Spinal stabilization—an update. Part 3—training

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Introduction

Reactivating spine pain patients is a key to early recovery from acute and subacute episodes (Malmivaara et al., 1995; Indahl et al., 1998), prevention of recurrences (Hides et al., 2001), and treatment of chronic pain, disability, and failed surgery syndrome (Fordyce et al., 1986; Lindstrom et al., 1992; Manniche et al., 1991; O’sullivan et al., 1997; Timm, 1994). The first part of this series described the role of instability in low back problems (LBP) as well as specific types of biomechanical advice to prevent low back irritation. The second part described an assessment of the stability system. This third and final part will describe a step-wise approach to patient reactivation from simple introductory exercises with wide margins of safety/stability to advanced functional performance training with much smaller margins of safety/stability.

Safe back principles have emerged from rigorous analysis of biomechanical and kinesiological aspects of spinal function (McGill, 2001; Liebenson, 1999). The goals shared with the patient are to offer palliative care, spare the spine (see part one), and then to stabilize the spine. Spine stability training includes 3 distinct levels of care. First, introductory exercises to find a patient’s functional range should be given. Second, low-load endurance training of stability patterns is emphasized (Hides et al., 1996; Timm, 1994; O’sullivan et al., 1997). Third, such stability patterns should be trained in functional activities to enhance performance during activities of daily living (ADLs), sport or work demands.

Sport psychology and behavioral medicine

Behavioral medicine or sports psychology tenets of "paced activity” and the relationship between hurt and harm should be discussed with the patient. Many low back pain (LBP) patients have excessive fear avoidance beliefs or catastrophizing behaviors which promote a passive, symptom-driven approach, excessive pathoanatomic diagnostic testing, and a poor prognosis (Linton, 2002). At the other end of the spectrum are individuals who are overly aggressive which can lead to a “boom or bust” mentality.

The middle path is best exhibited by the modern emphasis on quota-based “graded exposures” to feared stimuli (Linton, 2002). This operant conditioning model successively demonstrates to patients that hurt does not necessarily equal harm, and that activity—contrary to the patients beliefs—is actually beneficial. The activities chosen should be mutually agreed upon and at most have only slight mechanical sensitivity (MS). The exercises should be designed to improve the abnormal motor
control (AMC) identified in the evaluation (see Part two). Regular re-evaluation of activity intolerances (AI), MS, and AMC is necessary to prove to the patients that their fear is unfounded.

Training

Prior to initiating low back exercise training biomechanical advice about how to avoid low back irritation during ADLs—spine sparing strategies—should be taught (see Part one).

A step-wise approach to reducing activity intolerances and restoring function has been developed. Once advice has been given about how to spare the spine during ADLs, and the safety exercise discussed, then a progressive approach beginning with exercises with a wide stability/safety margin are prescribed to quota. The goal is to improve motor control by emphasizing coordination during simple movements designed to stabilize the back (i.e. hip hinging). Such introductory exercises are then progressed by adding low-load endurance challenges. Finally, exercises are progressed to include functional or performance components which mimic as closely as possible the actual ADL, work or sports demands that the individual faces (see Table 1).

Introductory training—graded exposures to grooved stability patterns

In level one training postural control, muscle balance and pain reduction or centralization is the focus. The goal is to "groove" motor patterns with safe, low-load activities. This requires an emphasis on the cognitive-kinesthetic awareness stage of motor control (Shumway-Cook and Woollacott, 1995). Most patients have poor kinesthetic awareness of how to produce and/or control motion of their problem area. The patient learns to "discover" how to move and "centrate" an important region such as the lumbo-pelvic, scapulo-thoracic, or cervico-cranial. They acquire the skill to perform the movement and then to limit it to a "pain-less" or pain centralizing functional range.

When a patient has a lot of MS with normal ranges of motion, especially if there is referred or radicular pain, the McKenzie approach of prescribing movements which centralizes referred pain and avoiding movements which peripheralize the symptoms is strongly recommended. In disc patients these movements often involve end-range positions such as extension. The key is to regularly recheck the patients MS to confirm that the patient’s overall functional range is expanding.

