. The participants were presented with 50 completed patient assessment forms that had been performed by other highly trained MDT therapists. They were then asked to classify the patients into the McKenzie syndromes based on the assessment presented to them. The authors found there was a 91% agreement of the physical therapy raters when it came to selecting the major MDT syndromes. The authors showed that reliability of patient classification could be adequately determined between raters when presented with a completed McKenzie assessment form. The clinical implication is that proper training provides common-enough language and techniques that enable different clinicians to communicate about their patients.

Kilpikoski et al.[67] tested interexaminer reliability among MDT-trained physiotherapists to determine the effectiveness of a standard education and assessment process. Two different physiotherapists evaluated 39 patients who presented with nonspecific back symptoms. These physiotherapists had a " . . . high level of training . . ." and an average of 5 years of clinical experience in the MDT method. Both examiners were present for the patient history and subjective findings; they then examined the patients separately. Among the 34 patients whose pain was described as centralizing, there was a 95% agreement and a 90% agreement on the directional preference. The authors concluded that there is a high level of interexaminer reliability among therapists who have been trained in the MDT method. The study further emphasizes the importance of a deliberate training methodology to ensure consistency in clinical management, as well as communication in a common language to other trained physiotherapists.[67]

Once an assessment has been performed and a directional preference established, it is then possible for the patient to perform the appropriate exercises. Exercises directed by the assessment generally guide repeated movements that the patient can do on a defined schedule until symptoms are either significantly reduced or completely abated. Once the patient's symptoms have been successfully treated, emphasis is placed on returning to function that includes exercises in all directions.

Clearly, good posture is important in any treatment mode. Patients are educated in good standing and sitting postures (Figs. 2A and 2B).[68]

Recommended exercises for the patient with an extension directional preference could include laying prone, progressing to supported elbow and full press-up exercises (Figs. 3A–3C).[68] Recommended exercises for patients with a flexion

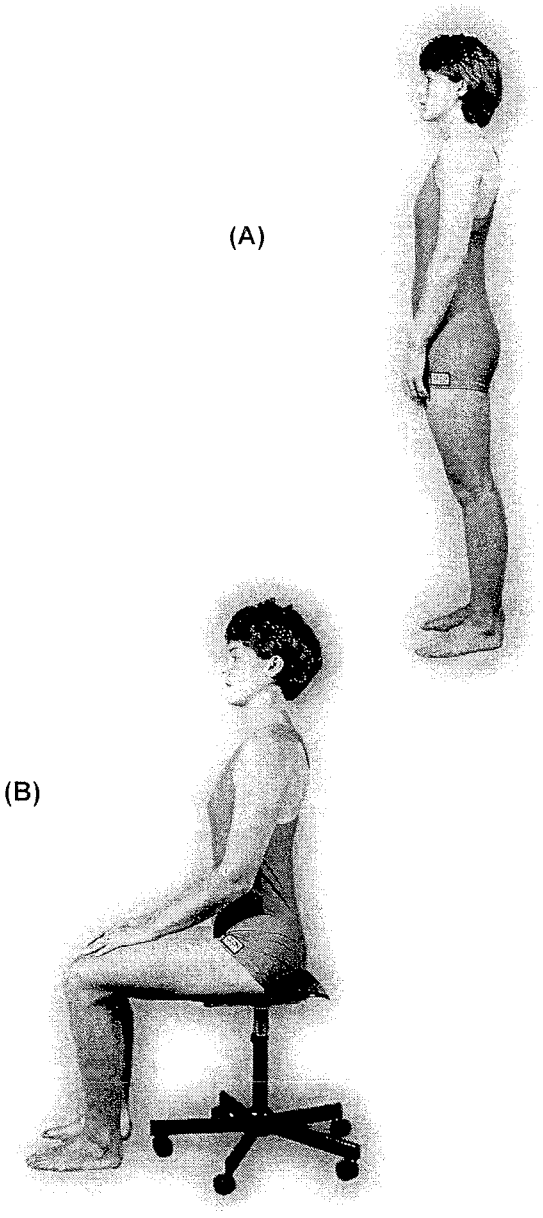
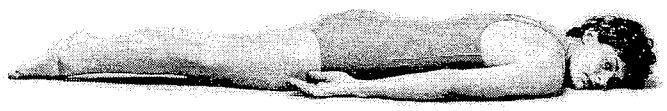


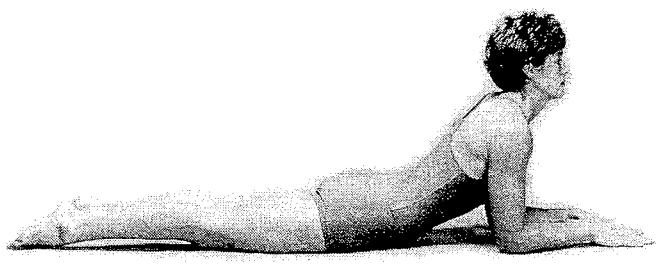
FIGURE 2. Proper standing (A) and sitting (B) positions. (Reprinted from McKenzie R, Treat your own back, © 2008. Reproduced with permission from Spinal Publications, New Zealand.[68])

directional preference could include laying supine, progressing to bent knee and then knees to chest (Figs. 4A–4C).[68] In addition, seated or standing flexion exercises might also be recommended (Figs. 5A and 5B).[68]

