

Low Back Rehabilitation and Stabilization Program

This protocol is based on rehabilitation models and techniques from a number of respected sources. References are located at the end of this document, but there has been little effort to cite sources within the text. Many of the detailed technique recommendations are based on expert opinion. The program outlined in this document is intended as a complete, formal physical rehabilitation program for the target populations indicated (e.g., chronic LBP, recurrent LBP). However, various components could be applied individually for a wider patient population and as a simple adjunct to regular care.

ICD Codes

➤ Therapeutic exercise	97110
➤ Neuromuscular re-education	97112

The focus of this program is to

- 1) help patients regain neuromuscular coordination and control of the low back and pelvis,
- 2) build endurance for key muscles involved in the stabilization of the lumbar spine,
- 3) improve function of the lower kinetic chain,
- 4) promote endurance and control in the upper body, and
- 5) help patients to overcome kinesiophobia and regain a sense of control over lives disrupted by pain.

The exercises primarily target the following two muscle groups:

1. Muscles that stabilize the spine and control the pelvis.

- Abdominals: segmental system (including the transverse and internal obliques) and global (rectus and external obliques)
- Posterior extensor muscles (multifidi, quadratus lumborum, and latissimus dorsi)
- Gluteus maximus and medius

2. Muscles that provide a stable lower kinetic chain.

- Quadriceps
- Hamstrings
- Gastrocnemius

An Overview

The initial step is for a patient to learn to control the pelvis and hold the lumbar spine in a neutral position. Neutral pelvis is a zone or range of positions in which the patient feels less pain (or at least feels more stable) and the joints are protected from end-range loading. In addition, the patient practices co-contracting the low back extensor and abdominal muscles with enough force to create a bracing “corset” for the low back while still being able to breathe from the diaphragm. This is practiced in a variety of postures, including supine, seated and standing.

Once this level of control has been achieved, the training can progress through a series of exercises designed to challenge the patient’s ability to maintain this kinesthetic control (i.e., within a narrow range of neutral pelvis while protected by co-contraction of the muscular corset). There is a continued emphasis on promoting kinesthetic awareness, that is, a sense of where one’s body is in space and how finely controlled the exercise can be performed.

The program is composed of a combination of training activities, including lumbar stabilization, directional preference, and aerobic exercises. Special attention is also paid to posture, breathing and muscle balance. (See P. 8.)

The lumbar stabilization exercises are organized into separate tracks, which are composed of a sequence of progressively more difficult steps. The following list is in alphabetical order. (Strategies for choosing and sequencing the tracks are on P. 22.)

Stabilization Tracks

- Abdominal bracing or hollowing and neutral pelvis and hip hinging
- Bridge
- Curl up/sit back
- Dead bug
- Kneeling
- Lung e
- Prone
- Quadruped
- Seated
- Side lying
- Side bridge
- Squats
- Standing

The initial steps of a given track usually concentrate on active range-of-motion (AROM) activities using the torso and the extremities.

The purpose is to first create short lever then long lever loads, challenging the patient's ability to *maintain* motor control, quality of form, and *proximal stability* (i.e., neutral pelvis and abdominal bracing/hollowing). Exercises with low compressive loads on the spine are often chosen first.

These steps are followed by more demanding ones designed to promote endurance. While the patient is performing AROM, endurance, or any of the exercises in this program, s/he will *always* be expected to maintain abdominal bracing/hollowing and neutral pelvis. Patients are advanced along the various levels of difficulty in the tracks. *It is not necessary for the patient to perform every step in the track, nor every track.*

The exercise tracks can be combined with a number of techniques to further promote co-contraction and control of core stability. These techniques include resisting

rotational challenges and balancing on a ball or rocker board, especially while introducing perturbations.

Exercises promoting strength and endurance of the neck, torso and upper extremities may be added to the track system or, in the case of some tracks, may already be represented in some of the steps.

Some of the tracks, like the standing track, tend to incorporate *whole body* training. In these cases, the clinician can focus attention to the patient's weak link (which might be the gluteus maximus in one patient, pelvic control in another, and scapular dynamics in a third).

It is critical that patients eventually make the transition from the non-weight-bearing to weight-bearing tracks and then to activities that recreate demands of their job or the sports in which they participate. Initially, these activities are practiced in a slow, controlled manner. Eventually, the patient is required to practice them at speeds consistent with real life demands.

At first, the clinician must be constantly aware of the form and quality of motor control the patient exhibits while doing the exercise tracks. Next, the focus shifts to how successful the patient is in translating the control to activities of daily living. Clinicians should ask patients to identify real life activities that they are having trouble performing. The [Patient Specific Functional Scale](#) (PSFS) is a useful instrument to this end (see CSPE protocol). If the patient is further requested to demonstrate the activity, the clinician may observe errors in motor control and may be able to train the patient to make helpful modifications.

Target Populations

Evidence is lacking as to exactly which patients would most likely benefit from a formal low back rehabilitation program. The literature, in general, seems to support application to chronic low back pain (e.g., three months or longer). (Hayden 2005, Koes 2001, Kool 2004, Liddle 2004, Mior 2001, Ostelo 2005, Ostelo 2003, Pengel 2002, Taimela 2000, van Tulder 2000, van Tulder 2005).

In addition, patients suffering from recurrent episodes, clinically suspected instability, and athletes or workers with high physical demands appear to be logical candidates. It may be worth noting that fear avoidance behavior and kinesiophobia are significant features of both acute and chronic LBP. Exercise therapies (combined with information and advice to stay active) probably exert a beneficial influence by addressing kinesiophobia and issues regarding the locus of pain control. Many of the basic components of the program in this document would also be appropriate as part of fall prevention in older patients.

NOTE: *It is clinic policy that patients with chronic or recurrent LBP* be offered a formal physical rehabilitation program unless there are extenuating circumstances in the judgment of the clinical supervisor. Offering this program to additional subpopulations of LBP patients is up to the discretion of each clinical supervisor.*

Developing clinical prediction rules for exercise prescription is still in its infancy. The following has not been adequately validated, but may be of interest. Hicks (2005) developed a clinical prediction rule to identify patients likely to benefit from lumbar stabilization exercise. The clinical prediction rule consists of four predictors: age less than 40 years, average straight-leg raise greater than 90° (taken to the maximum tolerated, not onset of pain), a positive prone instability test, and the presence of at least one aberrant movement during active lumbar ROM (e.g., painful catch, "thigh climbing," painful arc). Patients with at least 3 out of 4 criteria present were more likely to experience a successful outcome than patients who did not satisfy the rule (positive likelihood ratio, 4.0).

* For the purposes of this program, recurrent LBP is defined as having 2-3 episodes (spanning days to weeks) occurring in the last 2 years with relatively symptom-free periods between episodes.

Acute Low Back Pain

There is some evidence that traditional stretching and strengthening exercise programs are not effective for undifferentiated acute LBP patients. Given the favorable natural history of acute LBP, exercise therapy has not been shown to be cost effective and some patients may even become worse. (van Tulder 2000) Conversely, a large practice-based clinical trial demonstrated that exercise therapy leads to significant short-term (three month) improvements in LBP disability for people with LBP regardless of chronicity (UK BEAM 2004).

Furthermore, these broad reservations may not pertain to rehabilitation programs that focus more on motor control and stabilization strategies, match exercises to loading/directional preference, or include other interventions such as manipulation. (Erhard 1994, Fritz 2003, Little 2001, Long 2004, O'Sullivan 1997, O'Sullivan 1998, Wand 2004, Yilmaz 2003) These types of approaches appear to be more promising, may be applied in the more acute phases of injury, and have had better results in preventing recurrence, at least in the short term. (Keller 2006, Liebenson 2007)

Parts of the program in this document may be reasonably applied to this group of patients. Simple strategies such as neutral pelvis training, abdominal bracing, hip hinging, pain centralization exercises and reactivation strategies should be considered. These tools can provide patients with the means to control acute LBP during transitional movements and prevent or decrease activity intolerance.

Neutral pelvis activities may be based either on pain control or more simply mid-range protection. Bracing and hip hinging strategies should be emphasized, particularly when patients are involved in transitional movements and during functional demands.

8 Part Basic Low Back Rehabilitation Program

- 1. Neutral pelvis, hip hinge, and abdominal bracing/hollowing.** Patients are given neutral pelvis and abdominal bracing or hollowing as an exercise as soon as possible and are expected to do it throughout the day in a variety of positions. The patient is also taught strategies (e.g., hip hinge) to avoid end-range loading during activities of daily living.
- 2. Directional preference.** Patients are given exercises and advice to modify daily activities, capitalizing on any directional preference (therapeutic bias) that is discovered (see CSPE document, The McKenzie Protocol: [Centralizing Low Back and Leg Pain](#)) and taught to modify activities to prevent loads in the direction of any mechanical sensitivities.
- 3. Posture and breath training.** Assess and address inefficient posture and breathing patterns.
- 4. Return to activity (reactivation).** Gradually return the patient back to work and daily activities (i.e., walking, eventual aerobic exercise, etc.)
- 5. Floor exercises to reprogram stability.** Patients are given exercises in multiple body positions in a non-weight-bearing environment. Generally, all three of the following tracks are given, working all of the muscles forming the physiological corset. The patient progresses from the easiest to the most difficult steps of the three tracks.
 - * **Quadruped exercises.** Limbering exercises are done in a quadruped position (cat-camel), then the Quadruped Track is assigned. (If the patient cannot perform any steps in this track, consider starting with the Prone Track.)
 - * **Trunk curls.** Assign the Curl-up Track. (You may add or substitute the Dead Bug Track.) For qualitative assessment, use Janda's curl-up movement pattern. For endurance reference values, use the repetitive sit-up test or McGill's timed sit-back test.
 - * **Side-bridge exercise.** Endurance can be measured by holding times.
- 6. Weight-bearing exercises.** Double- and single-leg squats and various lunge activities (e.g., star diagram patterns) are assigned to reinforce core stabilization and to build endurance and coordination of anti-gravity muscles. Further exercises should be modeled after the patient's work or recreational demands. Pulleys and weights may be added to create resistance.
- 7. Balance large global muscles.** Stretch tight muscles (e.g., psoas, hamstrings, piriformis), activate inhibited muscles (e.g., gluteus maximus, gluteus medius, low back extensors), and build endurance as needed. Assess using postural analysis, Janda's key movement patterns, manual muscle tests, and static endurance tests. In the subacute phase, consider exercises to increase extensor endurance. Assign portions of the Prone Track such as superman on a ball. Use static back endurance test to assess.
- 8. Proprioceptive/balance training.** Prescribe exercises on unstable surfaces, such as a foam pad, rocker board, rocker sandals, gym ball, etc.

The synopsis above can be used as a basic menu to plan and track a patient's progression through a formal rehabilitation program. Exercises can be added or substituted as needed, depending on the strategy of the practitioner and the individual needs of the patient.

THE BASIC PLAN

1. Neutral Pelvis, Hip Hinge, and Abdominal Bracing/Hollowing.

These three maneuvers are usually taught together. They are intended to stabilize the spine and prevent individual segments from being loaded at end range. Consequently, they are utilized 1) in acute cases at all times to prevent unwanted movement or loading, 2) in general to aid in transitional movements, 3) as part of a strategy of active sitting, 4) when engaged in lifting or other activities that may be high risk for an individual patient, and 5) as part of the exercise tracks in this document.

Neutral Pelvis

The patient is taught to tilt the pelvis back and forth, exploring a functional range of painless motion, and to maintain a neutral position. In the acute patient, the neutral position may offer some symptom relief. More importantly, the value is in increasing kinesthetic awareness and protecting the joints from *unwanted end-range loading*.

LBP patients have more difficulty controlling their pelvic positioning than matched controls. Hamilton and Richardson (1995) demonstrated that patients with LBP had difficulty maintaining a neutral curve when asked to flex only 15 degrees forward from a sitting position.

The posterior pelvic tilt is achieved by a coupled action of *hip extensor muscles* (gluteus maximus when weight bearing, hamstrings when non-weight bearing) and the *abdominal muscles* (rectus abdominis and internal oblique when weight bearing; external oblique when non-weight bearing). (Richardson 2004)

The anterior pelvic tilt is controlled by coupled action of the anterior hip flexor muscles and posterior lumbar extensors. The hip flexor muscles are iliacus (weight bearing), psoas, rectus femoris, and tensor fascia lata (non-weight bearing). The posterior spinal muscles

include the lumbar and thoracic erector spinae (weight bearing) and the thoracic erector spinae (non-weight bearing). (Richardson 2004)

Once this is mastered by the patient, s/he practices maintaining the neutral position during nearly all rehabilitation exercises, as well as difficult tasks such as lifting.

Hip Hinge

Lumbopelvic rhythm refers to the combined movement of lumbar flexion and anterior rotation at the hip to achieve bending forward. By emphasizing motion of the hips, while keeping the lumbar spine relatively static, the patient can temporarily decrease the loads on the spine.

This *hip hinge* strategy can be taught to the patient during the initial visit to minimize torque on the lumbar spine and soft tissue.

Abdominal Bracing

Bracing is the conscious co-contraction of the abdominal and low back extensor muscles resulting in a stiffening of the muscular corset around the torso. Although often performed with the pelvis in neutral, this is not the same as neutral pelvis. Unlike abdominal hollowing, there is no attempt to selectively contract various layers of muscle.



abdominal bracing

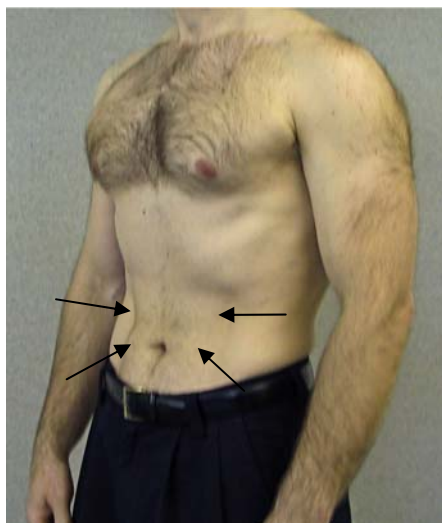
The practitioner can monitor this contraction by palpating the side of the abdominal wall and feeling the muscle contraction pushing out against his/her fingertips while simultaneously palpating the extensor bundle and feeling it stiffen.

Patients can be first taught this in a variety of body positions; however, McGill recommends teaching the patient in the standing position. (McGill 2004)

To teach this concept to the patient, the practitioner can co-contrast the muscles around a peripheral joint like the elbow and have the patient feel the muscle tension in the opposing muscles. The patient can then mimic the co-contraction while the practitioner checks. The patient is then asked to place one hand on the front or side of the abdominal wall and the other on the low back and practice until s/he can feel the co-contraction. This contraction must be light enough that the patient can breathe or speak with ease (10-20% of a maximum voluntary contraction).

Abdominal Hollowing

Although related to abdominal bracing, this procedure is quite different, more complex, and requires more training time to perform correctly. The patient consciously draws his/her navel in (and upward) as opposed to simply stiffening the abdominal wall as occurs with abdominal bracing.



abdominal hollowing

The patient must learn to focus on preferential activation of the deep trunk muscles (transverse abdominis and multifidus) during active movement. Activating these muscles has been theorized to improve the stability of the lumbar spine and has been found to significantly decrease symptoms associated with LBP. (Danneels 2001, O'Sullivan 1997, Richardson 2002, Saal 1990)

The patient is usually first taught this maneuver in the quadruped, supine or prone position. The abdomen is palpated (on each side) medially and inferiorly to the anterior superior iliac spine (Hides et al. 2000). With correct activation of the transverse abdominis, a slowly developing deep tension may be felt in the abdominal wall. In contrast, if a global pattern of activation is used, the external obliques will be felt to push out against the palpating finger—as occurs with simple abdominal bracing.

In one study of 30 patients with LBP, ultrasound imaging revealed patients could be taught to create (on average) a two-fold increase in the thickness of the abdominal transverse muscle. (Teyhen 2005)

Pressure cuff for training abdominal hollowing

A pressure cuff can be slipped under the patient's back or stomach to act as a biofeedback device. The clinician should perform three tasks while completing the test:

- 1) observe the dial on the pressure cuff
- 2) observe the pelvis and trunk for spinal or pelvic movement, and
- 3) palpate the abdominal wall.



pressure cuff



pressure cuff as biofeedback device

The patient either lies prone with the pressure cuff under the abdomen or lies supine with the bladder underneath the small of the back. When the test is done in the supine position, the bladder is inflated to about 40 or 50 mmHg (70 mmHg in the prone position). The patient then performs abdominal hollowing, and the patient and practitioner monitor the pressure dial to see if the patient can raise it 10-20 mmHg (8-10 in the prone position) and then hold it steady while performing various movements with the arms and legs. There should be no movement of the spine that would imply recruitment of large torque producers. The practitioner should palpate to make sure that the waist narrows rather than pushes out (as would be the case in abdominal bracing). The practitioner can also monitor the multifidi by palpating near the spinous process.

Often, the patient may remark that this action is painful. Of all the substitution strategies, this is perhaps the most concerning. The correct activation should not induce pain. Continue trying to teach the patient by verbal and tactile cues. Emphasize a very low level contraction and practice relaxing the larger muscles that are being recruited.

