CONSERVATIVE CARE OF LOW BACK PAIN

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SCIENTIFIC BASIS OF FUNCTIONAL ASSESSMENT OF THE LUMBAR SPINE PATIENT

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This chapter will analyze current technologies utilized in evaluating lumbar trunk strength, which will be placed in context of a host of other variables that affect low back injury and recovery. Medical practitioners are exposed to numerous isometric, isokinetic, and isoinertial technologies that all report to be the most reproducible and efficient methods of evaluating strength and predicting injury. The following review of the scientific literature related to trunk strength evaluating technologies will hopefully clarify the above claims.

NECESSITY OF FUNCTIONAL ASSESSMENT OF THE LUMBAR SPINE PATIENT

Low back pain affects approximately 85% of all persons in the western world at some point during their lives (1). Low back pain is second only to upper respiratory infections as the most frequent reason people seek medical attention. It is the most frequent cause of activity limitation and disability in persons under age 45 years and the third most frequent cause in the 45 to 64 year age group (2).

Approximately 2% of all workers injure their backs annually (3). Although the majority of low back pain sufferers improve within 3 months, the costs still exceed $16 billion each year (4). Incredibly, 10% of the injuries require 80% of the total costs (5). It is estimated that 50% of those people who are disabled because of low back pain have absolutely no objective findings (6, 7).

Exorbitant amounts of American health care money are spent on a small percentage of low back sufferers who have very few objective abnormalities. The economic magnitude of this problem has prompted investigators to try to objectify spinal function and dysfunction in an attempt to quantitate true abnormalities. Because of the complexity of the spinal unit and the large discrepancies among actual spinal diagnoses, practicing clinicians often completely rely on a patient’s subjective complaints. Recently, an attempt has been made to evaluate low back patients functionally rather than subjectively. The current cerebrovascular scales, for instance, concentrate on function and not subjective complaints of pain. James Evans and Abbott Kagan (8) have developed a functional rating scale for chronic low back patients that quantifies the patient’s level of activity and relative personal independence. Richard Deyo recently reviewed current functional status measurement techniques and their usefulness (9).

POTENTIAL BENEFITS OF FUNCTIONAL ASSESSMENT

It is clear that, in the current medical-legal climate of industrial and personal injury back claims, inordinate importance is placed on subjective complaints and not on objective findings or functional parameters. The benefits of functional assessment of the lumbar spine would include objective analysis of a patient’s condition and subsequent recovery. By objectively
an analyzing the spinal unit, one can determine deficits and conceivably correct them more rapidly. Also, through assessment of the multiple aspects of spinal function, our biomechanical and psychological understanding of the spine will increase. Functional assessment of the spine conceivably would legitimize the qualified injured worker and identify the malingering or individual concerned with secondary gain issues. Actual functional testing should reassure the worker of capability of performing the job task before returning to the actual job site. Once normative data have been obtained and the predictiveness of the testing has been established, preplacement screening can be instituted to prevent injuries.

**METHODOLOGIES TO REDUCE INDUSTRIAL BACK INJURIES**

Historically, preemployment histories and physical examinations were used to screen potential employees (10). Although it is established that a previous history of low back pain predisposes to additional low back pain (11), prospective employees can distort their own history to facilitate employment. Rowe estimates that only 7 to 8% of individuals prone to developing low back pain can be screened via the preemployment history and physical examination (12). However, Chaffin (13) and Snook (14) were unable to identify susceptible workers using preplacement examinations.

In the 1950s and 1960s, preplacement radiographs of the lumbar spine had gained acceptance (15–17). However, other studies have concluded that preemployment radiographs alone are not predictive of future low back injury (18–21). Recently, Frymoyer has demonstrated an association between low back pain and radiographic L4–5 disc space narrowing and spurs (22, 23). Current research is investigating the relationship between lumbar spinal canal diameter and the likelihood of low back pain (24). Jeff Saal has demonstrated that those with herniated nucleus pulposus who do not respond to nonoperative conservative care programs are likely to have spinal stenosis (25). Thus, although plain radiographs are not predictive of low back injury, it is possible that spinal canal diameter might be a predictive factor.

