Clin Sports Med 27 (2008) 463–479

CLINICS IN SPORTS MEDICINE

Clinical Prediction for Success of Interventions for Managing Low Back Pain

Jeffrey Hebert, DC[a,*], Shane Koppenhaver, MPT[a], Julie Fritz, PhD, PT, ATC[a], Eric Parent, PhD, PT[b]

[a]The University of Utah, College of Health, 520 Wakara Way, Salt Lake City, UT 84108, USA
[b]Department of Physical Therapy, The University of Alberta, Faculty of Rehabilitation Medicine, Edmonton, Canada

Low back pain (LBP) is highly prevalent in athletic and nonathletic populations, and is a common cause of pain and disability. It is difficult to identify the pathoanatomical cause for most cases of LBP, leading many to consider LBP as a single "nonspecific" disorder. Most studies evaluating the treatment effectiveness of interventions for LBP have been based on this presumption and have generally demonstrated small to no treatment effects. Most providers think of LBP as a more heterogeneous disorder, and the inability to more specifically match patients to interventions likely to be beneficial is one possible explanation for the lack of research evidence proving the effectiveness of treatments and the suboptimal outcomes of clinical care. Treatment-based classification, one approach to subgrouping patients with "nonspecific" LBP, focuses on identifying clusters of findings from the history and clinical examination that predict a more favorable outcome with a specific treatment approach. By matching patients with the appropriate specific exercise, stabilization exercise, spinal manipulation, or traction treatment, providers may expect a high probability of a successful clinical outcome.

LBP imposes an enormous burden in the United States, both to individuals and to society. LBP is the most common type of pain reported by adults [1], and is among the most frequent complaints seen in physicians' offices [2]. Moreover, 60% of LBP sufferers experience some form of functional limitation or disability as a result of their pain [3]. Pain and disability attributable to LBP are accompanied by an estimated $100 billion to $200 billion in health care expenditures and lost wages annually in the United States [4], equivalent to over 1% of the entire gross domestic product. Despite many recent advances in

*Corresponding author. Division of Physical Therapy, 520 Wakara Way, Salt Lake City, UT 84108. *E-mail address*: jeff.hebert@utah.edu (J. Hebert).

0278-5919/08/$ – see front matter
doi:10.1016/j.csm.2008.03.002

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imaging and surgical technology, LBP prevalence and its related economic and societal burden have remained largely unchanged in the past decade [1,4].

Athletes may be especially susceptible to LBP and low back injuries. The prevalence of LBP appears particularly high for participants in sports that place high demands on the spine, such as wrestling, gymnastics, and golf [5]. Among the general population, LBP symptoms only weakly correlate with abnormal imaging findings and the great majority of cases of LBP cannot be attributed to specific pathoanatomical causes [6]. Athletes may be more likely than non-athletes to have an identifiable pathoanatomical cause of LBP symptoms [7,8]. Higher rates of spondylolysis, spondylolisthesis, and disc degeneration have been reported in athletes than in the general population [9,10]. Despite an increased incidence of certain pathoanatomical findings, it remains difficult to identify a specific cause in the majority of cases of LBP in athletes. The inability to identify a cause can make it difficult for clinicians to determine which treatment strategy is most likely to be effective. To assist clinicians in predicting which intervention is likely to be most effective, this article reviews the evidence for various interventions commonly used in the treatment of LBP.

SUB-GROUPING PATIENTS WITH LOW BACK PAIN

Common treatment alternatives for individuals with LBP, including those involved in athletics, consist of various forms of exercise, stabilization training, manual therapy, traction, and the use of physical modalities. Physical modalities, such as therapeutic ultrasound and electrical muscle stimulation, are widely used in the treatment of LBP [11], but randomized trials, systematic reviews, and practice guidelines have not supported the efficacy of these approaches [12–18]. Therefore, they are not considered as unique treatment strategies.

Exercise, manual therapy, traction, and many other treatments have been the subject of extensive scientific inquiry. Despite research efforts, evidence showing the effectiveness of these treatments is generally lacking or inconclusive. Even in studies that show some benefit for these treatments, the magnitude of the observed effects is often small, and the utility of these treatments remains subject to debate [13,16]. This can leave clinicians in a quandary as to the best treatment approach for a patient with LBP. The unfortunate result of this clinical dilemma is that one therapy can appear as appealing as the next, which may lead to less effective and efficient treatment. An increasing volume of information is available, however, to assist clinicians in predicting which type of treatment may be most likely to benefit an individual patient with LBP. Incorporation of this information into practice may improve clinical decision-making and treatment outcomes. A top priority for LBP research is to identify criteria for various subgroups of patients with LBP [19–21]. The nature of these subgroups and the methods for detecting them have been the subjects of a great deal of recent debate and research activity [22].