Diagnostic ultrasound has been used to teach subjects to isolate the deep abdominal muscles by using abdominal hollowing (Henry 2005). One small study questioned whether training with ultrasound actually created any added training effect over a pressure cuff. (Teyhen 2005)

2. Directional Preference

It is useful to ascertain if loading the spine in a specific direction (e.g., extension) has a therapeutic effect. If it does, exercises can be designed to take advantage of this. Multiple repetitions can be performed for pain control and, some theorize, to affect the positioning of disc material.

The practitioner can assess the patient's response to various loads by taking the patient's spine to end range in various directions (either repetitively or sustained for 30 seconds) to see if a particular direction decreases the pain, centralizes the symptoms, or improves a particular gross range of motion. (See CSPE document, [The McKenzie Protocol: Centralizing Low Back and Leg Pain.](#)) For example, in a patient with low back and leg pain, the practitioner may discover that extension is the (therapeutic) *directional preference* (DP) by observing that repetitious or sustained extension actually decreases (or centralizes) the territory of the patient's leg pain or paresthesia. In a patient with LBP only, an extension DP may result in a decrease of the chief complaint pain, further shrinking of the pain territory toward midline, or subsequent improvement in forward flexion.

In one study, a DP was identifiable in 67-87% of acute pain patients and 43-52% with chronic pain patients. Although repetitive extension loading appears to be a common DP in patients thought to have a disc injury, flexion or rotation may also be preferences. The most common directions in descending order were extension, lateral or rotation movements, and flexion. (Donelson 2004) In another study of 230 LBP subjects who demonstrated a DP, the breakdown was 191 (83%) extension, 16 (7%) flexion, and 23 (10%) lateral responders. It is important to note that 24 of those labeled as having an extension DP first needed their pelvis offset from the midline (i.e., correct a lateral pelvic shift) before their prone extension exercises produced centralization or reduction of pain.

Specific DPs are sometimes referred to as a “flexion bias” or “extension bias.” In each case, an individual patient’s DP must be discovered empirically based on clues from the patient’s history and, most importantly, from a careful assessment while taking the patient through a variety of repetitive loads. This assessment is usually performed in the first visit, especially if the patient is acute.

Current speculation is that symptom centralization in response to repetitive or sustained loading suggests that the lesion is a disc injury (herniation or derangement) (Jacobs 2007).^{*} If a DP is not discovered, the most common reasons are that 1) the assessment was not done correctly, 2) the patient either does not have a disc lesion or has a non-contained disc herniation, or 3) there is too much inflammation and chemical irritation and the patient should be re-assessed at a later visit.

If a DP is discovered, it can then be used to guide manual therapy and specific exercise prescription. Since load intolerances and peripheralization of symptoms may also be discovered through this process, the practitioner may use this information in guiding activity modification for patients, keeping them away from loads that are deleterious.

Another documented advantage of this form of assessment is the ability to predict chronic pain and disability at one year by the early identification of those who are “noncentralizers.” (Werneke 2001)

In one study of 230 acute, subacute and chronic LBP patients, exercises matched with patients’ DP were compared to exercises in

^{*} There are both similarities and marked differences with strain counter-strain therapy (AKA, positional release techniques). Similarly, treatment is based on holding a joint in a particular position resulting in symptom improvement. The chief differences are that in strain-counter-strain the positioning does not require loading the joint at end-range, the position is sustained (e.g., 90 seconds) instead of repeated, improvement in a palpated tender point is monitored instead of pain centralization, the assessment does not lead to a particular exercise prescription, and it is speculated that therapeutic success does not hinge on changes in the disc.

the opposite direction and with mid-range exercises. The patients in the exercise-matched group consistently scored better in the domains of return to work, home and recreational activities, self-rated improvement and decrease in the Quebec Task Force severity classification. (Long 2004)

3. Posture and Breath Training

Posture

Poor posture may contribute to joint and soft tissue overload. Formal postural assessment is beyond the scope of this protocol. Postural problems may be corrected by pursuing muscle balance strategies (e.g., releasing tight psoas may reduce a forward flexed posture). There are a variety of other behavioral and postural correction techniques, but these, too, are beyond the scope of this document.

However, the sitting Brügger relief position (see Appendix 2) and a standing version of this posture (refer to Standing Track) can be used as part of an overall rehabilitation program. If postural changes are to be encouraged, they should start in the first week of the program and be incorporated into the patient’s exercise routine as appropriate. The sitting Brügger’s position can also be used periodically throughout the day by patients who sit for long periods at their jobs.

Breath and abdominal bracing

Breathing mechanics and breathing pattern disorders are recognized as playing a potentially important role in a wide variety of physical and emotional health problems. (Chaitow 2004) Currently there are many different approaches, with very different therapeutic goals and few clinical outcome studies.

It is beyond the scope of this protocol to provide an overview of the many systems of breath education or to provide a detailed description of a large variety of assessment

and treatment techniques. (See Appendix 1: Breathing Pattern Disorder Resources.) There are, however, important relationships between breathing mechanics and abdominal bracing that should be considered. In particular, poor coordination of respiration and abdominal bracing during increased demand can inhibit the abdominal wall muscles. An example would be during exercise when a patient's breathing becomes labored; to maintain the effort of respiration, the abdominal muscle effort will be reduced and this reduces the ability to maintain an abdominal brace, thus compromising spinal stability. (Liebenson 2007) In addition, the respiratory diaphragm is thought to play a role in maintaining posture (Kendall 1993, Skladal 1976).

The focus of this section will be on basic assessment of the movements of breath, identifying common breathing pattern disorders, training the patient in basic abdominal breathing, and coordinating breathing with abdominal bracing during exercises and activities of daily living.

Breathing assessment

Determining a patient's basic breathing strategy should not take long and should be done as soon as the patient is out of intense pain. It is best to do this observation when the patient is unaware that you are assessing his/her breathing. Often one can make these observations while doing other procedures. Patients should be assessed in a variety of positions but the supine position is the easiest to observe the degree of abdominal movement. If needed, the practitioner can ask for a "slow, relaxed, full breath," rather than "take a deep breath," but be aware that this may change the patient's movements from his/her habitual pattern to a more conscious breathing pattern. (Perri 2007)

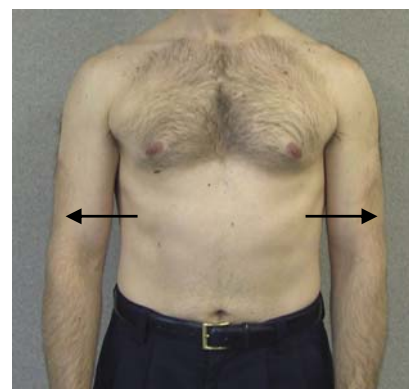
The practitioner should focus on a few specific observations:

- Breath should be initiated from the abdomen, and abdominal motion should be more prominent than that of the chest.



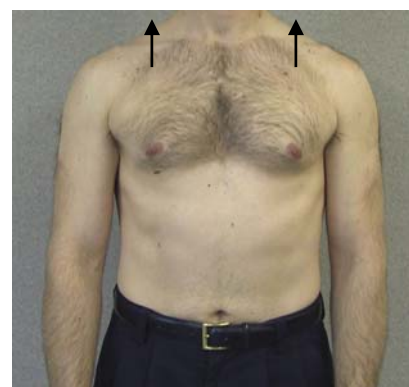
Analyze breathing pattern.

- There should be lateral (i.e., horizontal) movement of the rib cage.



lateral movement of rib cage

- There should be little vertical movement of the chest. This may be easier to see in the seated or standing position.



no vertical movement of chest

- There should be no evidence of paradoxical breathing (i.e., abdominal movement *in* during inhalation and *out* during exhalation). The presence of paradoxical breathing indicates a much more significant breathing error and a pattern more difficult to re-train.
- The spinous processes should separate during inspiration and approximate during expiration when the patient is lying prone. If s/he does not move at a particular segment, that motion unit may be amenable to manipulative therapy.

NOTE: *Some patients may demonstrate marked deviation from normal mechanics. Those who cannot perform predominantly abdominal breathing even with instruction and after appropriate manual therapy, should be considered for specific breathing pattern training either before or concurrent with their rehabilitation program.*

Basic abdominal breathing exercises

Patients with a normal pattern, or those who have minor variations that they can easily correct with instruction, can begin working on abdominal breathing.

- Patients are shown how to self-monitor their breathing pattern with hands on their chests and abdomens. They are instructed to practice breathing into the belly. Another option is to have them palpate only the abdomen.
- The patient should practice a “low, slow” steady breathing rhythm to the very bottom of the abdomen. S/he is to avoid sighing.
- Neck muscles should be relaxed, although the scalene muscles, once thought of as accessory muscles of respiration, are now considered to be involved even in normal respiration. (Perri 2007)
- Relaxed breathing during inspiration and expiration should be through the nose.
- The patient is to practice in lying, seated and standing postures.

Abdominal breathing with bracing and exercises

- Initially, breathing plus bracing is easier to learn in the supine position.
- During abdominal bracing, patients should breathe with normal abdominal movement while holding 10% of maximum contraction of the abdominal muscles. This is a vital skill for the patient to acquire.
- After the patient has demonstrated good control and proper movement in a variety of positions or tracks, the following advanced breathing exercise can be prescribed: After the patient’s heart rate has been increased with an aerobic activity, a side bridge is held with 10% MVC bracing and proper abdominal movement while the patient breathes in and out deeply (Perri 2007).

Exercise prescription

To gain facility with diaphragmatic breathing as outlined above, the patient can be asked to practice twice a day for 10-20 breaths.

Additionally, the patient should practice once per hour for two to three breaths (Perri 2007). This breathing strategy should be utilized whenever the patient is performing abdominal bracing, especially during rehabilitation exercises or activities of daily living. It may take three months of daily training to create a new habit. (Kotke 1980)

4. Return to Activity (Reactivation)

The patient should be reactivated, that is, encouraged to engage in common activities and return to work, even with restrictions, as soon as possible. *Abdominal bracing techniques, hip hinge strategies and patient education to avoid end-range loading in activities that are poorly tolerated* should enable the patient to engage in daily activities.

Daily walking or some other aerobic activity is recommended. It should be started as soon as possible. Walking may reduce incidence of injury and is commonly recommended (McGill 2004).

Faster walking (about 1.86 mi/hr or 3 km/hr) with arm swinging causes cyclic loading (Callaghan 1999) and is better tolerated by LBP patients than a slower gait. Fast walking has been a positive cofactor in the prevention of and recovery from LBP. (Nutter 1988) Arm swinging, when walking faster, decreases loads and reduces spinal torque up to 10%.

Reasonable targets would be to walk from 20-60 minutes a day, depending on the stage of injury recovery. One approach is to ease a patient into a progressive walking program (two walks a day, starting between 5 and 15 minutes per walk depending on tolerance and increasing by 2 minutes per walk per week) (Bishop 2010)

Home care can include walking on unstable, uneven, sloping or moving surfaces such as soft sand, grassy slopes, or rough ground. McGill (2004) recommends the following walking activity for those with discogenic pain who can tolerate compression: walking over undulating ground with a day pack containing 22 lbs or 10 kg (low in the pack about the level of the lumbar spine).

5. Floor Exercises to Reprogram Stability

A combination of three non-weight-bearing exercises performed on the floor is recommended as part of the basic program: **quadruped**, **side bridge** and **curl up** or **dead bug**. If there is gluteus maximus inhibition, adding a **bridge** exercise at some point is recommended.

The quadruped works the lumbar extensors (including multifidus) and gluteus maximus. Curl ups exercise the abdominal muscles. The side bridge has been suggested as an ideal training exercise to challenge the quadratus lumborum and the abdominal wall

(e.g., external oblique) based on EMG studies and measurement of spinal compressive loads. It also can be used as an outcome marker (see CSPE protocol, [Low Back and Leg Endurance Tests](#)) since it has good test re-test reliability (Liebenson 2007, McGill 2002)

In order to establish good spinal stabilization, the patient works progressively through the steps of each of the three tracks from easy to difficult while increasing the repetitions. The goal is to engrain or “groove” motor patterns and then build endurance while keeping the spine under relatively low loads. This cautious, non-weight-bearing approach may be particularly useful in patients with significant back injury or instability; however, it could be applied to any patient with LBP.

This particular group of tracks has been chosen because they train the patient to co-contract various muscle groups around the lumbar spine while still limiting the amount of load placed on the joints. Recommended subacute training exercises keep the load on the spine (the load penalty) below 3000 N.* (McGill 2002)

Quadruped single-leg raise	2000-2300 N
Side bridge on ankles	2600 N
Curl up	2000 N

Likewise, certain exercises are best avoided in not only the injured spine, but should be minimized even in healthy backs. These include the following:

Sit ups, bent knee	3350 N
Sit ups, straight leg	3500 N
Prone superman on the floor (McGill 2004)	> 6000 N

Normative Values

Three endurance tests are suggested: side bridge, Sorensen extension test, and a trunk flexion endurance test published by McGill. Normative values have been established for many of these tests. For instructions on how

* Divide Newtons by 9.8 to calculate the load in kilograms.

to perform the side-bridge test and Sorensen extension test, see CSPE protocol, [Low Back and Leg Endurance Tests](#).

The McGill trunk flexor test is performed by having a patient lean against a support angled at 60 degrees. The support is then pulled four inches away from the patient and the test is timed until the patient tires and leans back against the support.



McGill trunk flexor test

These tests are based on endurance times.

	FEMALE	MALE
Trunk extensors	130-sec avg	90-sec avg
Trunk flexors*	50-sec avg	70-sec avg
Side bridge	40-sec avg	60-sec avg
*Flexion was the ability to hold a backward sitting position at 60 degrees (with hips and knees bent).		

McGill suggests that more useful, perhaps, is to consider ratios of endurance times as opposed to absolute numbers. It should be noted that these ratios were derived from testing young healthy subjects. It is not known whether they are generalizable to other populations.

Ratios/percentages	FEMALE	MALE
trunk flexor/ extensor ratio	80% of extensors	1:1 or slightly less
side-bridge endurance	equal side to side	equal side to side
side-bridge/extensor ratio	40% of trunk extensors	65% of trunk extensors

6. Weight-Bearing Exercises

It is critical that all patients at some point be transitioned to weight-bearing exercises and then to *functional* weight-bearing exercises. Most commonly, the initial exercises are built around lunges and squats. The practitioner has the option of spending a few weeks “grooving” motor patterns using the safer floor exercises or moving immediately to weight-bearing.

The decision to move the patient immediately to weight-bearing exercises can be based on a number of factors: limited duration of the training program, symptoms that are relatively mild, or the patient demonstrates reasonable motor control displayed in easier non-weight-bearing exercises. On the other hand, patients often find it easier to access and learn to control muscle groups in the non-weight-bearing positions first. Even with these patients, slow lunges can often be introduced at the same time. Ultimately, it will depend on the particular case and the general philosophy of the practitioner.

As is true for the non-weight-bearing exercises, the emphasis for lunge training is on good motor control. Patients advance from simple exercise routines to more complex, sometimes including fast lunges to train speed and response time. Lunges are performed in multiple directions, include upper extremity exercises with resistance, and are designed to mimic functional activities whenever possible. Squats are performed two legged and then on a single leg. Both exercises can eventually be incorporated into balance board/pad routines.

7. Balance Large Global Muscles

Two types of muscle imbalance may need to be addressed. In general, muscle imbalance usually refers to an agonist-antagonist relationship where one muscle group is short, tight and overactive, while the other group is weak or inhibited. However, muscle imbalance can also be caused by agonist and

antagonist stabilizers that do not share an appropriate strength ratio to each other. Early research suggests that there may be optimum balances between muscle groups (similar to the 3:2 strength ratio of quadriceps to hamstrings) to contribute to knee stability.

- Side-bridge endurance should be about 1:1 side to side.
- Flexion endurance should not exceed extension endurance.
- Side-bridge endurance should not exceed 75% (3:4) of extension endurance.

(McGill 2004)

Some athletic populations and perhaps some occupations may require different ratios. For example, McGill (2004) reports preliminary data suggesting golfers may have greater side-bridge endurance and an altered ratio to extensors. In cases of disproportionate muscle endurance, the strategy would be to exercise all of the muscles, but increase the training demand on those with the poorer performance.

As the rehabilitation plan unfolds, muscle imbalances, such as a lower cross syndrome, may also need to be addressed. Generally in this syndrome, the gluteus maximus and abdominal muscles are weak or inhibited. The iliopsoas and lumbar extensors are often short and tight or are over facilitated. It should also be noted that short, tight muscles are often weak. The lumbar extensors are especially noted to have poor endurance in patients with LBP. One common approach is to stretch/relax tight muscles first and then strengthen weak or inhibited muscles.

Tight Muscles

Short and tight or overfacilitated muscles that are commonly addressed include the iliopsoas, hamstrings and piriformis.

A. Iliopsoas

Iliopsoas tightness is assessed by performing a Thomas or modified Thomas test.

Optimally, the hip should passively extend 10-20 degrees. The practitioner also assesses the quality of the end feel.



modified Thomas test

Treatment often requires that this muscle be relaxed or stretched in LBP patients. Janda suggested that it is a key muscle that should be one of the *earliest* muscles to address (personal communication).