Anthropometric measurements such as height, weight, or body frame have not been predictive of subsequent low back injury (11, 18, 26). Psychological factors certainly play a role in low back injury recovery, but they also are not by themselves good predictors of the development of low back pain.

The three current approaches to managing low back injuries in the work place include 1) ergonomic changes, 2) preplacement or preselection screening, and 3) education and training for employees. Stover Snook defined ergonomics as “designing the job to fit the capabilities and limitations of the worker” (27). Snook analyzed the above three approaches and found that only ergonomic change in the work place was actually successful in reducing injuries, while preplacement screening and education were not successful (14). Ergonomic changes, however, are often cumbersome and expensive to incorporate into the work place.

Preplacement screening is currently very appealing to employers. Rather than designing the work site for the worker, employers attempt to select workers who can be productive at a given work site. The preselection process is often based on determination of strength. The various techniques of evaluating strength will be discussed later in this chapter.

The most common technique used in the attempt to reduce injuries in the work place is education and training. The education often consists of inhouse instruction in proper lifting and bending techniques. A scientific review of these inhouse programs has not demonstrated a preventive value (14, 28).

Biomechanical studies have offered great insight into the stress and torque placed on the lumbar spine during manual material handling (29). Gunnar Andersson has demonstrated that the distance an object is away from the body influences the stress on the back more than the actual method used to lift (30). Physiologic studies have evaluated cardiovascular stress and muscular fatigue in relationship to low back injury (29). Additional prospective studies are needed to evaluate the efficacy of biomechanical and physiologic methodologies.

**BACK PAIN IN INDUSTRY**

To successfully analyze and objectively measure spinal function, one must understand the multifactorial nature of low back injury. For clarity, low back injury will be analyzed on the basis of both physical and psychosocial factors. To emphasize one at the expense of the other
would trivialize the actual problem. It is simplistic to try to isolate one or even a few variables that control low back pain and its recovery.

Epidemiologically, lifting is one physical factor that correlates with over 33% of low back injuries (31). Lifting places a compressive load on the intervertebral disc. Augustus White relates that workers whose spines are exposed to compression greater than 6000 newtons have an eight times higher incidence of low back injuries than those individuals whose spines are exposed to a compression of 3500 newtons (32). The frequency of lifting is also related to low back injury. Those who lift the most frequently are most likely to be injured, followed by those who rarely lift; those who lift occasionally seem to have less risk of injury (6). The amount of weight actually lifted also appears to correlate with the development of low back pain (26, 33, 34). Jobs requiring lifting loads greater than 25 pounds are associated with increased risk of low back injury (35, 36). There appears to be a definite relationship between the development of low back pain and the amount of lifting required in a specific occupation. Heavy industry workers, nurses, and truck drivers all must do significant lifting and these are the professions with the highest prevalence of low back pain (37).

Alexander Magora correlated sudden maximum physical efforts characterized by their unexpectedness as related to the development of low back pain (38). Magora hypothesizes that an unexpected sudden maximum motion is more likely to injure the spine than a controlled, rehearsed motion. Improper lifting is the most frequent cause of low back injury (39). Vibrational exposure and static work postures are also correlated with the development of low back pain (22).

The determinants of lifting and bending are also multifactorial. Successful lifting requires coordination, proprioception, pulmonary fitness, training, experience, intelligence, flexibility of the extremities and spine, strength of the extremities and trunk and, finally, endurance.

Psychosocial factors play a tremendous role in low back injury and recovery. The classic retrospective Boeing Aircraft Employee Study found a correlation between the incidents of back injury and poor employee appraisal rating performed by the employee supervisor 6 months prior to the injury (40). Magora demonstrated that employees not satisfied with their occupation, place of employment, or social status had a higher incidence of low back pain than controls. He also demonstrated that people who perceive a high degree of responsibility and mental concentration requirement at work, resulting in a feeling of tenseness and fatigue, were also more likely to develop low back pain (41). Richard Deyo reports that psychosocial and demographic features such as education, number of prior episodes of back pain, and whether or not a patient “always feels sick” correlated with low back pain outcome better than physical parameters such as presenting physical examination or the type of physical therapy undergone (42).