One approach to subgrouping patients with LBP has focused on identifying clusters of findings from the clinical examination that predict a more favorable outcome with a specific treatment approach [23]. Several experts in rehabilitation, including McKenzie and others, have advocated this treatment-based approach. This article focuses on treatment-based subgrouping hypotheses originally described by Delitto and colleagues in 1995 [24]. The subgrouping hypotheses proposed are intended for patients who may or may not be involved in athletic activities with acute LBP or an acute exacerbation of LBP causing substantial pain and limitations in daily activities. After screening patients for any signs of serious pathology, information collected during the history and physical examination is used to place a patient into a subgroup. The name of each subgroup describes the fundamental treatment approach believed to offer the best chance for a successful outcome: manipulation, specific exercise (flexion, extension, and lateral shift patterns), stabilization, and traction. The cluster of examination findings and treatment strategies associated with each subgroup is reviewed in the following sections.

TREATMENT SUBGROUPS

Specific Exercise

The specific exercise subgroup emphasizes treatment using repeated end-range movements of the lumbar spine in a specific direction to affect the location and intensity of the patient's pain. This relationship between movement and pain was first emphasized by McKenzie [25]. Examination findings believed to identify patients in this subgroup include the presence of symptoms in the lower extremities, signs of nerve root compression (eg, positive straight-leg raise test; diminished reflex, sensation, or strength). The principle finding related to the specific exercise subgroup is the presence of centralization or a directional preference during the examination. Centralization occurs when a movement or position results in the relief of pain or paresthesia, or causes symptoms to move from a distal/lateral position in the buttocks and/or lower extremity to a more proximal location, closer to the midline of the lumbar spine [26]. Research has demonstrated the prognostic importance of the centralization phenomenon in patients with LBP with or without sciatica [27–33]. For example, Werneke and colleagues [32] examined the prognostic value of 23 demographic, psychosocial, occupational, and physical examination variables in 223 consecutive patients with acute LBP. The absence of centralization in this sample was associated with delayed recovery and the development of chronic LBP and disability. A concept related to centralization is directional preference. Directional preference occurs when a movement in one direction relieves pain or increases range of motion, and is often associated with movement in the opposite direction resulting in a worsening of the patient's signs and symptoms [34].

Advocates of a treatment-based classification approach contend that the presence of centralization or a directional preference is not just a favorable prognostic finding, but is among the predictive variables indicating the need for a specific exercise approach in treatment (Table 1). The basic treatment premise for patients in the specific exercise subgroup is the use of repeated, or sustained, end-range movements in the direction that caused centralization or of the directional preference determined during the examination. The movement

Table 1
Subgroups of patients with low back pain with subgroup criteria and treatment approaches

Subgroup	Subgroup criteria	Treatment approach
Specific exercise: extension	Symptoms distal to the buttock Symptoms centralize with lumbar extension Symptoms peripheralize with lumbar flexion Directional preference for extension	End-range extension exercises Mobilization to promote extension Avoidance of flexion activities
Specific exercise: flexion	Older age (>50 y) Directional preference for flexion Imaging evidence of lumbar spine stenosis	End-range flexion exercises Mobilization or manipulation of the spine and/or lower extremities Exercise to address impairments of strength or flexibility Body weight–supported ambulation
Stabilization	Younger age (<40 y) Average straight-leg raise (>91°) Aberrant movement present Positive prone-instability test	Exercises to strengthen large spinal muscles (erector spinae, oblique abdominals) Exercises to promote contraction of deep spinal muscles (multifidus, transversus abdominus)
Manipulation	No symptoms distal to knee Duration of symptoms <16 d Lumbar hypomobility Fear-Avoidance Beliefs Questionnaire for Work <19 Hip internal rotation range of motion >35°	Manipulation techniques for the lumbo-pelvic region Active lumbar range-of-motion exercises
Traction	Symptoms extend distal to the buttock(s) Signs of nerve root compression Peripheralization with extension movement; or positive contralateral straight-leg raise test	Prone mechanical traction Extension-specific exercises

may be flexion, extension, or lateral translation. The most common specific exercise movement for younger individuals or athletes is extension [35]. Treatments for patients who centralize or demonstrate a preference for extension include repeated end-range extension exercises, such as prone press-ups

(Fig. 1), or lumbar extension performed while standing. Exercises are progressed by increasing the amount of force or increasing the range of motion to maximize symptom relief. It is important that patients in this subgroup perform these activities frequently throughout the day. Patients may also need to be educated to avoid activities that promote prolonged or end-range flexion activities, such as lifting with poor body mechanics or sitting for long periods. Mobilization of the lumbar spine into extension (eg, posterior-to-anterior mobilization) may also be a useful treatment adjunct. An important contraindication to repeated end-range extension activities that should be considered in athletes with LBP is spondylolisthesis.