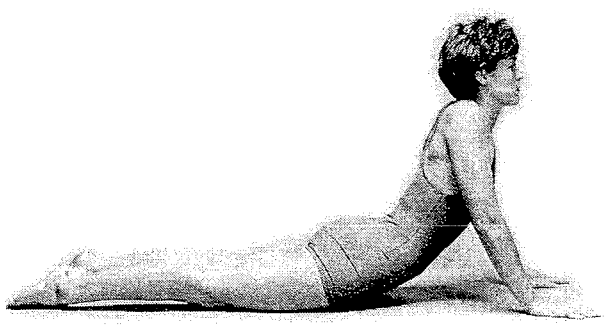
As previously discussed, most physical therapy has mostly been a "one-size-fits-all" approach, with little ability to know what is or is not successful. Long et al.[69] specifically tested the question as to whether it really matters which exercises are given to patients. In other words, was there clinical and, more importantly, prognostic value in performing a consistent assessment that directed treatment?[69] The authors performed a multicenter, randomized controlled trial, to determine how the effect of assessment-directed exercises would affect patient outcome. Therapists who were experts in the method administered the MDT assessment to 312 consecutive patients. This study used an intention-to-treat model, so any patients who did not show a directional preference were excluded from the study. The results revealed that 230 patients (74%) showed a directional preference and were included in the study, whereas 82 patients (26%) were nonresponders and were excluded from the study. Participating patients were randomly assigned into one of three groups: (1) exercises in line with the directional preference, (2) exercises in opposition to the directional preference, and (3) standard exercise as usual, expressed by evidence-based standards. Results demonstrated that patients who exercised in compliance with their directional preference on assessment had significantly more successful



(A)

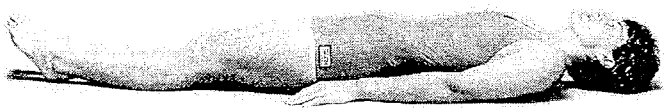


(B)

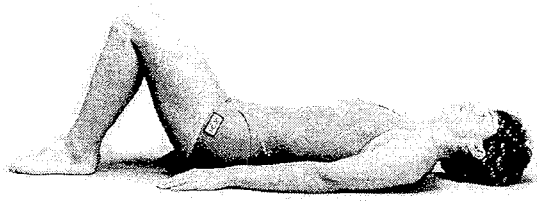


(C)

FIGURE 3. The progression of exercises for patients with an extension preference (**A–C**). (Reprinted from McKenzie R, Treat your own back, © 2008. Reproduced with permission from Spinal Publications, New Zealand.[68])



(A)



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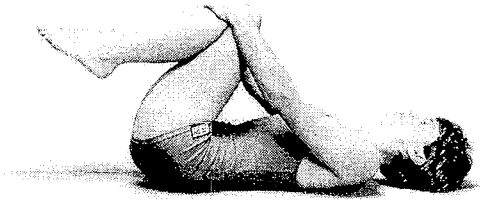
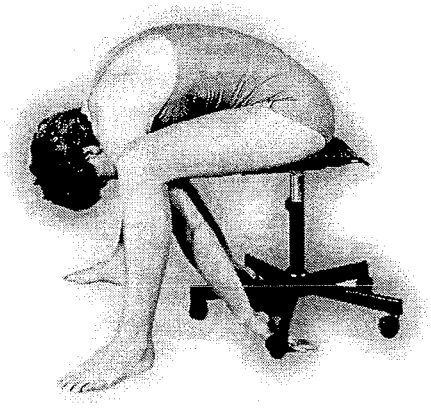
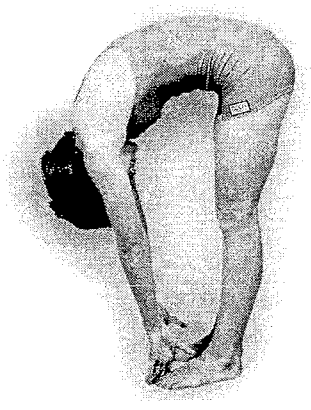


(C)

FIGURE 4. The progression of exercises for patients with a flexion preference. (Reprinted from McKenzie R, Treat your own back, © 2008. Reproduced with permission from Spinal Publications, New Zealand.[68])



(A)



(B)

FIGURE 5. Additional seated and standing flexion exercises. (Reprinted from McKenzie R, Treat your own back, © 2008. Reproduced with permission from Spinal Publications, New Zealand.[68])

results. Indeed, patients assigned to exercises that were opposite of those suggested by the assessment developed worsening symptoms. These data refuted earlier systematic reviews that suggested specific exercises were not warranted. What was the defining difference? The key to this finding was a consistent and reproducible assessment method, permitting the subgrouping of patients.

H. Summary

The key to effective treatment of any kind is being able to know where the process begins and, more importantly, to measure it. It is an initial and reproducible measurement, in this case a consistent assessment process, followed by treatment and examination of results, that leads to a better understanding of any process. In the world of physical therapy and its treatment of back pain, the McKenzie method stands out for its methodology and leadership in the arena of better patient classification.

VI. CONCLUSIONS

Two different forms of exercise have been detailed in the preceding paragraphs. Both have their place in treatment of spine pain, and both have a distinctive rationale that is supported in the literature. Unfortunately, their effectiveness depends upon the eagerness of a pained individual to participate in a regular and repeated manner. The desire to take control of one's own health matters is not a universal human trait. The failure of these two exercise methods to gain more traction in the clinical world is partly because of a lack of physician enthusiasm and patient enthusiasm for participation in persistent effort. As stated above, the impact of these two exercise regimens likely will be limited in the future because of the desire of all of us for a quick fix and magic. There is no magic in human reconditioning.

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