The muscle may be a pain generator. It can go into painful spasm or harbor trigger points. In such cases, treatment may bring immediate relief.

More often, the psoas is thought to be an important contributing or sustaining factor in LBP, *even when the muscle itself is not painful*.

The exact role of the iliopsoas in sustaining lumbar stability is controversial, perhaps participating only during significant hip flexion activities. (McGill 2004) It is also controversial whether tight psoas muscles promote hyperlordosis, hypolordosis or have any *predictable* effect on the curve at all. (Kappler 1973, Nourbakhsh 2006)

B. Hamstrings

Hamstring tightness is assessed by performing a passive SLR. Optimally, a patient should have 80-90 degrees of hip flexion. The practitioner also assesses the quality of the end feel.

Hamstring tightness has been reported as one of the most common findings in LBP (Nourbakhsh 2002). Hamstrings may go into painful splinting in a variety of acute low back conditions and therapeutic muscle relaxation may give the patient some immediate pain relief.

More often, the hamstrings are likely a painless co-factor or sustaining factor in LBP. Biomechanically, they may alter lumbopelvic rhythm by reducing the patient's ability to hip hinge. EMG studies have also demonstrated that, in addition to a delayed activation of gluteus maximus, LBP patients displayed significantly earlier activation of the hamstring muscles (i.e., biceps femoris) (Hungerford 2003). Tight, overactive hamstrings have also been implicated in the development of increased ligamentous loads associated with the sacroiliac joint (Vleeming et al. 1997).

Tight hamstrings are thought to result from prior injuries, overuse syndromes, or sedentary postures such as sitting that promote physiological shortening.

Occasionally, tight hamstrings may be a necessary compensation. For example, tight hamstrings are commonly associated with Scheuermann's disease and Janda informally reported stretching hamstrings in this population often made the patients worse.* Which actual subpopulation of LBP patients may respond in a similar fashion is usually discovered on a trial and error basis. Perri (2007) recommends stretching overactive hamstrings only after some lumbar stabilization training has taken place.

C. Piriformis

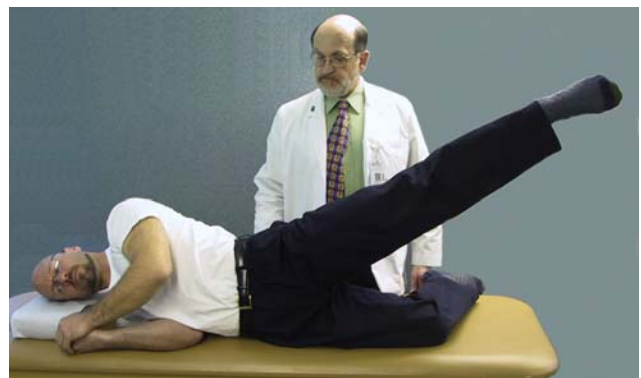
Piriformis tightness, unlike most muscles, is most often assessed by palpation, although ROM can also be useful. End feel can be assessed by resistance to internal hip rotation.

The piriformis has a tendency to go into spasm. It can cause local pain, referred pain

* Personal communication

into the buttock and down the posterior thigh due to trigger points within the muscle, or a piriformis syndrome in which it creates true sciatica. An overactive piriformis may also be present in sacroiliac syndromes.

Signs of piriformis involvement include palpatory spasm, tenderness, and increased resistance to internal rotation (especially at end range). Foot flare (external rotation of the hip) may be observed during quiet standing, gait or when the patient is lying supine. If the sciatic nerve is also involved, the SLR may be positive as a tension test, especially when combined with internal rotation of the hip.



G medius 10-second isometric contraction

Treatment strategy for tight muscles

Overfacilitated muscles, muscles in painful spasm, and muscles harboring trigger points may simply need to be relaxed. Post-isometric relaxation or direct massage is an appropriate treatment. Manipulation of the sacroiliac or hip is also thought to relax local musculature.

Occasionally, tight muscles may not respond to direct treatment or may seem to consistently require additional stretching. In these cases, facilitating the antagonist or synergist may help resolve the problem.

Muscles that are tight due to chronic connective tissue shortening and fascial causes need to be more aggressively stretched. Post-facilitation stretch (PFS), contract-relax, contract-relax agonist contract (CRAC), myofascial release, pin and stretch and many other stretching and massage

techniques are useful. The patient should also be shown a home stretch, which will become part of the stabilization exercise program.

Inhibited Muscles

Muscles may be weak, have poor endurance, or be inhibited. An inhibited muscle may test strong with conventional manual muscle testing, but nonetheless may have altered contraction patterns or altered timing resulting in inappropriate loads on related joints and poor stabilization.

The most common muscles to evaluate for weakness or inhibition are gluteus maximus, gluteus medius, and the low back extensors.

Observation, assessing AROM, manual testing, sustained isometric testing (10-second holds in a shortened position) and evaluating key movement patterns are the most common ways to identify this problem in a clinical setting.

A. Gluteus maximus

An inhibited gluteus maximus muscle is commonly associated with LBP (Hungerford 2003) and SI lesions (Vleeming et al. 1997). Poor function of this muscle is thought to be related to increased load on the lumbar spine during bending and lifting, shift of stress up to the TLJ during gait, and instability of the SI joint. (Vleeming et al. 1997)

Clinical clues include a drooping buttock on the inhibited side, loss of contour in the upper outer quadrant of the buttock, weakness with muscle testing, and premature shaking of the gluteus maximus with a 10-second isometric muscle contraction. Another strategy is to watch the patient walk backwards. A shortened stride may be due to poor hip extension secondary to an inhibited gluteus maximus muscle (short hip flexors would be another explanation). More significant weakness can be detected by asking the patient to perform single- or double-leg squats, either as single or multiple repetitions. (See Appendix 3: Assessment of Gluteal Muscles.)

B. Gluteus medius

Inhibited gluteus medius muscle can be associated with hip or SI dysfunction. Poor function of this muscle is thought to be related to increased shear load at the sacroiliac, pubic symphysis and lumbosacral joints.

Clinical clues of this inhibition include a lateral pelvic shift while walking or standing on one leg (a true positive Trendelenburg test is rarely seen), altered motion when testing the hip abduction key movement pattern, weakness with muscle testing, and premature shaking with a 10-second isometric contraction. (See Appendix 3: Assessment of Gluteal Muscles.)

C. Low back extensors

A number of studies suggest that patients with chronic LBP have extensor muscles that are weak (Hultman 1993, Mayer 1985) and easily fatigable (Biederman 1991, Biering-Sorenson 1984, De Luca 1993, Mannion 1997, Mayer 1989, Nicolaisen 1985, Roy 1989, 1990 & 1995, Suzuki 1983). Poor endurance has been correlated with an increased risk for first-time LBP (Luoto 1995). In these patients, maximum voluntary contraction (MVC) and time to exhaustion are reduced (Crossman 2004).

Treatment strategy for inhibited or weak muscles

Address the causes of the inhibition

- Manipulate related joints
- Stretch antagonist
- Treat MFTPs in agonist
- Treat MFTPs in related muscles in kinetic chain

The first step is to try to remove any sources of inhibition. Common interventions include joint manipulation, manual therapy aimed at MFTPs in the inhibited muscle, and stretching/relaxing the antagonist. It is suspected that any of these joint dysfunctions or MFTPs could result in reflex inhibition of the muscle in question. Less commonly, a

MFTP elsewhere in the kinetic chain also may also inhibit a muscle.

The next step is to check to see if removing the inhibition is sufficient. In some cases, removal of the inhibition will return the muscle to proper function and additional time doing exercises is not necessary. These manual therapy interventions, however, are generally coupled with targeted exercises. The exercise components follow the acronym *ACES*:

- **A**ctivation of patient's awareness
- **C**ontrol the muscle (by "grooving a pattern")
- **E**ndurance (strength)
- **S**peed of contraction and coordinated reactivity

Gluteus maximus

In the case of gluteus maximus, the practitioner should specifically address a tight iliopsoas on the same side, trigger points within the gluteus maximus, and joint dysfunction especially in the sacroiliac joints, but also the lower lumbar spine or hip. Manipulation (but not lower grades of mobilization) of the sacroiliac joints has been demonstrated to increase gluteal activity. (Herzog 1999) Inhibition has also been reported from ankle sprains. Significant delay in onset of activation of the gluteus maximus has been measured on the injured side (Bullock-Saxton 1994).

An exercise progression for the gluteus maximus may first require direct muscle goading and directing the patient to consciously activate the muscle. Once the patient can consciously control the muscle, the Quadruped Track or Prone Track can be used to repetitively "groove a pattern" of gluteus maximus activity. The Bridge Track can be added to increase the weight-bearing demand. The patient should be advanced to double-leg and especially single-leg squats, as well as lunges to build endurance. Balancing on a labile (or unstable) surface is useful to increase activity and speed of contraction. (See Appendix 4: Rehabilitation of the Gluteal Muscles.)

Gluteus medius

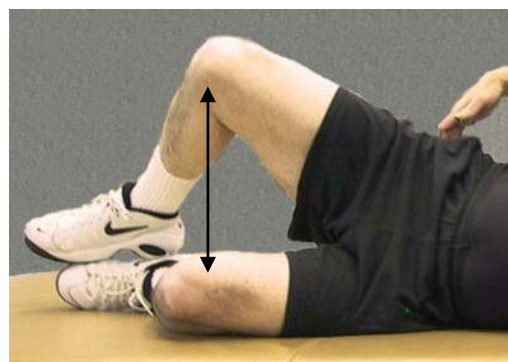
In the case of gluteus medius, the practitioner should specifically address tight adductors on the same side, trigger points within gluteus medius, and joint dysfunction especially in the sacroiliac joints, but also the lower lumbar spine or hip.

An exercise progression for gluteus medius may require direct muscle goading.



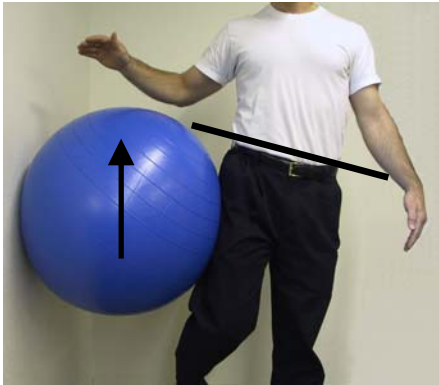
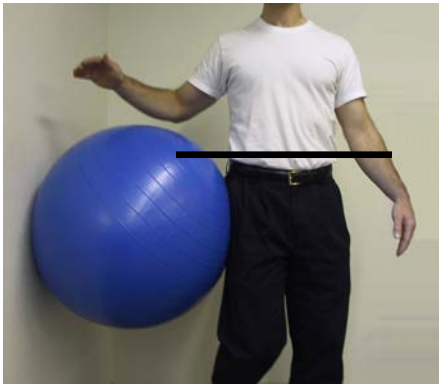
muscle goading

Once the muscle is temporarily stimulated, specific exercises can be prescribed. A simple starter exercise is side posture abduction (the "clam" exercise) which can be used to activate and "groove a pattern," encouraging activation of the muscle.



clam exercise

Next, more demanding activities on one leg can be introduced including followed the single-leg bridge, wall-ball exercise, single-leg squat, single-leg wobble board and rocker board in the frontal plane.



wall ball exercise for G medius

(See Appendix 4: Rehabilitation of the Gluteal Muscles.)

8. Proprioceptive/Balance Training

Balance and proprioceptive training is not done until the acute phase has resolved. The approach is to place the patient in an unstable environment while increasing demands on coordination and control. The patient performs more complex activities while attempting to maintain balance, good motor control and core stability.

A variety of equipment can be used including individual balance pads, rocker boards, wobble boards, rocker sandals, etc.

The activities should be performed barefoot unless a heel lift or orthotic is necessary.

The foot can be prepared by tactile stimulation of the skin (e.g., brushing the sole of the foot with a soft brush for 15-30



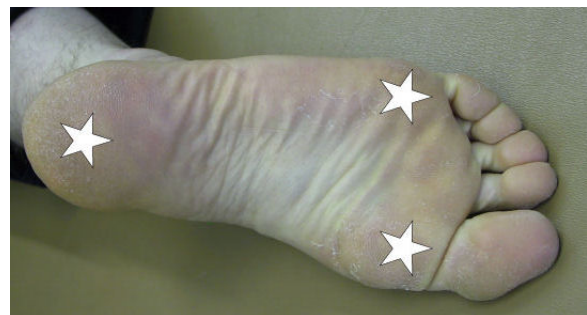
balance pad

seconds) and manipulation of any joint restrictions in the foot or ankle. The practitioner can also teach the patient to form a "short foot" and hold it during the balance training (see Standing Track.)



short foot

Alternatively, the patient can be coached to distribute his/her weight over a three-point tripod consisting of the heel and 1st and 5th metatarsal heads. While the weight is balanced in this fashion, the patient pushes off from those points resulting in a more upright standing posture.



weight-bearing (tripod) points on foot

A stylized posture can be adopted during the early phases of training (e.g., Brügger's standing posture with short foot or "tripod stance") which encourages activation and relaxation of specific muscle groups.

A wide variety of approaches to proprioceptive and balance training can be employed. Certain key ingredients, however, should be in place.

- The program should be structured to provide progressive demands on the patient's balance. Activities include trying to stand perfectly still, as well as slowly rocking back and forth in a controlled manner. Rocker board work should progress from an orientation in line with the rockers, to about a 45-degree diagonal orientation, then to one at 90-degree angle to the rockers; balance pads progress from firm to soft; rocker board progresses to wobble board, etc.
- Activities should be performed with eyes open and, when possible, with eyes closed.
- As soon as possible, the patient should progress to a level where the exercises are performed on one leg.
- Various arm activities should be incorporated (e.g., progressing through range of motion, PNF cross patterns, tossing and reacting to a ball, activities that mimic activities of daily living at various speeds).
- The patient should be challenged from time to time with rapid, shallow pushes (causing perturbations). These challenges can be done in a predictable pattern at first and then, as the patient's stability progresses, more randomly and unpredictably.

Exercises should be relatively brief, ranging from 1-2 minutes to no longer than Liebenson's 15-Minute Sensory Motor Program (see below). They should be done daily, preferably multiple times a day. This requires the patient having some equipment at home to support the program. If this equipment cannot be bought by or loaned to the patient, other substitutes can be sought (e.g., standing on a throw cushion).

Liebenson's 15-Minute Sensory Motor Program

The overall progression includes advancing from easier to more difficult balance platforms (e.g., from green to blue stability pads) and from easier to more difficult poses and activities on the board (e.g., single-leg standing with eyes open and then with eyes closed). Each of the following maneuvers can be performed for 2-3 repetitions. Static positions can be held for 10 seconds.

1. Rocker board (2-3 minutes)
2. Grip toes, lean forward (hold for 10 seconds), stand up straight and sway side to side (8-10 reps side to side)
3. Perform 3 sets.

GENERAL STRATEGIES FOR A COMPLETE REHAB PROGRAM

If a directional preference is identified, exercises favoring that direction should be prescribed. At some point either in parallel or later in the program, stabilization of the spine may be the next goal. There are many strategies reported in the literature to achieve this end; however, there is insufficient evidence to strongly advocate one approach over another. What follows is a discussion of several general strategies with suggestions for application by the primary author of this CSPE protocol.

STRATEGY 1 (based on McGill's work)

The exercises employ abdominal bracing and neutral pelvis. The bracing is taught rapidly with no intention to selectively activate individual layers of muscle. (McGill 2004) Great emphasis is placed on holding and protecting the spine in neutral range while doing floor (non-weight-bearing) exercises of progressively greater demand. These exercises generally consist of the curl up, side bridge, quadruped, and sometimes the bridge. Slow lunges are also introduced early, while the patient is still doing the floor exercises.

Eventually the patient is brought into weight-bearing activities and most of the other components of the basic program. The training emphasis is on spinal protection while building endurance and coordination of the anti-gravity and phasic muscles. When treating athletes, significant effort is funneled into breaking down the athletic activity into specific components, which are drilled while maintaining controlled bracing and while keeping the lumbar spine within a neutral range. These components are

- squat/lift
- push/pull
- lunge
- gait
- twist
- balance

If the patient must lift objects at home or work, then conscious abdominal bracing should be employed. Increased lumbar lordosis can be achieved by performing an anterior pelvic tilt or by instructing the patient to thrust his/her buttock backward. The object should be positioned close to the body and the legs used as much as possible. As the patient recovers and returns to routine lifting activities, McGill (2004) recommends that, prior to lifting, the patient acquires the habit of placing his/her hands on the abdomen and lumbar region monitoring for co-contraction and practicing a few knee bends to be sure that the motion occurs from the hips and not the lumbar spine (hip-hinge strategy). After this, the lift can be performed.