Several studies have investigated the effectiveness of an extension-specific exercise treatment approach. Studies that have applied this treatment to patients who fit the subgrouping criteria described above have reported evidence favoring the approach over other exercise interventions [36,37]. Trials that have evaluated an extension-specific exercise approach without an attempt to limit patients to those with these subgrouping criteria have generally not supported the effectiveness of this treatment option [38–41]. For example, Long and colleagues [35] randomized 230 patients with LBP who had a directional preference to receive either usual care, specific exercises in the direction of their preference, or specific exercises in the direction opposite their preference. The directional preference was extension for 83% of patients. Patients receiving exercises in the matched direction showed greater reductions in pain and disability after 2 weeks of treatment [35]. Browder and colleagues [35] randomized 48 patients with LBP who centralized with extension to receive either an extension-specific exercise approach or stabilization exercises. Patients receiving the extension-specific exercise approach, which included extension exercises, patient education, and graded posterior-to-anterior mobilization, showed greater improvement in disability at both short- (1- and 4-week), and long-term (6-month) outcomes [35].

Stabilization Exercise

Functional deficits of the trunk muscles have been observed in general [42,43,44] and athletic [45,46] populations with LBP. Similar deficits in trunk

Fig. 1. Example of specific exercise: prone press-up.

muscle function have also been associated with traumatic knee injury [47,48] and chronic groin pain in athletes [49], suggesting that a lack of trunk control may compromise function or stability of the lower extremities during athletic activity. In addition to deficits in neuromuscular control of the trunk muscles, patients with LBP have also been observed to have morphologic changes, including atrophy [50–54] and fatty infiltration [55–57] in the lumbar multifidus and erector spinae muscles. Stabilization exercise programs are typically designed to address the deficits in strength, endurance, and function of the trunk musculature that have been identified in patients with LBP. It is thought that improvements in trunk muscle function lead to decreases in pain and disability by improving the control of spinal segments during movement. In support of this hypothesis, stabilization exercise has been shown to improve trunk muscle function [58,59] and morphology [60–62] in individuals with LBP.

Improvements in trunk muscle function and morphology may represent important outcomes of rehabilitation programs. However, these physiologic changes may not correspond to patient-centered improvements in pain and disability. This concern is highlighted by the conflicting results of research examining the effects of stabilization exercise programs on patient-centered outcomes. While some studies support stabilization exercises as an effective treatment for LBP [63–66], others have demonstrated equivalence between stabilization exercise and traditional rehabilitation approaches [67] or manual therapy [68,69]. A recent systematic review by Rackwitz and colleagues [70] concluded that stabilization exercise for LBP is more effective than treatment by a general practitioner but not more effective than other physiotherapy interventions.

Conflicting findings of research evaluating the effectiveness of stabilization exercise support the consideration that there may be a subgroup of patients with LBP who are most likely to benefit from this approach. Hicks and colleagues [71] investigated variables that may identify which patients with LBP are likely to experience clinical success when receiving stabilization exercises. Four variables (see Table 1) were most predictive of success, defined as a 50% reduction in disability as measured by the Oswestry Questionnaire. When three or more of these variables were present, the probability of achieving clinical success increased from 33% to 67%. While the presence of these variables was associated with an increased likelihood of success, it is clear that future research may be able to identify additional factors to improve the prediction of success with stabilization exercises.

The most effective exercises for use in a stabilization program are also a matter of current debate. A good deal of recent attention and research has focused on specific retraining exercises for the deep trunk muscles, in particular the transversus abdominus and multifidus [58,60,64]. The goal of this approach is to retrain the normal stabilizing motor patterns of these muscles, which are often compromised in individuals with LBP. Some evidence for this approach exists [58,64]. However, most studies have compared this specific retraining approach to management involving no exercise or poorly defined exercise protocols. Other stabilization regimens have placed greater emphasis on exercises designed to improve the strength and endurance of larger, more superficial trunk muscles (ie, erector spinae, oblique abdominals, quadratus lumborum) (Fig. 2) [70,71]. This approach to stabilization exercise emphasizes the use of strengthening exercises that sufficiently challenge these important muscle groups while minimizing potentially harmful compressive and shear loading of the spine. Since the stabilizing activity of any of these muscles is generally that of a low-intensity contraction [72], exercise protocols focus on high repetitions of low-load contractions to promote muscle endurance. Recent research has compared specific muscle retraining programs to this more general stabilization approach [61,63,67]. These studies have not found differences favoring one approach over the other. Although many experts advocate the necessity of specifically retraining the deep spinal muscles, the evidence does not clearly support this perspective. Further research should help define the optimal mix of stabilization exercises for patients with LBP.