Programs directed at altering management’s perspective of the injured worker have been extremely successful in reducing low back injury costs. The Chelsea Back Program consisted of structural, technological, and attitudinal changes of management and resulted in a 75% reduction in the total cost per back injury claim (43). David Wood compared a management attitudinal program with a back school program in back injury prevention. Interestingly, the management attitudinal program was successful in reducing injuries while the back school program had no effect (44).

It is quite apparent that there are multiple variables that affect the development of pain and the outcome. The amount and frequency of lifting is an important physical variable that affects the development of low back pain. The functional task of lifting consists of multiple components, one of which includes strength (45). Increased abdominal and trunk strength has been correlated with improved outcome following low back injury (46–49). In the remainder of this chapter we will evaluate techniques of quantifying lumbar trunk strength and their relationship to the prediction of low back pain. Table 36.1 summarizes the multiple factors affecting the manual materials handling activities.

**TECHNIQUES OF EVALUATING STRENGTH**

There are three common methods of evaluating strength: isometric, isokinetic, and isoinertial (psychophysical). Isometric strength is defined as the static measure of maximum voluntary contraction with the muscle at a fixed length.
Isokinetic strength is defined as a dynamic measure with body segments moving at a constant rate of speed. Isoinertial (psychophysical) strength is defined as a dynamic measure of maximum weight moved through a range. The following six criteria will be used to evaluate the above methods.

1. Safe to administer,
2. Reliable and reproducible,
3. Practical to administer,
4. Predictive of capability and/or risk,
5. Specific to the requirements of the job,
6. Ethically and legally defensible (50).

**ISOMETRIC STRENGTH TESTING**

There are two current basic techniques used in evaluating isometric strength. Technique 1 will be described as a low-technology approach using a simple strain gauge, while the high-technology approach uses computerized instrumentation such as Cybex, Kincom, Biodex, or LIDO. The low-tech strain gauge apparatus (Fig. 36.1) costs approximately $300, while the high-tech computerized equipment generally runs over $50,000 per unit.

The reliability and reproducibility of isometric strength instrumentation has been established (51). One major concern with isometric testing is the safety of the actual procedure. Hansson, using biomechanical analysis, has calculated compressive loads on the L3 vertebral body ranging from 5,000 to 11,000 newtons during squat and torso lifting in isometric testing (52). These loads in vitro have caused structural failure in the vertebral endplates. Hansson noted, however, that isometric testing of trunk flexors and extensors caused significantly

**Figure 36.1.** Low-tech isometric strength testing device. (Reproduced by permission from Cady LD, Bischott DP, O'Connell ER et al. Strength and fitness and subsequent back injuries in firefighters. J Occup Med 1979; 21(4):271. © Am. College of Occupational Medicine.)
less load on the L3 vertebral body. Zeh analyzed over 1,000 volunteers testing isometric strength (53). Approximately 5% of the subjects could not continue testing because of pain and 0.5% actually developed an injury. Zeh’s recommendation was to reduce the number of exertions, which substantially reduced the probability of injury and still provided accurate assessment of isometric strength. Overall, isometric techniques, particularly using the strain gauge device, are quite simple and practical to administer.

Don Chaffin is a pioneer in isometric strength testing. In a series of elegant papers, Chaffin first demonstrated that the incidence rate of low back pain is correlated with increased lifting strength requirements (11). In a following study, he demonstrated that the incidence of back pain increased when loads exceeded a subject’s isometric lifting capability (11, 54, 55). Finally, in a classic study, Chaffin actually reduced low back injuries by selecting workers on the basis of their isometric strength and placing them in jobs where their strength exceeded their lifting requirements (50, 57). However, Battie and Bigos have found no correlation between isometric strength and injury, yet they did not match job demands with strength (58). Considering there is no demonstrated significant difference in static back extensor strength among workers performing a wide variety of physically demanding jobs (45), isometric strength testing might be a useful tool in preplacing workers. Currently, no scientific study demonstrates that isokinetic or isoinertial technologies are predictive of subsequent back injury (59).