STRATEGY 2 (based on Jull and Richardson's Australian school of thought)

There is a strict emphasis on abdominal control. Patients work with the therapist to isolate and activate the transverse abdominus and multifidus with minimal activity of the larger global muscles. The target activity is a precisely controlled hollowing of the abdomen rather than generalized bracing. The waistline will narrow instead of widen. (Richardson 2004)

Extensive feedback mechanisms are recommended, including tactile and verbal

cues. Devices such as the Chattanooga Lumbar Stabilizer or a regular blood pressure cuff can be used to provide biofeedback (see P. 6-7). Patients are given the basic non-weight-bearing floor exercises (e.g., quadruped, bridge) only when they can demonstrate good muscular control. In the case of some patients, several sessions per week for one to three weeks may be necessary before they have sufficient control. Most patients will acquire the basic skill faster than that. They are then progressed into some or all of the remaining components of the basic program (see P. 4).

McGill's research clearly suggests that all of the extensors and muscles of the abdominal wall, both local and global, play important roles in stabilizing the lumbar spine throughout a variety of activities (McGill 2004). While the deep abdominal and extensor muscles are *not* purported to contribute the most to stability, the clinical debate is whether at least some patients with LBP can benefit from exercises that specifically target these deeper muscles. (Richardson 2004)

Richardson (2004) argues that it is the local muscle system which is most impaired in LBP. Although computer models demonstrate that the larger global muscles provide the principal control preventing spinal buckling (McGill 1996), she maintains that limiting a program to "training those muscles is unlikely to resolve the deficits in muscle control." (Richardson 2004)

In addition to helping to stabilize the lumbar spine, there is some evidence suggesting that when subjects perform a specific voluntary contraction of the transverse abdominus, any laxity of the sacroiliac joint is reduced (Richardson 2002). In this case, the reduction in laxity was greater with precise hollowing activities than with more general bracing. The muscles were monitored by real-time ultrasound and EMG.

Likewise, contraction of the lumbar multifidus was responsible for more than two-thirds of the increase in segmental stiffness according

to one report (Wilke 1995). These results supported those obtained by Steffen (1994) in an in-vitro study.

Whether or not precise training of these muscles is clinically and significantly more effective than starting patients with simpler, easier-to-learn bracing activities is still controversial. However, this training approach remains a viable option.

STRATEGY 3 (based on Gray's work)

The patient can be instructed in simple abdominal bracing and neutral control, but floor (non-weight-bearing) exercises are usually skipped altogether. The patient is immediately advanced to weight-bearing activities (e.g., squats, star lunges, etc.) along with weights or pulleys. Exercises are further individualized based on job or recreational demands. The emphasis is on training efficient use of balance and coordination of the kinetic chain in an effort to prevent unnecessary stress on the spine.

STRATEGY 4 (based on Janda's approach)

Janda's general approach to rehabilitation can be compatible with all three of the strategies above and is nested into the basic program presented earlier. His greatest emphasis was on restoring muscle balance (relaxing overactive postural muscles and activating any inhibited phasic muscles), assuring joint integrity (manipulating or mobilizing joints), and then moving the patient to weight-bearing rocker board/balance board activities that sought to reprogram the nervous system to coordinate better stability. The basic program outlined on P. 4 incorporates all of these strategies.

THE EXERCISE PRESCRIPTION

Exercise Repetitions

There are two approaches from which to choose. The first and most commonly employed is to have the patient work toward a prescribed number of sets and repetitions.

This *target goal* can also be used as an endpoint marking a transition from one level of difficulty to the next in the lumbar stabilization program. Patients may start out with sets of 6 repetitions and progress to 10-15 reps. If an isometric hold is added at each repetition, then it can be held for 6-10 seconds. In the second approach, the patient works until s/he feels a *muscle burn* regardless of the number of repetitions.

Independent of approach, patients must stop if their pain is reproduced, if they lose form (Morgan 1988), or if they start to shake. Loss of form would include no longer maintaining an abdominal brace, losing neutral pelvis, or whenever kinesthetic awareness is sacrificed, indicated by specific cues that the clinician sets for a particular track (e.g., lifting the heels while doing the Trunk Curl Track). Shaking suggests early fatigue and perhaps recruitment of fast twitch muscles. This unwanted recruitment may be promoting the synergistic substitution pattern that the practitioner is trying to break.

If shaking occurs or form is lost before patients can achieve a muscle burn during a particular session, the exercise can be continued either at an easier step (one which they *can* do properly) or within a smaller range of movement (keeping within the functional range). Moving to a less difficult step of an exercise is sometimes referred to as *peeling back*. Patients continue to exercise until either they achieve the burn or target number of repetitions or become aware that the quality and form has once again been lost.

NOTE: *Patients should be assigned an exercise step with the highest degree of difficulty that they can perform with good form. When that step can be maintained through multiple repetitions, they are then advanced to the next most difficult step or exercise.*

Pain during Rehabilitative Exercises

While performing the exercises, patients may experience some discomfort or muscle burn but should not feel significant joint pain or reproduce their original symptoms. They may

also experience an increase of pain or discomfort after the exercise. The question that arises is whether the patient has overdone the exercise and aggravated injured tissue. Although there is no commonly agreed upon set of indicators, pain exacerbation lasting into the following day (i.e., 12-24 hours) may suggest that the exercises may have been done improperly or excessively. Such a patient should be encouraged to continue the rehabilitation program, but with an adjustment in quality of form, range of movement, frequency, intensity, or duration of the exercises. Patients with conditions such as rheumatoid arthritis (RA), post-polio syndrome, or primary fibromyalgia should be handled with more caution. Significant symptom exacerbation lasting more than an hour after exercise may signal a need to revise the exercise prescription.

Frequency: Office Visits and Home Exercise

The frequency of office visits will depend partially on whether patients will be doing their activities directly under the supervision of the clinician/intern or primarily at home.

NOTE: *Supervised or partly supervised programs tended to have better long-term results and would be the first choice in patients in the selected target groups mentioned earlier. (Liddle 2004)*

The initial schedule can range from 1-2 visits to 3-4 per week (Liebenson 1996). The higher frequency may be necessary when patients require supervised sessions.

Exercises are taught and briefly monitored during the office visit, checking for quality of form, appropriate compliance and progression. Longer, supervised sessions may be necessary for patients with severe chronic pain, well-entrenched pain-avoidance behaviors, or patients with poor kinesthetic awareness who have difficulty properly performing the exercises.

Frequency of home exercise depends partially on the goal of the activity. Exercises

that train control and coordination (e.g., abdominal bracing activities, abdominal clocks) should be performed every day, multiple times per day (Bakhtiary 2005, McGill 1998). The tracks in general and especially those steps of a track that promote endurance should be done daily.

If muscle soreness develops to the point that a patient is having difficulty complying, then tracks that target different muscles can be alternated from day to day (which would be preferable so that patients remain active), or the exercises can be cut back to every other day.

If specific steps in a track require a greater percentage of MVC and strength is the goal (e.g., when weights are added), these activities should be done every other day.

Duration of Exercise Sessions

Here again, the practitioner can choose from among several strategies.

1. Assign brief sessions that do not work the muscles to fatigue. Increased endurance will not be gained, but neuromuscular control may be established (especially if the sessions are performed frequently). This may be sufficient for abdominal bracing exercises in general, for balancing exercises, or for the other tracks (e.g., Dead Bug) in uncomplicated low back cases with few negative predictors. *However, it is not recommended as a preferred strategy in more difficult cases. (Liebenson 1996)*
2. Longer sessions that create a muscle burn (but not pain from excessive spinal loading) are necessary to ensure *endurance* gain. Key muscles that should be trained for endurance are the low back extensors and abdominal obliques, followed by gluteus maximus and quadriceps. It may take 30-40 minutes of exercise activity to achieve the training effect in multiple tracks (Liebenson 1996).
3. An intermediate strategy is one that incorporates multiple brief activities

throughout the day along with short structured track exercises. In one study, training sessions of 10-15 minutes were used, but abdominal bracing/hollowing activities were repeated throughout the day in a variety of static and dynamic body postures (O'Sullivan 1997).

Program Length

Usually a basic program is about 4-6 weeks, but can be 8-12 weeks in cases of herniated disc or chronic pain (Robinson 1992). In one study of patients with spondylosis or spondylolisthesis, a 10-week program was utilized with good results (O'Sullivan 1997).

Selecting Tracks: Strategies

Two general approaches to selecting tracks are possible:

1. A comprehensive program can be used in which the majority of the tracks are utilized to ensure an optimum training effect. This approach may be necessary in moderate to severe cases of disc herniation or stenosis, chronic pain syndromes, or in patients with a long history of recurrence.
2. In cases of less severe mechanical back pain, without complications and a benign prior history, a briefer, modified version of the program may be used where fewer specific tracks are used.

Use the core program when unsure how to proceed. Preferably, personalize the exercise program by selecting specific core or alternate tracks. Do not assign more than 3 or 4 exercises at a time unless they are part of a longer, supervised session. Selections can be based on some or all of the considerations below.

NOTE: *Patients should be assigned tracks and specific steps within a given track based on the most difficult challenge that the patient can successfully perform. Assigning exercises that patients cannot do with good form encourages poor motor control habits. Assigning exercises that are too easy limits the training effect.*

Considerations

Job requirement. Choose tracks appropriate to job demand. For example, tracks involving kneeling may be important if a worker must kneel on the job.

Activity limitation questionnaires. For example, a patient complaining of pain with lifting would unlikely be able to forego the tracks that train the quadriceps, like the Squat Track.

Postural and movement pattern analysis. Patients with visible signs of gluteus maximus atrophy or poor muscle-firing sequence with hip extension may initially benefit from the Bridge and Quadruped Tracks.

Performance. A patient able to do most of a track in the first visit would more likely benefit from performing other tracks that are more challenging.

Patient motivation. Poorly motivated patients may not be willing to focus on the details required by many of the tracks to assure adequate exercise quality. If their condition allows, they may be better off immediately proceeding to balancing activities on exercise balls and the rocker board since at least some therapeutic effect may be achieved reflexively at a subcortical level.

Patient Education and Activity Modification

A number of messages should be continuously given to patients to help curtail fears that light activities or properly performed exercises may further harm their backs. Repetition of this message is very important.

- Light activity will not injure them.
- Deconditioned tissues are typically uncomfortable to move because they are stiff.
- Small flare-ups of symptoms do not mean re-injury (they are more likely transient spasms or soreness which will improve with movement and gentle stretching).
- Anxiety increases muscle tension and reduces the pain threshold.

Troubleshooting

Patients may be having trouble with a particular track due to inhibited or tight/overactive muscles, or the presence of joint dysfunction. These issues would then need to be addressed independently to allow the patient to be more successful in each track. For example, tight muscles may need therapeutic muscle stretching and inhibited muscles may need to be facilitated.

If a patient cannot make any progress in the program because of pain after about three sessions, consider more assertive pain control interventions such as analgesics or NSAIDs, wearing a TENS unit during the activity, or referral for epidural injection (Saal 1992).

Training Tips

- If patients cannot find a pelvic position that reduces pain while supine, try passive pre-positioning by sliding a pillow under their back and moving the pillow through a variety of positions until they can identify a position of comfort. Visual cues include muscles either tensing or relaxing and the ease with which they can breathe. Alternatively, patients may need to start in a sitting or quadruped position.
- Train patients in a variety of positions. Positions should be weight bearing and non-weight bearing (supine, prone, standing sitting) and include functional positions that mirror actual demands of life (getting out of a chair) and work or recreation.
- *Start* patients at the most difficult step in a track that they can do properly. Teach them how to “peel back” to an easier step on the track when they have trouble maintaining the quality of the exercise.
- Always limit movements within a track to the patient’s *functional range* (i.e., a range that demonstrates good biomechanics, little or no muscle

recruiting, no joint pain, and no peripheralization of pain).

- Exercise progression should be relatively pain free within the constraints of the patient’s pathology and ability.
- Be sure that the patient maintains neutral pelvis and abdominal bracing/hollowing when doing the training activities. Either the clinician or the patient can monitor the abdominal contraction by palpating the abdomen.
- If patients have trouble becoming kinesthetically aware of what they are doing wrong in a track, have them exaggerate their error to bring it into focus. Watching themselves in a mirror is also helpful in the beginning.
- Whenever possible, introduce rotational isometric contractions in the various tracks.
- Advance the patients to more difficult levels where they can feel a muscle burn and build endurance. Supported exercises (where limbs are allowed to momentarily touch the floor) precede unsupported (where they do not touch down between repetitions). See the Dead Bug Track for an example.

When patients are attempting to do a more difficult step, have them stop for a moment and relax their abdomen and pelvic positioning. If neither the clinician nor the patient can detect any change, it is likely that the patient had already lost the abdominal bracing and/or neutral pelvis. The step may be too difficult for them at this point.

- Be sure that exercise movements are initially slow and controlled.
- Introduce as soon as possible activities that require balance on an unstable surface (e.g., rocker board, ball, rocker sandals, etc.), eventually introducing rapid challenges to patients’ balance. This

will introduce a component of reflex training.

NOTE: *Balance board/pad activities may sometimes precede the stabilization tracks.*

- Choose tracks that address patients' functional deficits. Try to find training exercises that will mimic their job or recreational demand, first in slow controlled movements and then advancing to the normal speeds required by that activity.

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Appendix 1: Breathing Pattern Disorder Resources

For more information on breathing pattern disorders, please refer to the following.

Books:

Chaitow L, Bradley D, Gilbert C. Multidisciplinary Approaches to Breathing Pattern Disorders. London: Churchill Livingstone; 2002.

Liebenson C. Rehabilitation of the Spine. Chapter 17, Perri M. Baltimore: Lippincott Williams & Wilkins; 2007: 369-87.

Weil A. Breathing. Boulder: Sounds True; 1999.

Middendorf I. The Perceptible Breath. Paderborn: Junfermann-Verlag; 1990.

Websites:

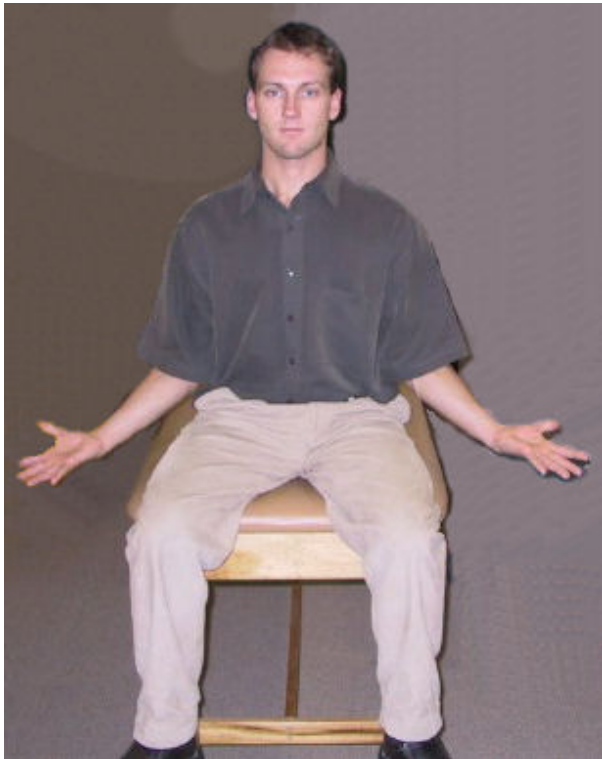
Buteyko Asthma Management: <http://www.buteyko.co.nz/bnz/us/default.cfm>

Middendorf Breath Institute: <http://www.breathexperience.com/>

Appendix 2: Brügger Relief Position

The Brügger relief position can be used as a postural awareness and rest position, useful for low back conditions. The patient should be instructed to take brief, periodic breaks throughout the day (for perhaps 10 seconds, every 20-30 minutes) and settle into this stylized posture.

Instructions are as follows: Sit at the edge of a chair, with the legs slightly abducted, the feet and knees turned out, and the hip at an open angle (greater than 90 degrees). The pelvis is tilted forward and the stomach allowed to “pooch out,” establishing a hollow in the low back which encourages maximum lordosis. The sternum is lifted up and out, which will have the automatic effect of allowing the shoulders to settle back without strain. The arms are allowed to rest on the thighs, preferably in slight external rotation. Lastly, the chin is gently tucked in and the head held high and erect.



Appendix 3: Assessment of the Gluteal Muscles

Below are listed a number of procedures that can be performed as part of a functional assessment of the patient. Findings suggesting inhibition or weakness of the gluteal muscles are described.

G MAXIMUS	
Postural analysis	Asymmetrical buttock (flattening of upper outer quadrant of buttock, drooping of the cheek).
Gait	Shortened stride (especially with backward walking or quadruped crawl).
Prone voluntary contraction of buttock	Asymmetrical contours and tone.
Prone hip extension	Abnormal motion in first 20 degrees (excessive arching of lumbar, rotation of pelvis).
Manual muscle test	Grade 4 (often normal) or weaker (much more rare).
Repetitive squats	Patient falls below norm. See CSPE protocol, Low Back and Leg Endurance Tests .
Isometric muscle test (in shortened position)	Shaking compared to opposite side or before 10 seconds elapse.
Functional deficits	Trouble squatting, walking up stairs, or getting out of chair not due to pain (often more associated with quadruped weakness).

G MEDIUS	
Gait	Excessive lateral shift to weak side.
Single leg stand	Positive Trendelenberg sign (rare). Lateral shift (> 1 inch) to weak side.
Side lying hip abduction	Abnormal movement (forward drift, backward drift with external rotation, or hip hiking in first 45 degrees).
Manual muscle test	Grade 4 (often normal) or weaker (much more rare).
Isometric muscle test (in shortened position)	Shaking compared to opposite side or before 10 seconds elapse.
Functional deficits	Difficulty keeping pelvis level during single leg stabilization exercises (e.g., bridge, squat).