Behavioral principles/sport psychology are essential to exercise training. It is important to initiate exercise training with exercises that have a large safety/stability margin. Such exercises should be mutually agreed upon with the patient. They should be carried out to a quota even if mildly uncomfortable. In chronic pain patients the expectancy of re-injury is typically based on an activity avoidance belief or catastrophizing tendency and not an actual experience (Crombez et al., 1998). Graded exposures to feared stimuli are an excellent way to operantly condition pain patients, and thus prevent deconditioning and initiate functional reactivation. Pacing is important with any exercise prescription so that both too little or too much activity is avoided (Harding and de Williams, 1995; Harding et al., 1998; Butler and Moseley, 2003).

Exercises prescribed should be those with wide margins of safety/stability. Generally, loads under 3000 N of force are considered safe for acute/subacute exercise training. Routine ADLs involve about 2000 N and the NIOSH limit for repetitive tasks is 3300 N (see Part one). Table 3 shows the load profiles for a variety of low back exercises. They should be performed after limbering up and not immediately upon arising or after prolonged sitting (Snook et al., 1998; Green et al., 2002; Wilder et al., 1996). Good form or coordination is a prerequisite for such training (O’Sullivan et al., 1997). Finally, trunk muscle co-activation (e.g. abdominal bracing) is recommended to increase the stability margin (Cholewicki and McGill, 1996; McGill, 2002; Granata and Marras, 2000; Stokes et al., 2000).

The cat-camel is an ideal way to warm-up the spine. It is not a stretch and teaches the coordination to move and position the spine through an arc of motion. 8–10 repetitions of gentle limbering without stretching is appropriate.

- Limbering—cat-camel (see Fig. 1).
- Quadruped leg reach (see Fig. 2).

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The quadruped leg reach teaches "neutral" spine control during distal extremity motions. The key is avoiding spinal torsion or lumbar hyperextension. 8–10 slow repetitions with brief isometric hold is the goal.
Abdominal bracing involves co-activation of muscles in 360° around the lumbar spine. It is a light contraction 5–10% of MVC similar to being tickled or bearing down slightly (McGill, 2002; McGill et al., 2003). However, the key is that the breath is not held during the brace, nor is abdominal contraction entrained to a certain phase of respiration. If a patient holds the quadruped position and the clinician attempts to gently push the torso to and fro bracing will automatically be facilitated. The same can be done in other positions or exercises such as the dead bug or side bridge.

Often mobility of surrounding regions is restricted thus increasing load on the spine. One example, would be reduced mobility in the mid-thoracic, hip, knee and ankle during a squat or lunge resulting in poor maintenance of lumbar lordosis and thus disc overload. In such cases flexibility training such as of the mid-thoracic or hip flexors will help to spare the spine.

- T4–8 stretch (see Fig. 3).
- Psoas stretch (see Fig. 4).

Once the patient learns to move and position their spine in fundamental ways then a progression to more complex exercises and functional activities can occur. There are always two aspects to the decision of whether or not a patient is ready to progress or not. The first is concerned with MS and the second with AMC. The sooner in the program actual functional activities are trained the better but, it is necessary at each step that (a) mechanical sensitivity is not increased, and (b) that motor control is re-educated. MC involves functional centration or “neutral posture” of key joints, normal respiration (i.e. no breath holding), and avoidance of abnormal patterns of muscle substitution (Richardson et al., 1999). If for instance, an exercise increases MS by either peripheralizing symptoms or increasing painful ROMs on post-exercise auditing then the correct introductory training has not been achieved. Similarly, even if mechanical sensitivity is decreasing but the patient is not learning how to perform simple movement patterns with good form they are not ready to progress.