**ISOKINETIC STRENGTH TESTING**

There are four popular, commercially available isokinetic testing devices. Cybex provides a sagittal strength device as well as a torsional strength device. Kincom provides an attachment to its extremity dynamometer so that it can be used as a back testing device. Biodex also provides an attachment to the existing extremity system. Finally, LIDO provides a sagittal strength tester similar to the Cybex unit, but theirs allows subjects to sit or stand. (See Figure 36.2, the LIDO isokinetic trunk tester.) Tom Mayer and Robert Gatchel provide an excellent review of the above manufacturers’ equipment (60).

The allure of isokinetic trunk testing is that dynamic testing theoretically would more closely re-create functional lifting than would static testing. This premise, however, has not been proven scientifically. Also, individuals do not actually lift items isokinetically, but rather isoinertially. Isokinetic testing, however, has been proven to be safe and the data are reproducible and reliable (61–67).

Another popular aspect of isokinetic testing is curve analysis. The hypothesis is that curve variability distinguishes submaximal from maximal efforts in isokinetic trunk and lift testing. The hope is that through computerizing strength testing, it would be possible to distinguish a malingering patient from an injured one, or one who is not providing full effort from one who is. Certainly this would be a tremendous help in the medicolegal arena. Rowland Hazard and co-workers evaluated the variability of isokinetic curves as an indicator of effort. Their conclusion is that clinical observation of the subject using the isokinetic equipment is more accurate than analyzing curve variability. It was extremely difficult to discriminate between submaximal effort secondary to pain, malingering, or fatigue (Fig. 36.3).

Although isokinetic technology is safe and provides repeatable, reproducible data, it is extremely costly. It also has not been scientifically shown to have greater inferential capacity than the available isometric technologies described above. It is also not specifically job-related, as people do not lift isokinetically. It does appear, however, that quantifying trunk strength using isokinetic technologies facilitates recovery from low back injuries.

**ISINOERTIAL STRENGTH TESTING**

There are two basic approaches to isoinertial strength testing—a low-technology and a high-technology approach. Stover Snook introduced the first strength evaluation using a low-technological isoinertial approach (69). This involved lifting boxes filled with lead shot or bricks. More recently, Thomas Mayer has introduced progressive isoinertial lifting evaluation (PILE) (70, 71). In the high-technology arena, Isotechnologies has introduced a computerized isoinertial testing device.

The data from the low-tech and high-tech approaches are repeatable and reproducible (72). The technology is safe to administer and relatively easy to use, particularly with the low-technological approach. The cost for Snooks’ or
Mayer's low-technological approaches is minimal, while the cost for Isotechnologies' equipment exceeds $50,000 per machine. Although isoinertial techniques are job-related, as a multiaxial, uncontrolled speed evaluation most closely replicates motion of the spine (73), they are poor predictors of future low back pain (74).

It has been demonstrated that using high tech isoinertial testing can reduce low back disability time (75). It is likely that the reduced disability time associated with using both isokinetic and isoinertial high-technological approaches is related to the actual objectification of function. By objectifying function, the patient has a direct feedback about recovery, which most likely serves as a motivator.

Table 36.2 is a summary slide of the six criteria that isometric, isokinetic, and isoinertial testing devices have been judged by. It is clear that all of the devices are relatively safe, easy to use, and provide reproducible data (76). The costs for the high-tech isokinetic and isoinertial equipment appear prohibitive. The costs for isometric and low-tech isoinertial devices are quite reasonable. Only isometric and isoinertial techniques are actually job-related. Most importantly, only isometric strength testing has been proven to be predictive of future low back injury.
Figure 36.3. Cybex trunk extension/flexion curves. A, consistent curves; B, variant curves; C, slightly variable curves. (Reproduced by permission from Hazard R, Reid S et al. Isokinetic trunk and lifting strength measurements: Variability as an indicator of effort. Spine 1988; 13(1):55.)
### Table 36.2. Status of Whole Body Strength Testing