Appendix 4: Rehabilitation of the Gluteal Muscles

The strategy presented here is to remove any source of inhibition, activate the muscle by stimulating it as necessary, and then retrain the muscle to fire in a properly coordinated fashion, eventually building strength and/or endurance.

G MAXIMUS		G MEDIUS	
Remove inhibition	Adjust SI, hip, lumbar as needed	Remove inhibition	Adjust SI, hip, lumbar as needed
	Stretch/relax hip flexors		Stretch/relax hip adductors
	Clear g max MFTPs*		Clear g med MFTPs*
Stimulate muscle	Direct goading/shaking	Stimulate muscle	Direct goading/shaking
Exercise/track progression†	Quadruped/prone	Exercise/track progression	Clam exercise/side posture leg raises
	Bridge		Single leg bridge
	Squat (esp. single leg) & star lunges		ball
	Single leg balance board (especially in sagittal plane)		Squat (esp. single leg) & star lunges
			Single leg balance board (especially in frontal plane)

Wall

* Occasionally the MFTPs may be located elsewhere in the kinetic chain.

† The exercise progression is a general recommendation. If non-weight bearing exercises (floor exercises) are done, they usually precede weight bearing. The slow lunge can sometimes be introduced along with the floor exercises. The weight bearing exercises themselves need not be given in strict order.

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Program Contents and Organization

On the following pages, you will find the UWS Low Back Rehabilitation and Stabilization program. It is organized by tracks in alphabetical order. Since all tracks should begin with Neutral Pelvis & Hip Hinge, it has been placed at the beginning of the list. Each track contains instructions on how to do the exercise(s), photos, and two checklists: one that will help the practitioner ensure that the track is being done properly, entitled *Make sure patients...*, and another, *Prescription*, in which repetitions, sets and so on are prescribed. Following the precise set of instructions for doing the track are Practitioner Tips, which present information that will help practitioners know when to assign certain tracks, ways of assessing their effectiveness, and troubleshooting. The tracks that are part of the Basic Program are marked as such, and are indicated below in bold. Those that are not designated are part of the Alternate Program.

Low Back Rehabilitation and Stabilization Program

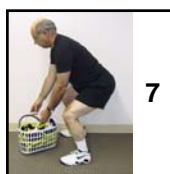
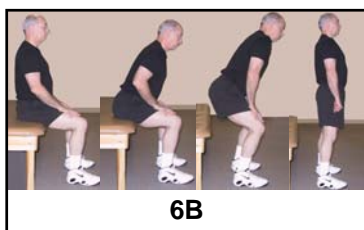
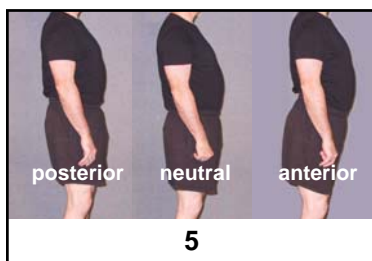
Foundation Tracks

- **Neutral Pelvis & Hip Hinge**
- **Abdominal Bracing**
Abdominal Hollowing

Exercise Tracks

- Bridge
- Bridge on Ball
- **Curl Up/Sit Back**
Curl Up/Sit Back on Ball
- Dead Bug
- Kneeling
- **Lunge**
Prone
Prone on Ball
- **Quadruped**
- **Seated**
- **Side Bridge**
Side-lying
- **Squats**
Squats with Ball
- **Standing (stable surface)**
- **Standing (unstable surface)**

➤ = **Basic Program**



Neutral Pelvis, Hip Hinge, and Abdominal Bracing or Hollowing

Neutral Pelvis & Hip Hinge: Gluteus maximus, hamstrings, low back extensors, psoas and abdominal muscles (especially rectus)

Have patient do A-P pelvic tilts, find neutral pelvis, and hold abdominal bracing/hollowing in each of the positions listed below (see Abdominal Bracing and Abdominal Hollowing tracks for more details). Most exercises in the program are done in neutral. The spine should also be held in neutral range whenever performing strenuous activities like lifting or during transitional movements, (e.g., getting out of a chair or out of bed) especially if the patient is having a flare up of back pain.

Practice finding and holding neutral pelvis (with abdominal bracing or hollowing) in various positions:

STATIC (NEUTRAL PELVIS)

1. Quadruped (a good teaching position).
2. Hooklying (a good teaching position).
3. Lying on back, legs extended (minimal downward heel pressure).
4. Seated.
5. Standing.

DYNAMIC (NEUTRAL PELVIS + HIP HINGING)

6. Transitional movements. [lying to sitting (see 6A) to standing (see 6B) and vice-versa]
7. Picking something up off the floor.
8. Kneeling with buttocks on heels/with thighs vertical. (This step is optional.)
9. During activities at home or work which were difficult or pain producing for the patient. (First performed slowly, then at more natural speeds.)

Note: Steps 1, 2, 4, 5 and 6 are taught as soon as possible, often on the first day of treatment. Step 9 should not be attempted until the patient has demonstrated good control in the earlier steps and is usually progressing through some of the other tracks.

Prescription

When doing exercises, transitional movements, lifting.

Make sure that patients . . .

- Maintain neutral pelvis.
- Maintain abdominal bracing/hollowing.
- Breathe properly.
- Don't flex the spine (hip hinge).



Practitioner Tips

Neutral Pelvis & Hip Hinge

Indications

- May offer pain control in the acute case (first visit).
- First step of a low back stabilization program (early visits).
- Neutral pelvis is used throughout the rest of the tracks.

Applications

- Moves through a posterior and anterior tilt (a pelvic clock), exploring the range of pain-free movement.
- Patient finds pain-free neutral pelvis.
- If no position or range is pain free, direct the patient to find a position of increased sense of stability or relative comfort.
- If the patient cannot find and hold neutral, instructing the patient to stick their buttocks out will help prevent unwanted flexion.
- The patient can also hold a stick against the spine, learning to flex forward (from the hips) without allowing the stick to move away. (*see pictures*)



correct



incorrect

- Lock spine with abdominal bracing/hollowing (monitor abdominal contraction).
- Perform as an exercise in a variety of static body positions (e.g., sitting, standing, kneeling), as well as “functional” activities (e.g., bending, twisting, lifting), including other dynamic activities that may have been aggravating in the past.

Neutral Pelvis, Hip Hinge, and Abdominal Bracing or Hollowing

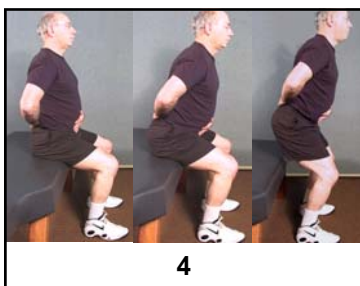
Abdominal Bracing: Abdominal and low back extensor muscles

When holding neutral pelvis and doing various exercises, tighten abdominal and low back muscles.

1. Place one hand on abdomen and one on back.
2. Co-contrast both muscle groups at the same time.
3. Breathe properly (“belly” breathe).
4. Practice holding this contraction while transitioning in and out of a chair (remember to hold neutral pelvis and to hip hinge.)
5. Perform this co-contraction when doing exercises.
6. Perform this co-contraction when lifting (remember to hold neutral pelvis, to hip hinge, and to use your legs).

Prescription

When doing exercises, transitional movements, lifting.



Make sure patients. . .

- Maintain neutral pelvis.
- Maintain abdominal bracing.
- Don't contract too hard.
- Breathe properly.



Practitioner Tips

Abdominal Bracing

Indications

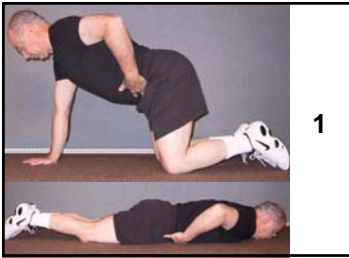
- May offer pain control in the acute case (first visit).
- First step of a low back stabilization program (early visits).
- Neutral pelvis and bracing are used throughout the rest of the tracks.
- Use when lifting, going through transitional movements, or participating in activities that have been identified as potentially difficult for the patient.

Applications

- Patient finds pain-free neutral pelvis.
- Stabilize spine with abdominal bracing (monitor with fingers on lateral/anterior abdomen and low back extensors). May additionally check for contraction medial to ASIS.
- Contraction need only be in around 20% MVC for most exercises and activities.
- Contraction should be gentle enough that the patient can still breathe while maintaining muscle control.

Troubleshooting

- Try different positions (e.g., quadruped, standing against a wall).
- To facilitate, contact the antero-inferior portion of the patient's knee and instruct him/her to push against your hand along the axis of the femur.
- Sometimes the multifidi may need to be directly stimulated to ensure its active participation in co-contraction.
- Contraction of the pelvic floor may be necessary to activate the deep abdominal muscles (e.g., patient tries to draw the anus inward similar to Kegel exercises). Unless activity of the diaphragm and pelvic floor muscles accompanies that of the transverse abdominus muscle (TrA), contraction of TrA will simply move the abdominal contents within the abdominal cavity with minimal effect on stability.



1



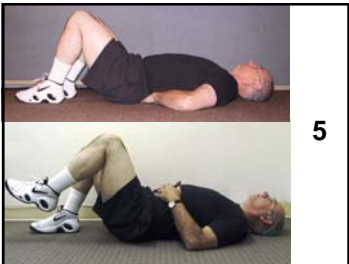
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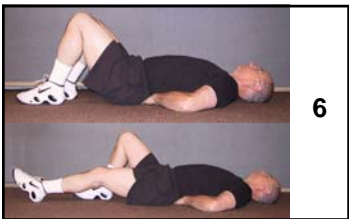
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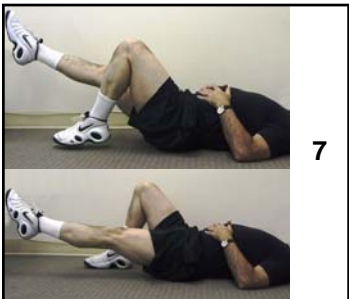
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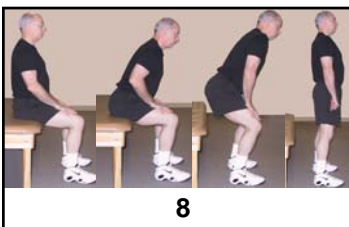
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11

Neutral Pelvis, Hip Hinge, and Abdominal Bracing or Hollowing

Abdominal Hollowing: selective contraction of transverse abdominus, internal obliques and multifidus

Note: Monitor contraction just medial to the ASIS.

Non-Weight Bearing

1. Quadruped or prone (a good teaching position)
2. Hooklying
3. Seated
4. Standing
5. Lying on back, marching in place.
6. Lying on back, slide heel out, straightening leg (alternate legs).
7. Lying on back, lift heel off the ground and straighten leg out (alternate legs).

Weight Bearing

8. Getting in and out of a chair.
9. Getting up and down from a lying position.
10. Picking something off the floor (bracing, not hollowing should be used for lifting demands).
11. During activities at home or work which were difficult or pain producing. (First performed slowly, then at more natural speeds.)

Prescription

A target of 10 repetitions of 10 second holds can be applied to a variety of body positions (e.g., sitting, standing, kneeling), as well as "functional" activities (e.g., bending, twisting), including other dynamic activities that may have been aggravating in the past.

Make sure patients. . .

- In quadruped, TLJ shouldn't move.
- Maintain neutral pelvis.
- Maintain abdominal hollowing.
- Maintain light contraction ≤ 20 maximum voluntary contraction (MVC).
- Minimal recruiting of superficial abdominals.
- Breathe properly.

STOP if patient shakes, loses form or back pain is aggravated (a muscle *burn* is okay).



Practitioner Tips

Abdominal Hollowing

Indications

- May offer pain control in the acute case (first visit).
- First step of a low back stabilization program (early visits).
- Neutral pelvis and hollowing are used throughout the rest of the tracks.

Applications

- Patient finds pain-free neutral pelvis.
- Navel is drawn in and up. The abdominal wall should not bulge out (unlike what occurs in abdominal bracing).
- Use a low level contraction. Have them reduce contraction to a little less than 25% of a maximum voluntary contraction (MVC).
- Have the patient breathe while exercising muscular control.
- Co-contract multifidus.
- A target could be 10 low-level contractions with 10 second-holds before moving on to other tracks.*
- Perform as an exercise in a variety of static body positions (e.g., sitting, standing, kneeling), as well as “functional” activities (e.g., bending, twisting, lifting), including other dynamic activities that may have been aggravating in the past.

Check for

- Monitor the deep abdominal wall (transverse and internal obliques). Palpate (on each side) medially and inferiorly to the anterior superior iliac spine (Hides 2000). The contraction should feel like a slowly developing deep tension rather than a rapid jerky contraction suggesting more superficial activity.
- The trunk or pelvis should not move.
- The contraction should not be painful.
- The shoulders/clavicles should not rise.
- Periodically check external obliques above the iliac crest (the lateral aspects of the abdominal wall with verbal and tactile feedback, discouraging contraction here).
- The patient then consciously contracts these muscles along with the multifidus and deep abdominals in all of his/her training sessions.

Using a pressure cuff

Supine: The pressure cuff is placed under the patient’s low back. After the patient attains neutral pelvis, inflate the cuff to fill in the space under the low back (e.g., about 40 mmHg). The patient practices abdominal hollowing until the pressure rises at least 10-15 mmHg but no more than about 20 mmHg. The needle should then remain stable without further increases or decreases. (Some authorities suggest that some movement would be acceptable since neutral pelvis represents a range). This control can be monitored throughout a variety of supine exercises.**

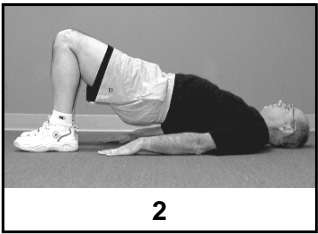
Prone: The pressure cuff is placed under the patient’s abdomen. It is inflated to 70 mmHg. Hollowing should result in a change of 8-10 mmHg which the patient must be able to maintain steadily.

* O’Sullivan P. Evaluation of specific stabilizing exercise in the treatment of chronic low back pain with radiologic diagnosis of spondylosis or spondyloolosthesis. *Spine* 1997;22(24):2959-67.

** Richardson C, Jull G. Concepts of assessment and rehabilitation for active lumbar instability. In: Grieve’s Modern Manual Therapy, 2nd edition. Boyling J. (ed.) Edinburgh: Churchill Livingstone; 1994.



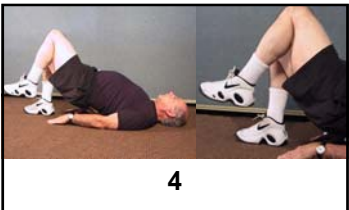
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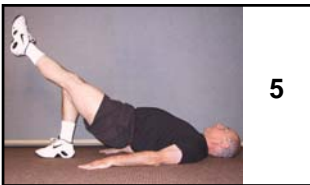
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7A

7B

7C

7D

Bridge Track: Gluteals and Quadriceps

1. Partial (short arch) bridge: lie on back, knees bent, contract buttocks, slowly raise then lower the pelvis and lumbar spine, one segment at a time.
2. Full bridge.*
3. Alternate heel lifts while holding bridge. (This can be made more difficult by moving the heels closer to the buttock).
4. Perform bridge, then lift one knee at a time toward the ceiling, advance to "marching."
5. Bridge up, extend one knee, keeping both thighs parallel, hold one-leg bridges.
6. Hold one-leg bridge and do dips (dip hip toward the floor).
7. Holding bridge with straight leg, lower and raise leg. (Test: patient can repeat for 1 minute.)

*A training effect is possible with application of exercises from step 2 on. Slow alternating arm raises as if doing a backstroke may be added to step 2.

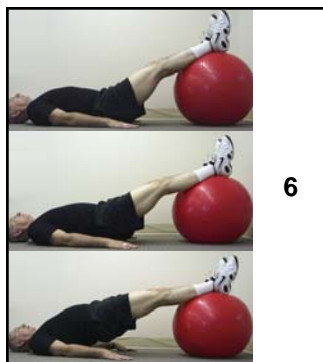
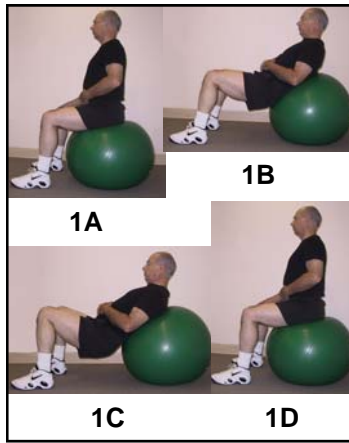
Make sure that patients . . .

- Maintain neutral pelvis.
- Maintain abdominal bracing/hollowing.
- Breathe properly.
- Focus on the gluteal muscles you are exercising.
- Relax everything else.
- Keep pelvis level.
- Don't arch back at the top of the bridge.
- Do the exercise *slowly*.