**Isolation of specific stability patterns**

The goal of the second level of stability training is to build endurance into the new spine sparing motion patterns. This requires that the intensity of
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McGill and colleagues have demonstrated that both muscle output and spinal load can be measured for a variety of exercises (McGill, 1995; McGill et al., 1996; Axler and McGill, 1997). Muscle output is determined as a percentage of maximum voluntary contraction ability (MVC) and spinal load as a measure of spinal compression and shear forces. Ideal exercises are those that have a high ratio of muscle challenge to spinal load. Such analysis gives surprising data about common exercises which are prescribed for low back pain. For instance, spinal load is not different during sit-ups with knees bent or straight. In either case the load is over 3000 N and therefore should not be prescribed in the low back recovering population! (Axler and McGill, 1997; McGill, 1995). There are safer back exercises (see Table 2).

Besides using exercises with acceptable load profiles and maintaining core stability a number of traditional exercise science principles should be followed so results can be maximized. These relate to training with the appropriate intensity, frequency, and duration. Motor control or stability training requires an emphasis on endurance rather than strength (McGill, 1998; Richardson et al., 1999). For this reason the intensity of training is sub-maximal. As an example a typical prescription would involve three sets using a reverse pyramid approach (12/8/6 repetitions). Each exercise is performed slowly with a prolonged isometric hold time (5–10 s/repetition or about 2 breaths). A frequency of twice a day with a duration of up to 3 months is often required to remediate chronic spinal pain (Manniche et al., 1991).

Learning to coordinate breathing and bracing is one of the key skills taught. As long as an abdominal brace is held during an exercise such as a side bridge while simultaneously taking several breaths this coordination can be learned. It can be challenged further by adding heavier breathing such as might occur when one is aerobically challenged.

There are certain stages of motor learning that patients go through as they develop this stability skill. These are kinesthetic-conscious awareness, associative learning, and autonomous control (Shumway-Cook and Woollacott, 1995). Patients do not comply well if they have to be hypervigilent. Therefore, it is important to minimize the conscious awareness stage and find something which is easy for the patient to succeed with. This is termed “attacking success” or “finding the positive slope”. The astute clinician guides the patient effortlessly through these stages with the help of encouraging and facilitory cues, contacts, resistance, commands, etc.

McGill has developed the concept of “the big 3” in isolating and training stability patterns for the low back region (McGill, 2002). Such training encompasses low-load exercises for the anterior, lateral and posterior musculature.

The quadruped position is used to train the back muscles. Once the quadruped single leg reach is mastered then movement in the opposite arm can be added.

- Quadruped opposite arm+leg reach (see Fig. 5).
- Side bridge on knees (see Fig. 6).

The side bridge is an excellent, safe way to “groove” the hip hinge and train the lateral oblique musculature. It can be progressed from knees to ankles. Then an added challenge is add a rolling movement while maintaining the spine stable in a plank position.

- Trunk curl-up (see Fig. 7).

The supported dead bug is an alternative low-load way to initiate abdominal training and coordinate “neutral” spine control with reciprocal arm/leg patterns of motion. The unsupported dead bug is a more advanced progression

- Dead bug supported (see Fig. 8).
- Dead back unsupported (see Fig. 9).

The decision about advancing beyond stability to functional exercises is a simple one. If the patient

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<td>Exercises</td>
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<td>- Quad single leg raise—2000–2300 N (one side of lumbar extensors at 20% of maximum) (McGill, 1998)</td>
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<tr>
<td>- Opposite arm/leg raise 3000 N (1 side thoracic extensors around 30–40% max+opposite side lumbar ext. 20% of max) (McGill, 2002)</td>
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<tr>
<td>- Side bridge on ankles—2600 N (McGill, 1998)</td>
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<td>- Sit-ups straight knee—3500 N (McGill, 1998)</td>
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<tr>
<td>- Roman Chair exercise 4000 N (890 lb) (McGill, 2002)</td>
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<td>- Prone superman—up to 6000 N (over 1300 lb) (McGill, 2002)</td>
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can easily perform a sets of 10–12 slow repetitions with good form they are ready to move on. For example, 

**Move on:**

- Quadruped opposite arm/leg reach with "neutral" spine control.

**Don’t move on:**

- Quadruped opposite arm/leg reach with lumbo-sacral hyperextension or trunk rotation.