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Isometric</th>
<th>Isokinetic</th>
<th>Isoinertial</th>
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<tbody>
<tr>
<td>Repeatable</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Safe</td>
<td>Good</td>
<td>Excellent</td>
<td>Excellent</td>
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<tr>
<td>Easy to Use</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Good</td>
</tr>
<tr>
<td>Cost</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Job-Related</td>
<td>Good</td>
<td>?</td>
<td>Good for Lifting</td>
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<tr>
<td>Predictive</td>
<td>Good</td>
<td>?</td>
<td>?</td>
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### MEDICOLEGAL ASPECTS OF EVALUATIONS

In the state of California, discriminative hiring based on latent or potential disability is against the law. To reject a job applicant legally on the basis of a potential back problem, the employer must meet the following criteria: 1) The applicant is unable to do the specific job; 2) all or substantially all of the excluded people are unable to safely and efficiently perform the job; and 3) there is an identifiable and substantial immediate danger imposing a substantial degree of risk. Currently, preemployment screening is illegal in the state of California because it is deemed discriminatory based on a latent or potential disability. However, preplacement screening, once a person is hired, is legal. Chaffin's techniques using isometric strength testing and matching a worker's job to actual lifting capabilities once the worker is hired is legally defensible.

### STRENGTH VERSUS ENDURANCE

One major question in the scientific literature is whether low back pain sufferers have weaker trunk muscles or if muscles become weak once pain develops. Multiple scientific studies have demonstrated that low back pain sufferers have less isometrically tested strength of the trunk muscles (77–80). There is also abundant literature reporting that low back pain sufferers have weaker trunk muscles as tested dynamically (68, 81–83). However, Berkson and Nachemson report that there is no difference in isometric abdominal or trunk strength in those individuals with low back pain and age-matched controls (84, 85).

Biering-Sorensen has published two studies stating that trunk strength alone is a poor predictor of low back pain (86, 87). However Biering-Sorensen has demonstrated that isometric back endurance is significant for predicting the first back pain occurrence in men (87). Nicolaisen and Jorgensen found no difference in abdominal and back strength in back pain patients and normals. However, they did find decreased endurance of the trunk muscles in low back pain sufferers (88, 89). Reduced endurance in the trunk musculature might force the spine to perform functional activities in an uncoupled, unprotected manner, making injuries more likely.

It is quite obvious that there is extensive controversy about the relationship between trunk strength and low back injury. After this critical review of the literature, Chaffin's concept of matching the strength of workers to the strength demands of their jobs based on pure isometric strength testing still carries tremendous merit. Additional investigation in isometric strength versus isometric endurance needs to be explored in light of Biering-Sorensen's, Nicolaisen's, and Jorgensen's recent studies.

### FUTURE APPLICATIONS OF FUNCTIONAL ASSESSMENT

Lee Cady's classic description of firefighters demonstrated that the most physically fit individuals had the least number of low back injuries. The prospective measurements included flexibility, isometric lifting strength, bicycle ergometer exercise measurements of 2-minute recovery of heart rate, diastolic blood pressure at a heart rate of 60 beats per minute and watts of effort required to sustain heart rate at 160 beats per minute (90). In a follow-up study, Cady demonstrated that after a 14-year program promoting health and physical fitness, there was a 16% increase in the physical work capacity, a slight increase in spinal flexibility, no clear increase in muscle strength, a decrease in smoking, a decrease in disabling injuries, and a 25% decrease in workers' compensation costs (91). Cady's demonstration of decreased workers' compensation costs as a result of a physical fitness program, Chaffin's demonstration of reduced injuries using isometric testing, and management approaches described previously all suggest that there are active ways that modern industry can reduce the incidents of low back pain and subsequent compensation.

In summary, evaluating low back injury is a complicated problem affected by a myriad of physical, psychosocial, and legal issues. To
focus on only one variable, such as strength, results in a gross simplification of this challenging problem. It is quite apparent that industry requires uniformity in testing of the multitude of variables. It also appears that emphasis placed on objective parameters appears to facilitate recovery from a low back injury. Ergonomic changes, preselection of the worker, and a more informed management appear to be the prerequisites for reducing low back pain in industry. Generally improved fitness also appears to be very promising. Certainly, additional research and standardization is required in all of these areas.

References


73. Parnianpour M, Nordin M et al. The triaxial coupling of torque generation of trunk muscles during isometric exertions and the effect of fatigue...