Prescription

_____ repetitions (8-30)
 _____ sets (1-3)
 _____ seconds held (1-10)
 _____ times per day/week
 (1-3/dy; 3-7/wk)

STOP if patient shakes, loses form or back pain is aggravated (a muscle burn is okay).



Bridge Track on Ball

1. Seated, perform abdominal bracing/hollowing and roll down ball into bridge position. Return to sitting position with neutral pelvis (small steps, do not stop). (see 1A - 1D)
2. Seated (refer to 1D), abdominal hollowing/bracing, and roll down ball part way until abdominals begin "working." Hold position and slowly march in place.
3. Lie with shoulders on ball, abdominal bracing/hollowing and bridge up. Hold bridge and lift one flexed leg (knee bent, bending from the hip). Keep abdominal hollowing/bracing and prevent opposite hip from falling and/or hiking.
4. Hold bridge and raise one leg with knee fully extended.
5. Bridge up and down with one leg on floor.
6. Lie with back and arms on the floor, feet up on the ball, and slowly bridge up.
7. Same as above, but with arms folded on the chest.
8. Alternating short arc foot raises off of ball, with arms on floor (advanced).
9. Alternating short arc foot raises off of ball, with arms on chest (advanced).

Make sure patients. . .

- Maintain neutral pelvis.
- Maintain abdominal bracing/hollowing.
- Breathe properly.
- Focus on the gluteal muscles you are exercising.
- Relax everything else.
- Keep pelvis level.
- Don't arch back at the top of the bridge.
- Avoid chin poking.
- Do the exercise *slowly*.

Prescription

_____ repetitions (8-30)
 _____ sets (1-3)
 _____ seconds held (1-10)
 _____ times per day/week
 (1-3/dy; 3-7/wk)

STOP if patient shakes, loses form or back pain is aggravated (a muscle burn is okay).





Practitioner Tips

Bridge Track (Gluteals and Quadriceps)

Indications

- Can be used to specifically train the gluteus maximus and quadriceps muscles as well as part of an overall lumbar stabilization program, emphasizing pelvic control and bracing. (See also Kneeling, Lunge, Prone, and Quadriceps Tracks.)
- History indicators: difficulty squatting, climbing stairs, rising from a chair (especially if patients use their trunk rather than their legs), or lifting (poor lower body strength).
- Physical Indicators: “drooping” of one buttock (a flattened upper, outer contour); poor hip extension seen on forward or backward gait; and poor firing pattern with hip extension.
- Single-leg bridge can be used to train gluteus medius (indicators include poor hip abduction pattern, excessive pelvic shift during gait or single-leg stand). [See also Lunge, Side-lying, Squat (single leg), and Standing (single leg) Tracks.]
- May not be suitable in the acute phase of either disc herniation or stenosis.
- **Application:** Arm movements may be added to the bridge track to further challenge pelvic control or when patients cannot lift their legs while holding the bridge. Rhythmic stabilization may be added to this track to facilitate the internal obliques (alternate isometric rotation resistance, 30-40% MVC).
- **Operational endpoint/outcome measure:** Patient can hold bridge and raise and lower leg for 1 minute.

Check for

- abdominal bracing (palpate lateral aspect of abdominal wall) or hollowing (palpate just medial to ASIS bilaterally)
- general asymmetry
- gluteal contraction during the bridge (palpate gluteus maximus to be sure it is engaged)
- pelvic unleveling (placing a stick across the ASIS, cue the patient to consciously contract glut before trying to raise a knee)
- overactivity in the hamstrings or low back extensors
- recruiting other parts of the body (pressing arms hard against the floor, extending neck, uneven pressure on one foot more than another)

Troubleshooting

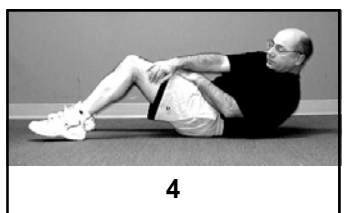
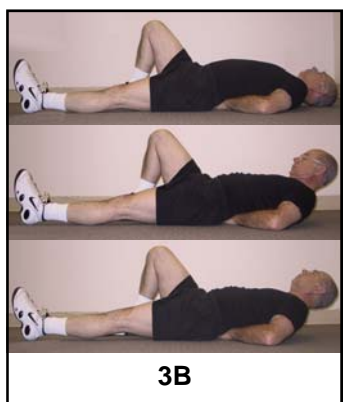
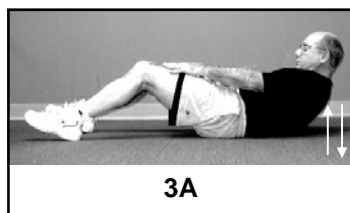
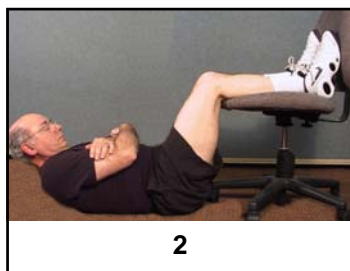
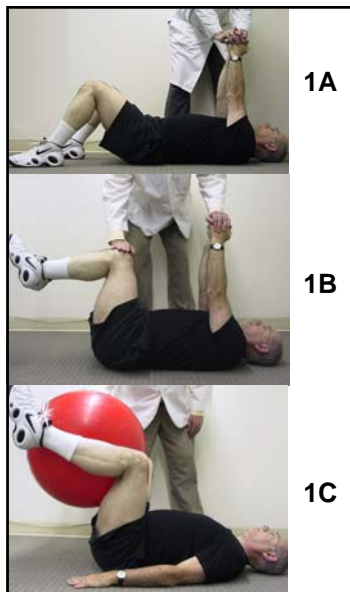
- You may need to stimulate the gluteus maximus with digital pressure or resist abduction at the knees to engage the gluteus medius.
- You may need to facilitate the quadriceps as the patient begins to go into the bridge by 1) scratching or stimulating it or 2) asking the patient to try to extend there legs while blocking any forward movement of the feet with the side of your foot. (see pictures)
- You may need to stretch/relax overactive lumbar erector spinae muscles.
- If hamstrings are overactive, move heels closer to buttock.
- Pelvic unleveling while doing a one-leg bridge exercise may indicate that the g. medius may need to be facilitated; in turn, the piriformis or adductors may need to be relaxed/stretched.
- Lumbar segments may have decreased flexion motion.
- Sacroiliac and thoracolumbar joint dysfunction should also be considered.
- If patients cannot march in place raising the entire foot off the ground, have them just lift their heels instead.



Curl Up/Sit Back Track: Abdominals

These exercises should be performed in neutral pelvis and with abdominal bracing or hollowing.

1. Activate muscles with isometric rhythmic stabilization activities (see 1A, 1B, 1C).
2. Crunch in 90/90 (lift shoulder blade off of floor, hips and knees positioned at 90 degree flexion supported on a chair or ball; can also involve arm raises).
3. Crunch/curl up (see 3A) (raise head then scapula with knees bent to about 30 degrees). Sit back (lower trunk one segment at a time, slower than curl up phase). An alternate method is shown (see 3B): one hand under low back; one leg straight, keep neck and upper back straight (no curl), hinging around T6.
4. Partial curl, diagonals.



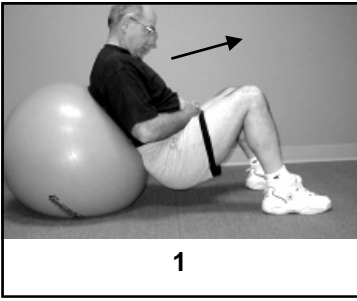
Make sure patients...

- Maintain pelvic control.
- Maintain abdominal bracing/hollowing.
- Breathe properly.
- Relax everything else.
- Avoid chin poking.
- Do the exercise *slowly*.
- Do not lift feet off the ground.
- Don't secure feet to the ground in any way.

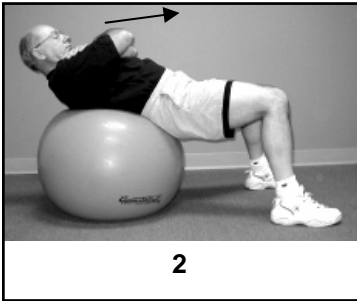
Prescription

_____ repetitions (8-30)
 _____ sets (1-3)
 _____ seconds held (1-10)
 _____ times per day/week
 (1-3/dy; 3-7/wk)

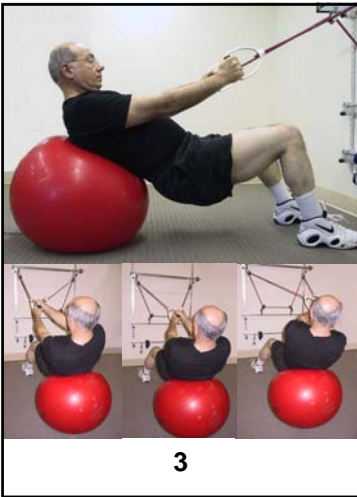
STOP if patient shakes, loses form or back pain is aggravated (a muscle burn is okay).



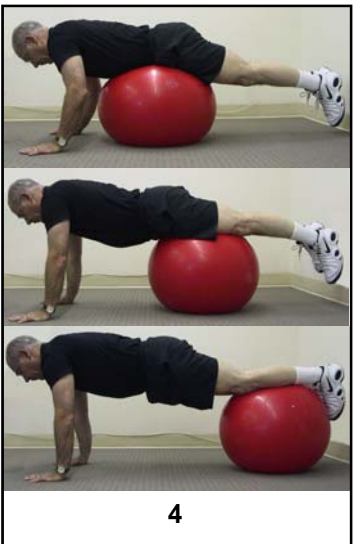
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Curl Up/Sit Back Track on Ball: Abdominals

1. Do crunches, starting low on ball (passively pre-positioned in flexion) and progress higher on ball.
2. Lie with the middle of the back on ball and do trunk curls.
3. Middle of back on ball, perform partial trunk curl, pull pulley or exercise tubing in rotary direction (elbows should stay extended, move from waist and not shoulders or arms). Progress by adding resistance.
4. Starting with ball under abdomen, roll forward using hands, keeping legs on ball.

Make sure patients. . .

- Maintain pelvic control.
- Maintain abdominal bracing/hollowing.
- Breathe properly.
- Relax everything else.
- Avoid chin poking.
- Do the exercise *slowly*.
- Do not lift feet off the ground.
- Don't secure feet to the ground in any way.

Prescription

_____ repetitions (8-30)
 _____ sets (1-3)
 _____ seconds held (1-10)
 _____ times per day/week
 (1-3/dy; 3-7/wk)

STOP if patient shakes, loses form or back pain is aggravated (a muscle *burn* is okay).



Practitioner Tips

Curl Up/Sit Back Track (Abdominals)

Indications

- Not recommended for patients with osteoporosis.
- Exercises emphasizing abdominal *control* can be introduced early in the rehabilitation program.
- Many patients may need to strengthen the abdominal muscles. Abdominal *strengthening* exercises are often reserved until later in the rehabilitation process when the patient has made progress in some of the other tracks.

Application

- Crunch can be done without any neck flexion, having the patient flex from T4 (this may be particularly useful if the patient has a neck problem)
- The patient can do sit-back step (step 5) in a sitting position, leaning back against the practitioner who limits the range of the activity.
- Patient holds a crunch position with foam cylinder held between knees and resists the practitioner's attempts to push/pull/trace diagonals with the cylinder.
- Patient holds crunch position (90/90 hip/knee flexion) with medicine ball or light object held the knees or further out between the feet. (see picture)
- Patient holds crunch. Doctor throws ball to patient overhead.
- Patient holds crunch position, ball held between feet, gymnastic ball on abdomen. Patient resists slow movement of gymnastic ball by the doctor in different directions.
- Patient lies with the middle of his/her back on a ball and holds a partial trunk curl, while catching a ball thrown by the practitioner or resisting trunk rotations.
- Posterior tilt not recommended.



On ball: Doubles rectus and increase oblique activity 4x. (Vera-Gerneir 2000) But also increase spinal compression (4000 N). Lower abdominal activity is greater than upper. Not for LBP patients in early care. Appropriate for athletes.

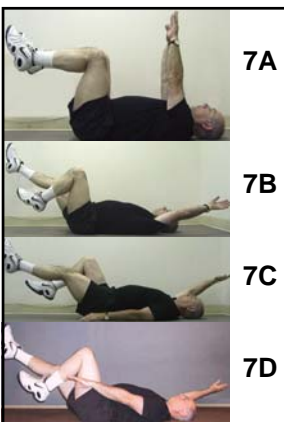
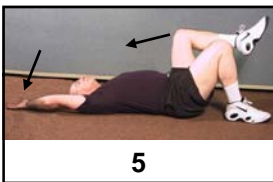
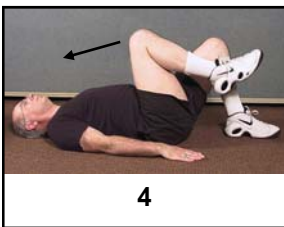
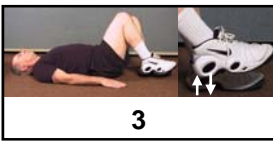
Operational end point/outcome measure: Consider using the Janda curl up test to evaluate quality and the Sorensen sit-up test to evaluate endurance. (See CSPE [Low Back and Leg Endurance](#) protocol.)

Check for

- abdominal bracing/hollowing (palpate)

Troubleshooting

- Erector spinae or hip flexors are overactive/tight.
- Lumbar spine subluxations may also be present.
- Use a rolled up towel to position the patient in neutral pelvis or have patient slip his/her hand under the low back for support while keeping one leg straight and the other bent in a "hooklying" position.



Dead Bug Track: Abdominals

1. Lying on back, knees bent, raise one arm at a time overhead.*
2. Same as above, raise both arms overhead.*
3. Raise one foot a few inches off the floor at a time, switching to the other foot as if "marching."
4. Bring one knee to chest at a time.
5. Bring one knee to chest at a time while raising opposite arm, return foot and arm to the floor.
6. Perform alternating kicks unsupported, that is, without letting feet touch the floor (the lower the legs and the further the leg is extended, the harder the exercise). 10 second holds, 5-10 reps.
7. Dead bug. (When patient can maintain for two minutes, move to step 8). Arm and leg movements can be ipsilateral, or cross crawl. Cross crawl (see 7D) is more difficult but can reinforce gait patterns.
8. Add ankle (e.g., 2-5 pounds) and wrist weights (e.g., 2 pounds). Work up to 2 minutes.

The first five steps will help program pelvic control, but may not appreciably affect conditioning. When patients can perform exercise 6 properly and repetitively, a training effect will be achieved that will promote both control and endurance.

* Many patients may have difficulty keeping the pelvis stable while moving the arms. In this case, begin with step 3-5 and introduce the single and bilateral arm movements later.

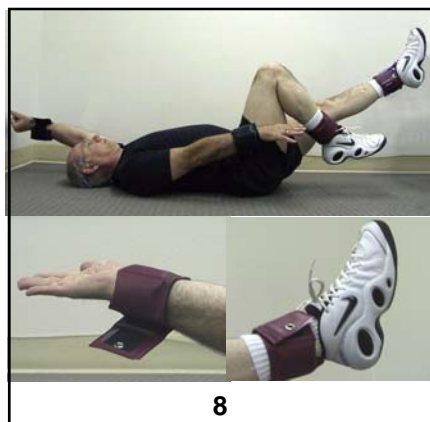
Make sure patients. . .

- Maintain neutral pelvis.
- Maintain abdominal bracing/hollowing.
- Breathe properly.
- Relax everything else.
- Do the exercise *slowly*.

Prescription

_____ repetitions (8-30)
 _____ sets (1-3)
 _____ seconds held (1-10)
 _____ times per day/week
 (1-3/dy; 3-7/wk)

STOP if patient shakes, loses form or back pain is aggravated (a muscle burn is okay).





Practitioner Tips

Dead Bug Track (Abdominals)

Indications

- May use as a substitute for trunk curl in “Basic Program” especially for patients that can’t do a partial sit-up due to pain, osteoporosis, or fractures. Often a good starting point for mechanical low back pain patients, especially for patients whose symptoms improve with flexion (a flexion bias).
- Poor abdominal strength or a report of lifting/standing activity intolerance. (Janda curl-up movement patterns, repetitive sit-up test, etc.)
- Patients with herniated discs may only be able to perform the initial steps in the acute phase.

Application

- Consider having the patient coordinate the arms and leg movement into a cross crawl pattern.
- Consider doing operator-resisted isometric counter-rotation as a peel back. Consider doing a supine pelvic clock as an initial training phase. See also the Side Bridge exercise (e.g., for oblique abdominals) and Trunk Curl Up track.
- **Operational endpoint/outcome measure:** Patient can maintain dead bug for 2 minutes (with or without weights).

Check for

- neutral pelvis (slight movements can be acceptable)
- abdominal bracing/hollowing (palpate abdominal muscles)
- slow controlled movement
- excessive pressing against floor with the neck or arms during steps 3-5
- during arm movements, if patients have to flex their elbows or shift their pelvis (suggesting tight pectoralis muscles)
- hip flexes while extending opposite leg, indicating the patient may have weak lower abdominals.