Spinal Manipulation

Spinal manipulation is generally defined as the application of a high-velocity, low-amplitude thrust to a joint, which frequently results in an audible "crack" or cavitation [73]. The clinical outcomes associated with spinal manipulation have been the subjects of a great deal of scientific investigation. This research has resulted in several randomized clinical trials [74–77] and systematic reviews [16,78] demonstrating effectiveness for manipulation when compared with placebo or other interventions. However, other trials and reviews have failed to

Fig. 2. Examples of stabilization exercises: side bridge (*above*) and bird dog (*below*).

demonstrate a clear clinical benefit of spinal manipulation when compared with other therapies [37,79–81]. Clinical experience suggests that spinal manipulation is effective for at least some patients with LBP. The conflict between research outcomes and clinical experience may be due in part to uncertainty in defining which subgroup of patients with LBP is most likely to benefit from manipulation [82].

Manipulation has been used for centuries [83], yet the mechanism by which manipulation may have a therapeutic effect is subject to debate, which leads to confusion in determining the subgroup that responds best to the treatment. Traditional explanations of the therapeutic mechanism of spinal manipulation have emphasized the importance of directing forces to specific spinal joints for the purpose of correcting a biomechanical dysfunction or misalignment [84–87]. While these constructs may seem intuitive, several studies have questioned their validity. Research has questioned the ability of clinicians to direct manipulative forces in a manner to affect specific spinal joints [88,89]. Furthermore, while there is a small degree of intervertebral movement produced during spinal manipulation [90–92], sustained changes in alignment have not been observed [93].

Flynn and colleagues [94] used a different approach to examining the patient characteristics that may define a subgroup of patients likely to benefit from manipulation by focusing on the prediction of clinical success instead of presumptions based on biomechanical theories. This study identified five variables (see Table 1) predictive of success, defined as a 50% reduction in the Oswestry Questionnaire within 1 week. Patients were considered to be likely responders to manipulation when four or more of these variables were present. When patients met this threshold, the probability of achieving clinical success increased from 45% to 95%.

A follow-up study [76] was performed to examine the validity of these predictive criteria. The results found that patients with LBP receiving manipulation who met these criteria experienced greater decreases in pain and disability than did patients who received manipulation but did not meet the criteria. Additionally, patients who met the criteria and received manipulation experienced greater improvement than did patients who met the criteria but were treated with stabilization exercises. Two important conclusions can be inferred from this study. First, while results do not support spinal manipulation as a superior treatment for all patients with LBP, they do suggest that manipulation is effective for the appropriate subgroup of patients. Second, the presence of these criteria does not automatically equate to a more favorable prognosis unless the appropriate treatment is provided.

The manipulative technique used in this research (Fig. 3) involves a high-velocity, low-amplitude thrust delivered to the anterior superior iliac spine of the supine patient after being sidebent away from and rotated toward the clinician. This procedure was originally thought to be appropriate for patients with biomechanical dysfunction of the sacroiliac articulation [24]. Except for the presence of stiffness somewhere in the lumbar spine, none of the variables

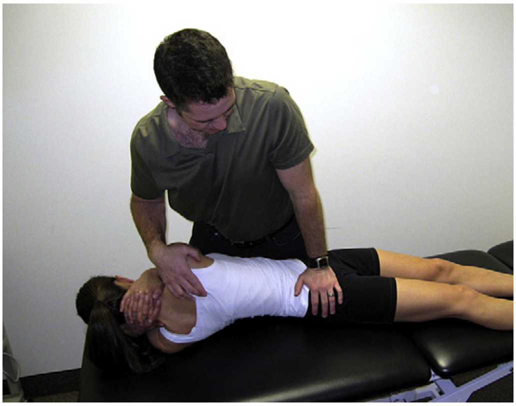

Fig. 3. Manipulation technique.

predictive of success with this procedure related to biomechanical dysfunction. The lack of relationship between clinical success and specific biomechanical dysfunction seems consistent with the growing body of evidence supporting a primarily neurophysiologic mechanism of manipulation. Studies have shown spinal manipulation to affect both sensory and motor nerve activity as well as electromyographic-measured muscle activity [92,95–101]. Although further research is needed, one conclusion can be drawn: If the mechanism of action for spinal manipulation is primarily mediated by neurophysiologic mechanisms rather than biomechanical "realignment," clinicians may be forced to change their paradigm for determining which patients are most appropriate for spinal manipulation.