**Integration—functional integrated training (FIT)**

Functional stability training is goal oriented. Non-functional positions such as recumbent may be used as stepping stones to isolate and “groove” stability patterns. However, as soon as possible “core” stability must be trained in exercises mimicking the demands the patients face in their home, occupational, and recreational activities.

The sooner in the program actual functional activities are trained the better. But, it is necessary at each step that the movement is in the patients
functional range—reducing mechanical sensitivity and abnormal motor control while being as functional as possible.

Unless, functional training occurs there is no guarantee that the individual will be stable during "real world" challenges. Examples of functional training include squats, lunges, pushing, pulling, catching, carrying, etc. For more fit individuals and to enhance performance or prevent injury in demanding sports or occupations stability patterns may be further challenged by the addition of unstable surfaces such as balance boards and gymnastic balls. This provides enhanced proprioceptive stimulation which facilitates motor learning.

A patient’s “functional range” should be identified for each functional training exercise. For instance, to train for lifting, rising from a chair, throwing, pushing, or pulling activities squatting should be analyzed and trained. Typical findings of dysfunction with squats are poor control of the lower quarter (medial collapse—knee valgosity, subtalar hyperpronation, Trendelenberg hip position or patello-femoral shear) or lumbo-pelvic (stooping substituting for squatting) regions.

A simple squat exercise is the squat with back to the wall which automatically facilitates hip hinging.

- Squat with back to wall (see Fig. 10).

Troubleshooting for medial collapse can include single leg stance balance exercises.

- Balance reaches (see Fig. 11).

Functional stability during activities such as walking, climbing or descending stairs, rising from the floor, kneeling, throwing, pushing, or pulling can be re-educated with an exercise such as the lunge. A typical dysfunction or faulty movement pattern with forward lunging is excessive hip and trunk flexion. A simple exercise that is usually within the patient’s “functional range” is to perform a forward lunge while raising the arms overhead. This will usually re-educate “neutral” lumbo-pelvic posture automatically.

- Forward lunge with arms overhead (see Fig. 12).

If the forward lunge occurs with subtalar hyperpronation and excellent way to “attack success” is to attempt an angle lunge with an arm reach (see Fig. 12), this will typically “drive” the foot into supination automatically! Whatever is the most challenging functional activity the patient can perform with appropriate stability should be the one selected for exercise.

- Angle lunge with an arm reach (see Fig. 13).

Common movements such as pushing and pulling require the patient to make simple multi-planar weight transfers. Pushing is part of functional activities such as a tennis forehand, throwing, boxing punch, pushing a shopping cart or vacuum cleaner. Pulling is part of functional activities such as a tennis backhand, golf swing, throwing a frisbee, lifting a grocery bag out of a car or a baby out of a crib. Pushing and pulling can be trained with simple pulley or exercise tubing exercises.

- Core twist—push (see Fig. 14).
- Pull (see Fig. 15).
Reactivation progressions should continue until the patients’ "functional range" includes their home, sports, occupational demands. Athletes will require high-level performance training which will also include strength/power, agility, and speed challenges. These would be superimposed on the 3 levels of training already described. A frequent training error in programs designed for highly fit individuals is the performance of trunk or spine exercises with high-level strength or agility demands, without proper motor control. A step-wise approach built upon a foundation of conscious kinesthetic awareness of appropriate motor control is the best guarantee of injury prevention when performing high-level activities with a narrow safety/stability margin.

Conclusion

Safe back training in the acute stage should reduce fear of movement, reduce or centralize the patients pain, and "groove" appropriate movement patterns for basic ADLs. In the subacute recovery stage training should build endurance in progressively more challenging and functional movement patterns. Exercise should be prescribed in a goal-oriented manner with the patient’s active collaboration. In most instances, a realistic goal is to teach patients better spinal awareness during ADLs to spare their spine, and then to give them a few simple exercises to stabilize their spine. Patients engaged in higher level functional activities or with chronic problems will require more challenging exercises.
References


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