Troubleshooting

- Usually associated with poor neuromuscular control or weak abdominals.
- If patients has trouble with step one, try placing a pillow under their heads or pre-positioning them in a 90-90 configuration.
- If the patient loses neutral pelvis when flexing the hip, the ipsilateral psoas may need to be relaxed/stretched.
- Shortened erector spinae muscles may also need to be relaxed.



1A

Kneeling Track: Quadriceps, Gluteus Maximum, Abdominals, Scapula Stabilizers

1. Sitting on heels, neutral pelvis with abdominal hollowing/bracing, raise the body upright by extending the hips.
2. Same position with arms raised (shoulder height or above the head, in a variety of work positions).
3. Same position as step 2 introducing resistance (tubing, weights, exercise ball), at different heights and held closer or further from the body.
4. Hold raised position while flexing and extending arms using weights or tubing.
5. These exercises can be done while kneeling on a rocker board.



1B

Make sure patients. . .

- Maintain neutral pelvis.
- Maintain abdominal bracing/hollowing.
- Breathe properly.
- Relax everything else.
- Don't hike your shoulders when raising your arms.
- Do the exercise *slowly*.

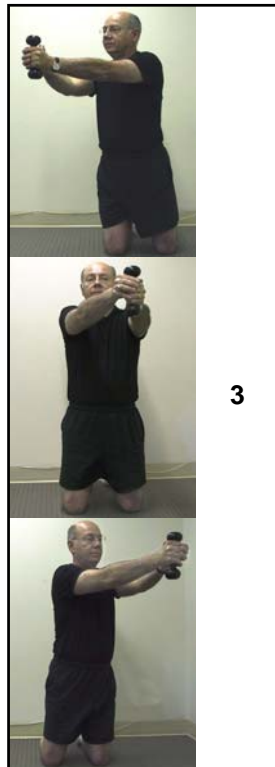
Prescription

_____ repetitions (8-30)
 _____ sets (1-3)
 _____ seconds held (1-10)
 _____ times per day/week
 (1-3/dy; 3-7/wk)

STOP if patient shakes, loses form or back pain is aggravated (a muscle burn is okay).



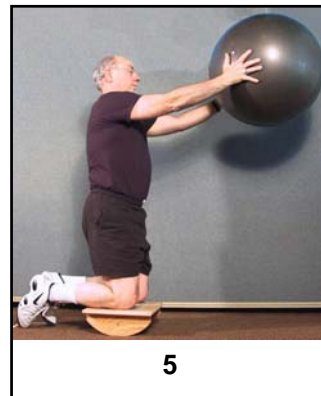
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3



4



5



Practitioner Tips

Kneeling Track

Note: Used primarily for the quadriceps and gluteal muscles; secondarily, for abdominals and scapular stabilizers.

Indications

- Useful for patients whose work or household chores (e.g., cleaning a bathtub) may require kneeling. Patients may report either difficulty when kneeling or may avoid this position altogether.
- Repetitive raising up and sitting back on heels (step 1) can be used to build gluteus maximus and quadriceps endurance.
- **Application:** rhythmic stabilization may be added to this track to facilitate the internal obliques (alternate isometric rotation resistance, 30-40% MVC).

Check for

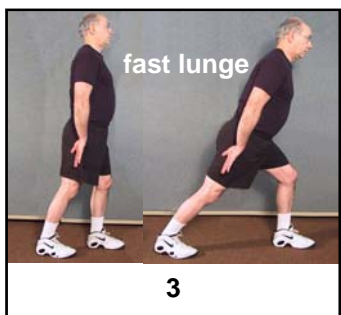
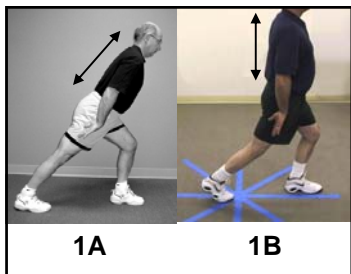
- abdominal bracing/hollowing (palpate)

Troubleshooting

- Kneeling may be difficult because of knee problems or tightness in the erector spinae or rectus femoris.
- Decreased lumbar flexion motion is also a factor.

Lunge Track: Quadriceps and Gluteals

1. Forward lunge, slant (see 1A) or straight up (see 1B).
2. Lunge into multiple directions (star diagram).
3. Fast, forward lunges (optional).
4. Lunge on to labile surface (optional).
5. Add arm movements during lunge (cross body, elevation, etc).
6. Add resistance with hand weights, medicine ball, pulley system, etc.



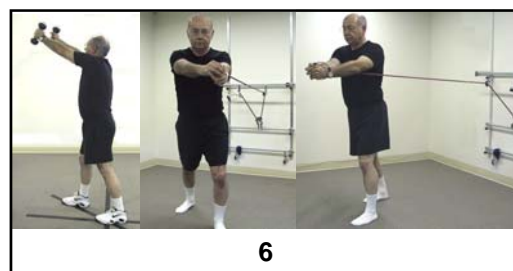
Make sure patients. . .

- Good balance on short foot or “3 point” foot.
- Maintain neutral pelvis.
- Maintain abdominal bracing/ hollowing.
- Breathe properly.
- Don’t arch back.
- Keep knee slightly rotated outward toward the second toe.
- Do not let ankle roll in.
- Don’t let knees push past tips of toes.
- Work on smooth controlled movement.
- Work on good balance when landing.
- Drop faster as lunges improve.
- Try to land quietly (without a foot slap).

Prescription

_____ repetitions (8-30)
 _____ sets (1-3)
 _____ seconds held (1-10)
 _____ times per day/week
 (1-3/dy; 3-7/wk)

STOP if patient shakes, loses form or back pain is aggravated (a muscle *burn* is okay).





Practitioner Tips

Lunge Track (Quadriceps and Gluteals)

Indications

- Slow lunges help to train pelvic control.
- Fast lunges create sudden eccentric load and trains speed of contraction.
- Part of the weight-bearing component of the basic rehab program.
- This exercise targets both the quadriceps and gluteal muscles and serves as useful dynamic balance training.

Application

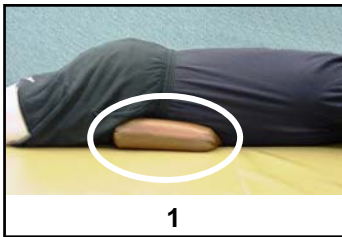
- Slow lunges should be introduced in the early phase of the program.
- There are two styles of lunges. In one, the patient ends up with the back flexed so that the torso and back leg form a straight line (the long lever of the torso makes this a more demanding balance challenge and adds more load on the knee). In the other style, the patient ends with his/her back upright, as might be the case when used as a lifting technique.
- To check for and train balance, perturbations can be administered as the patient holds the new position at the end of the lunge.
- Lunges should be performed in various directions (e.g., star diagram) and can be used with weights and pulleys.
- Lunge onto unstable surfaces (foam cylinders, balance pads, rocker boards, etc.). Start with more stable liable surfaces progressing to more difficult ones. Be sure patient knows these must be on on-skid surfaces.

Check for

- neutral pelvis (except for at the very end when a slight posterior tilt may be needed)
- abdominal bracing/hollowing (palpate to check)
- ideally heel lands first (followed by the outside of the foot)
- no hyperextension upon landing
- knee of forward leg should not drift beyond the toes
- little or no pelvic rotation
- knee slightly turned out (over middle of foot or over 4th toe)

Troubleshooting

- Overpronation and excessive knee rotation can be corrected by reaching across the body with the opposite arm.
- Hip flexors (back leg) or hamstrings (front leg) may be tight.
- If patients have balance problems, use Standing track then return to Lunge track.



1

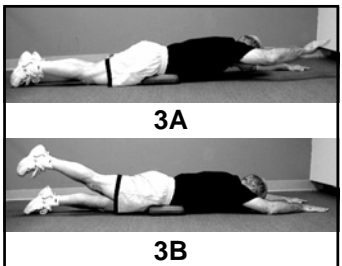


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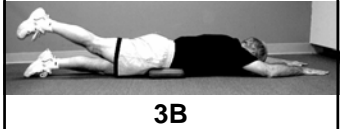
Prone Track: Gluteus maximus, low back extensors

1. Always begin with a pillow under the patient's pelvis.
2. Gluteal contractions (squeeze buttocks together).
3. Alternating arm raise or alternating leg raise with pillow (1-2 minutes).* (see 3A, 3B)
4. Arm and opposite leg raise (reciprocal) with pillow (1-2 minutes).
5. Upper/lower half extensions with pillow.
6. Reciprocal arm/leg with/without weights (without pillow).
7. Upper/lower half extensions with wrist (3#)/ankle (3-5#) weights.

* Many patients may have difficulty keeping the pelvis stable while moving the arms. In this case, begin with leg movements first.



3A



3B

Make sure patients. . .

- Maintain neutral pelvis.
- Maintain abdominal bracing/hollowing.
- Breathe properly.
- Focus on the muscle you are exercising.
- Relax everything else.
- Avoid arching the back when lifting arms or legs.
- Do the exercise *slowly*.

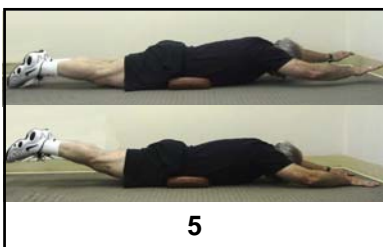
Prescription

_____ repetitions (8-30)
 _____ sets (1-3)
 _____ seconds held (1-10)
 _____ times per day/week
 (1-3/dy; 3-7/wk)

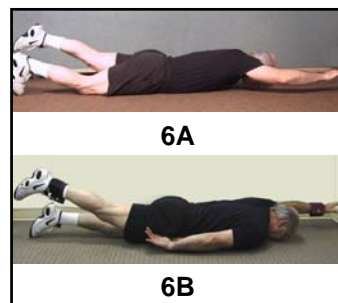


4

STOP if patient shakes, loses form or back pain is aggravated (a muscle burn is okay).



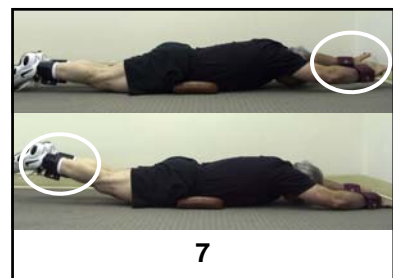
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6A



6B



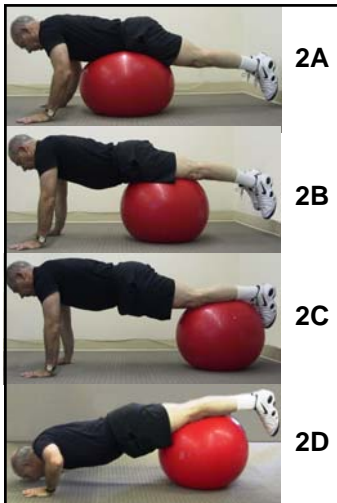
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1

Prone Track on Ball

1. Alternating arm/leg exercises over exercise ball with/without weights (may start with arms alone, first unilaterally, then bilaterally, then alternating combined with leg movements).
2. Ball walk out (push-up).
3. Prone on ball with feet against the wall, arms at side. Adopt neutral pelvis and then extend the trunk by pushing off from wall and straightening the back. Be sure to maintain some gluteal and abdominal co-contraction throughout movement.
4. Same as step 3 but arms extended (Superman).
5. Do arch ups on ball with arms at side.



2A

2B

2C

2D

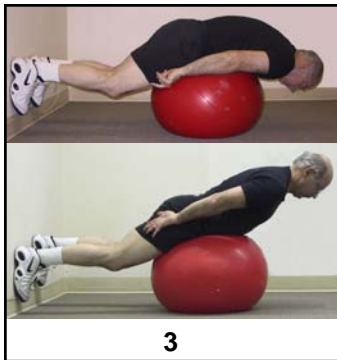
Make sure patients. . .

- Maintain neutral pelvis.
- Maintain abdominal bracing/hollowing.
- Breathe properly.
- Avoid arching the back when lifting arms or legs.
- Do the exercise *slowly*.

Prescription

_____ repetitions (8-30)
 _____ sets (1-3)
 _____ seconds held (1-10)
 _____ times per day/week
 (1-3/dy; 3-7/wk)

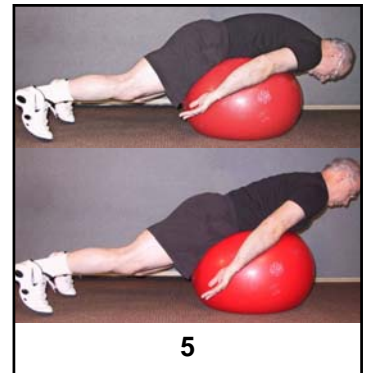
STOP if patient shakes, loses form or back pain is aggravated (a muscle burn is okay).



3



4



5



Practitioner Tips

Prone Track (Gluteus Maximus)

Indications

- Some practitioners prefer to use this in place of the Quadruped track.
- Often contraindicated in stenosis cases and in the acute phase of a disc herniation (although a passive prone McKenzie exercise may be therapeutic).
- Indicators include “drooping” of one buttock (may also have flattened lateral contour) and poor firing pattern with hip extension.
- **Application:** Steps 3-5 are particularly useful for building lumbar extensor endurance.

If this exercise is difficult to perform, use earlier steps of Prone track or move to the Kneeling track.

Check for

- abdominal bracing/hollowing (palpate)
- proper breathing
- hyperextension at the lumbar (don't raise arms or legs too high)
- scapular winging or shoulder hiking
- excessive motion (early pelvic rotation) or premature arching of lumbar spine

Troubleshooting

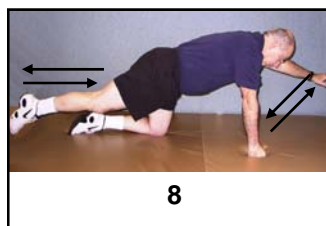
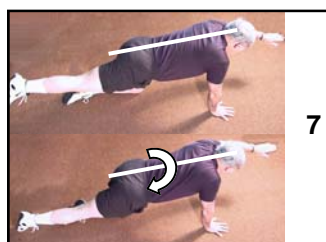
- Difficulty often arises because of decreased spinal and hip extensibility.
- A tight psoas (hip flexor) muscle or hip capsule may be involved.
- Decreased lumbar spine mobility in extension (fixed kyphosis) is also a factor.
- Some patients may do better starting on an exercise ball.

Operational endpoint/outcome measure: Consider static or repetitive extensor test. (See CSPE [Low Back and Leg Endurance](#) protocol.)

Quadruped Track: Gluteals, Multifidus, Extensors, Transverse

Abdominals, Scapular Stabilizers

1. Warm up with “cat dog” spine movements (AKA “cat camel”) (6-10 reps)
2. Neutral pelvis with abdominal bracing/hollowing.
3. Alternate raising one arm forward then the other.
4. Alternate sliding one leg back, then the other.
5. Raise one leg up and backward (without arching the back) then the other.
6. Raise opposite arm and leg (AKA, “bird dog”) (5 second hold, progress to 10 second hold, 5-10 reps).
7. With one arm and opposite leg raised, perform trunk rotation.
8. Do rapid “sweeps” with opposite arm and leg.
9. Trace out squares (see 9A) or circles (see 9B) with raised arm or leg (optional).
10. Support arm on balance board, perform trunk rotation.
11. Raise opposite arm and leg with resistance: tubing, wrist (3 pounds) and ankle (3-5 pounds) weights, slight manual resistance provided by the doctor.



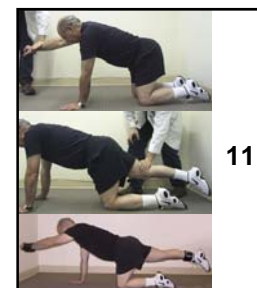
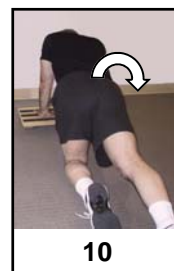
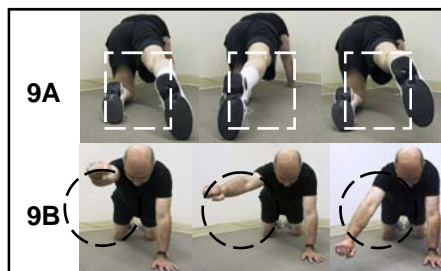
Make sure patients. . .

- Palms and knees should form a square.
- Hip should be at 90 degrees.
- Maintain neutral pelvis.
- Maintain abdominal bracing/hollowing.
- Breathe properly.
- Focus on the muscle you are exercising.
- Relax everything else.
- Avoid arching the back when lifting arms or legs.
- Keep shoulders and hips square to the floor—don't rotate pelvis (unless it is part of exercise).
- Do the exercise *slowly*.

Prescription

_____ repetitions (8-30)
 _____ sets (1-3)
 _____ seconds held (1-10)
 _____ times per day/week
 (1-3/dy; 3-7/wk)

STOP if patient shakes, loses form or back pain is aggravated (a muscle burn is okay).





Practitioner Tips

Quadruped Track

Note: Primarily used for training transverse abdominals, scapular stabilizers, multifidus and the low back extensors while producing minimal load on spine. Secondly can be used to facilitate gluteus maximus and to lesser extent medius.