Traction

Traction techniques for the lumbar spine have a rich history in medicine dating back more than 200 years [102]. Lumbar traction is commonly used [103] and has been referred to by some as "decompression therapy" [104]. Many clinicians believe traction is effective [103,105,106], but the usefulness of traction for treating LBP has been the subject of debate and controversy [107,108].

The traditional presumption of clinicians has considered the presence of sciatica or signs of nerve root compression as indications for traction [103]. Yet, until recently, little research evidence has been available to assist clinicians in predicting which patients with LBP were most likely to benefit from traction. We recently examined the outcomes of patients with LBP who also had symptoms below the buttock and signs of nerve root compression. Our purpose was to determine if these criteria were specific enough to define the subgroup of patients who respond to traction, or if additional criteria were required [27]. We found that the presence of symptoms below the buttock and signs of nerve root compression were not specific enough to define this subgroup of patients. Two additional factors were found to identify patients likely to respond favorably to traction: (1) peripheralization with extension movement and (2) a positive crossed (ie, contralateral) straight-leg raise test. The presence of either of these, in addition to symptoms below the buttock and signs of nerve root compression, define the subgroup of patients who respond to traction. Peripheralization occurs when a movement or posture causes symptoms to move distally, away from the spinal midline. A positive crossed straight-leg raise test is defined as reproduction of the patient's familiar lower extremity symptoms when the contralateral leg is passively raised with the knee maintained in an extended position [109]. When patients with symptoms below the buttock and signs of nerve root compression had either of these findings and received traction along with an extension-specific exercise program, they showed greater short-term reductions in disability than patients with these findings who received only the extension exercise program. These results suggest that traction may be essential to maximize improvement in a specific subgroup of patients (see Table 1).

There has been considerable diversity in the recommended parameters to be used when applying traction. The most common patient position used with mechanical traction is reported to be supine with the hips and knees flexed approximately 90° [103,110]. Although this position is comfortable for many patients with LBP, the position places the lumbar spine in flexion and may therefore be contraindicated for patients who meet the traction subgroup criteria. Prone-lying (Fig. 4) may therefore be a preferred position for these patients. There is no clear evidence regarding the most effective traction force. Many experts contend that the force needs to be higher than is typically used in clinical practice (~50% of body weight) to produce a therapeutic effect [111,112]. It may be appropriate to initiate treatment at a slightly lower force (~40% of body weight), then increase the force as tolerated up to a maximum of 60% of body weight. With high-force traction, the duration of treatment may need

Fig. 4. Traction therapy.

to be shorter (8–12 minutes), with allowances for ramping up and ramping down the force. Because the goal of traction is vertebral separation, static traction is often recommended [111,112]. Traction is rarely delivered as a stand-alone treatment. Because the overall goals of treatment for patients in this subgroup are to reduce and centralize leg symptoms, traction is frequently delivered along with an extension-specific exercise program as described.

Evidence-based guidelines and systematic reviews have not supported the effectiveness of traction for patients with LBP [16,113,114]. The discrepancy between clinical perceptions and research evidence may be attributable to the manner in which traction has been applied in the majority of studies that have examined its effectiveness. Studies that have shown no benefit from using traction have used nonspecific inclusion criteria, essentially allowing all patients fitting a broad definition of acute or chronic LBP to enter [115,116]. Most studies have also failed to adequately define the parameters used for delivering the traction, or have used parameters that are not consistent with expert opinions or typical clinical use [108]. To use traction most effectively, greater attention is needed in the identification of clinical factors that pinpoint patients who need traction and in the application of appropriate dosages of traction.

SUMMARY

The identification of predictive factors in patients with LBP should allow the patient to be matched with the most appropriate treatment intervention, maximizing the likelihood of a favorable clinical outcome [117]. While the identification of predictive factors for the treatment of patients with LBP represents a significant advance in patient care, much more information and research are needed. Nevertheless, it appears that using simple baseline evaluation findings can help clinicians more efficiently and effectively select the most appropriate treatment for an individual patient with LBP.

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