Indications

- Indicators include “drooping” of one buttock (may also have flattened lateral contour), poor firing pattern with hip extension, and poor performance on lumbar extension tests. (See CSPE [Low Back and Leg Endurance](#) protocol.)
- Shoulder hiking during shoulder abduction or winging may indicate problems with scapular stabilizers. *See also the Prone and Standing Tracks.*
- **Warning:** Avoid reciprocal arm and leg raises (step 7) too early because this step substantially increases the spinal load.

Applications

- The patient can place a towel or other padding under the knees if necessary.
- 6-8 repetitions of the dog-cat (cat-camel) may be useful as a warm-up.
- Practitioner can add external challenge with sudden pushes to facilitate the internal obliques (rhythmic stabilization challenging isometric rotation, 30-40% MVC).

Operational endpoint/outcome measure: Patient can do for 3 minutes, 5 second hold.

Check for

- abdominal bracing/hollowing (palpate)
- no dipping or unintentional rotating of shoulder/pelvic girdle
- scapula stabilization
- no chin poking
- no excessive lumbar extension (leg kicks should not be too high)

Troubleshooting

- Patients having trouble with the first step may need to perform the exercises lying over an exercise ball or they may need to go back to the prone track.
- Patients with wrist discomfort may need to make a fist and rest on their knuckles or place their hands on small wedges to reduce the wrist extension.
- Also, gluteus medius weakness/inhibition on the support leg side may be present because of adductor, piriformis, tensor fascia lata, or quadratus lumborum hyperactivity /tightness.
- Consider adjusting hip and lumbar joint restrictions.

*McGill S. Low back exercises: evidence for improving exercise regimens. Phys Ther 1998 Jul;78(7):754-65.



Seated Track

On Stable Surface

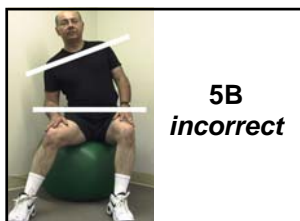
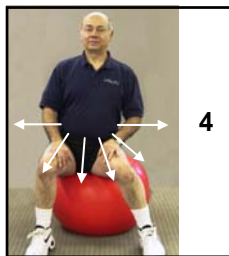
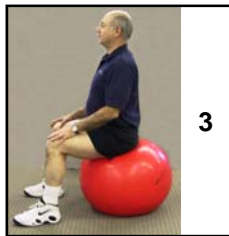
1. Neutral pelvis with abdominal bracing/hollowing.
2. Perform A-P (anterior and posterior) pelvic tilts.

On Ball (or other labile surface)

3. A-P pelvic tilts, hold neutral pelvis.
4. May perform tilts in various points on the compass (optional).
5. Do pelvic clocks (a "hula hoop" circumduction on ball or a chair) clockwise and counterclockwise (10 reps in each direction). (see 5A) Do not let shoulder drop—keep them level. (see 5B)
6. Single leg raise (on ball)*
7. Alternating arm and leg (on ball)*
8. Single leg raise and roll back on ball (maintains slight lumbar curve)*
9. Bouncing on ball (aerobic workout).

Note: Short range bouncing can be introduced during any of the steps to facilitate muscles, promote better balance, and create an aerobic training effect.

* Some patients may find it easier to reverse these steps and do step 7 first, then 6, then 5.



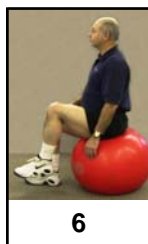
Make sure patients. . .

- Sit with chin retracted, sternum raised.
- Maintain neutral pelvis.
- Maintain abdominal bracing.
- Breathe properly.
- Focus on the muscle you are exercising.
- Relax everything else.
- Try to keep shoulders level.
- Avoid arching the back when lifting arms or legs.
- Do the exercise *slowly*.
- *When directed, do rapidly for aerobic workout.*

Prescription

_____ repetitions (8-30)
 _____ sets (1-3)
 _____ times per day/week
 (1-3/dy; 3-7/wk)

STOP if patient shakes, loses form or back pain is aggravated (a muscle burn is okay).





Practitioner Tips

Seated Track

Indications

- Part of the Basic Program. The use of the ball will introduce some automatic, reflex training and also often increases compliance.
- May stimulate multifidi.
- Indicated when patients (especially with signs of instability) are returning to a job with long periods of sitting or when sitting exacerbates symptoms.

Applications

- Ball should be on a non-skid surface.
- If necessary, patients can start with the ball up against a wall, in a corner, or with chair near-by to provide stable surface to grab on to.
- The ball should be well inflated so that the patient's knees are at a greater angle than 90 degrees.
- Resisted isometric rotations or quick approximation of low back extensors (thrust down on shoulders) can be added by the practitioner in the office.

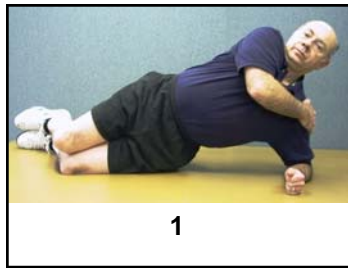
Check for

- abdominal/hollowing bracing (palpate)
- smooth symmetrical movements
- no shoulder hiking with arm movements

Side-Bridge Track: Gluteus Medius, Quadratus, Lumborum, Obliques

Side Bridge (Basic Program)

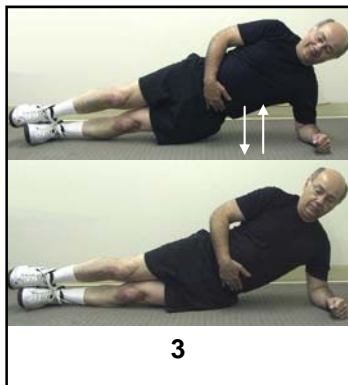
1. Knees bent
2. Leg straight
3. Perform dips
4. Rotate pelvis
5. "Log roll"
 - against wall (see 5A)
 - on floor (see 5B)



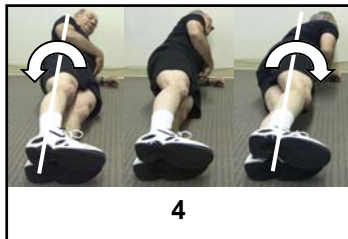
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2



3



4

Make sure patients. . .

- Maintain neutral pelvis.
- Maintain abdominal bracing/hollowing.
- Breathe properly.
- Push pelvis forward.
- Do the exercise *slowly*.
- Log roll—shoulders and hips must stay in the same plane.

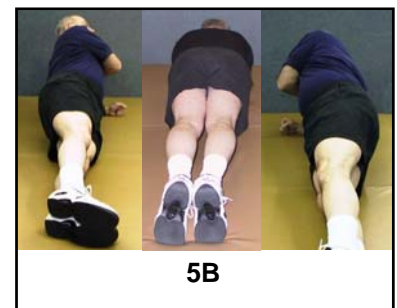
Prescription

_____ repetitions (8-30)
 _____ sets (1-3)
 _____ seconds held (1-10)
 _____ times per day/week
 (1-3/dy; 3-7/wk)

STOP if patient shakes, loses form or back pain is aggravated (a muscle burn is okay).



5A



5B



Practitioner Tips

Side-Bridge Track

Note: This track targets the quadratus lumborum and external abdominal obliques.

Indications

- McGill suggests that the side bridge (aka, horizontal side support) exercise may be a good core exercise for rehabilitating most low back patients because of its low load penalty on the spinal joints and excellent targeting of the quadratus lumborum and oblique abdominals.
- Patients who cannot hold a side bridge for 45 seconds (McGill 1999).

Exercise parameters

- External oblique = $43 \pm 13\%$ MVC (higher than a cross curl)
- Compression load = 1991 N
- Flexion load = none
- Psoas activity = lower than full sit up higher than a curl up
- Safe for LBP, Good for athletes, preferred to twisting curl ups for the external obliques.

Operational endpoint/outcome measure: See CSPE [Low Back and Leg Endurance](#) protocol.

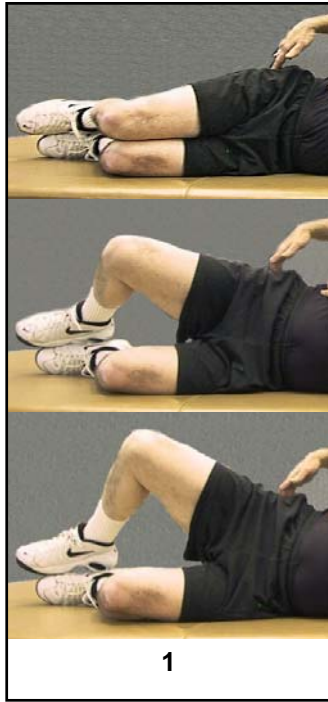
Check for

- abdominal bracing/hollowing (palpate)

Troubleshooting

If there are shoulders problems or the patient does not have sufficient strength, peel back to side bridge upright (leaning against a wall), lateral flexion exercises on vertical bench, or trunk lifts in a side-lying position.

*McGill S. Low back exercises: evidence for improving exercise regimens. Phys Ther 1998 Jul;78(7):754-65.



Side-Lying Track: Gluteus medius

1. Clam exercise (hip abduction with heels on the floor)
2. Single leg raises (hip abduction) while lying on side (with/without resistance)
3. Double leg raises (hip abduction) while lying on side (with/without resistance)
4. Trunk raise (with legs anchored)

Make sure patients. . .

- Maintain neutral pelvis.
- Maintain abdominal bracing/hollowing.
- Breathe properly.
- Push pelvis forward.
- Do the exercise *slowly*.

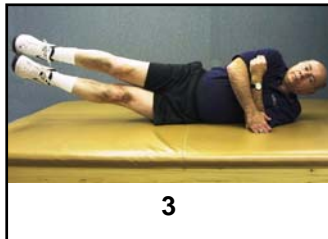
Prescription

_____ repetitions (8-30)

_____ sets (1-3)

_____ seconds held (1-10)

_____ times per day/week
(1-3/dy; 3-7/wk)



STOP if patient shakes, loses form or back pain is aggravated (a muscle *burn* is okay).



Practitioner Tips

Side-Lying Track

Note: This track targets the gluteus medius muscle.

Indications

- Indicators for hip abduction exercises include excessive side-to-side pelvic shifting during gait, poor firing pattern during hip abduction, lateral shifting more than an inch with single leg stand, and inability to maintain a level pelvis during a quadruped or bridge track.
- See also single-leg standing activities (Standing Track) and single-leg bridges (Bridge Track).
- Trunk side raises will work the quadratus and obliques.

Check for

- abdominal bracing/hollowing (palpate)
- gluteus medius (palpate)
- leg drifting into external rotation
- leg drifting into flexion
- early QL hiking

Troubleshooting

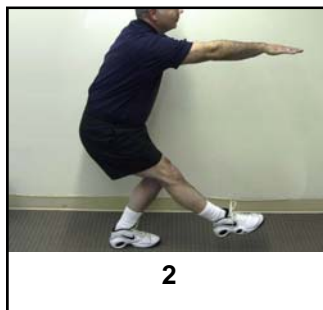
- Gluteus medius may need to be facilitated (direct stimulation), patients may need to be pre-positioned during the exercise or key muscles relaxed (e.g., leg placed in slight flexion to correct for forward drift and over-facilitated psoas, external rotation to offset an overactive piriformis or TFL, pelvis hiked superior to inhibit quadratus lumborum engagement).
- Consider adjusting any sacroiliac, hip or lumbosacral restrictions.

*McGill S. Low back exercises: evidence for improving exercise regimens. Phys Ther 1998 Jul;78(7):754-65.

Squats: Quadriceps and Gluteals

1. Partial squat, with feet shoulder width apart, actively preposition (see 1A) in partial anterior pelvic tilt (no more than 90 degree of knee flexion). Other options include a wall slide (see 1B) or facing a wall with fingertips touching the wall. (see 1C)
2. Single leg squats.
3. Single leg squat reaching back wards (see 3A) or sideways (see 3B) with non weight-bearing leg. (advanced)
4. Progress to rocker board.*

*Another strategy is to have the patient perform some or all of the ball options before progressing to the rocker board.



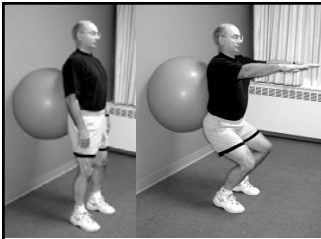
Make sure patients. . .

- Feet shoulder width apart, feet parallel.
- Good balance on short foot or “3 point” foot.
- Don’t squat too deep
(thighs should NOT be parallel to floor).
- Maintain position of pelvis.
- Maintain abdominal bracing/hollowing.
- Breathe properly.
- Keep heels on floor.
- Don’t rotate pelvis.
- Don’t let knees buckle in.
- Don’t let ankle roll.
- Don’t let knees push past the tips of toes.
- Keep weight evenly balanced on both feet.
- Avoid chin poking.
- Do the exercise *slowly*.

Prescription

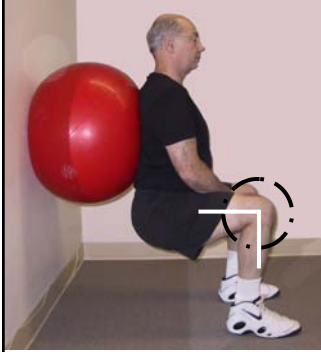
_____ repetitions (8-30)
 _____ sets (1-3)
 _____ seconds held (1-10)
 _____ times per day/week
 (1-3/dy; 3-7/wk)

STOP if patient shakes, loses form or back pain is aggravated (a muscle burn is okay).



1A

1B



1C

Squats with Ball

1. Wall sit/slide with lower back reclined against wall and slight anterior pelvic tilt. (Target: 1 minute, slow reps.) (see 1A, 1B) Do not squat to 90° of knee flexion (see 1C).
2. Perform with a weight in hands: as legs extend, gradually raise the weight overhead. When the arms reach horizontal, transition from an anterior to a posterior pelvic tilt. Target: 3 min., slow reps.
3. Perform a squat with one foot on floor (single-leg squats with the ball may not be as deep). Target: 3 min.

Make sure patients. . .

- Feet shoulder width apart, feet forward.
- Good balance on short foot or "3 point" foot.
- Don't squat too deep (thighs should NOT be parallel to floor).
- Maintain position of pelvis (hip hinge).
- Maintain abdominal bracing.
- Breathe properly.
- Keep heels on the floor.
- Don't let knees push past the tips of toes.
- Keep weight evenly balanced on both feet.
- Avoid chin poking.
- Do the exercise *slowly*.

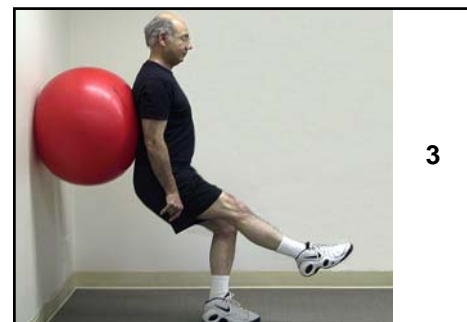
Prescription

_____ repetitions (8-30)
 _____ sets (1-3)
 _____ seconds held (1-10)
 _____ times per day/week
 (1-3/dy; 3-7/wk)

STOP if patient shakes, loses form or back pain is aggravated (a muscle burn is okay).



2



3



Practitioner Tips

Squats

Indications

- Target muscles: Double leg squat works primarily the quadriceps and gluteus maximus. G. maximus becomes active only in the deep phase of the squat. Single leg squats work g. maximus earlier in the exercise, works the gluteus medius, and trains balance.
- Part of the weight-bearing component of the basic rehab program.
- Good for building strength and endurance.
- Useful for patients whose work demands include bending, lifting or stooping, or for patients who failed the Sit/slide Test (see [Osteoporosis Care Pathway](#)) or squat test. (See CSPE [Low Back and Leg Endurance](#) protocol.)

Applications

Squats should be started as wall slide, ball slide, or facing a wall. Challenge balance as patient holds stick behind low back while on a firm surface or on a rocker board.

Operational end point/outcome measure: Consider squat test. (See CSPE [Low Back and Leg Endurance](#) protocol.)

Note: The wall slide on a ball can often magnify asymmetry or balance problems.

Check for

- abdominal bracing/hollowing (palpate)
- asymmetries
- poor balance
- weight shifted to one leg

Troubleshooting

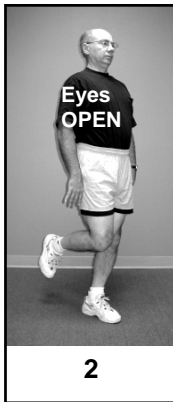
- If a patient cannot do a squat with knees bent to 90 degrees, it may be necessary to begin with a partial squat.
- If a patient has trouble holding neutral pelvis, have them push their buttock out (creating more of a lordosis).
- Difficulty can be encountered if adductors are shortened. If heels lift up, soleus may need to be stretched.
- Temporarily placing a small wedge under the medial forefoot may provide enough tactile feedback to correct a balance or supination fault during the exercise.
- When a patient favors one leg, single-leg wall slides focusing on the underutilized leg may help.

Standing Track

Stable Surface

1. Double leg stand (young and old should be able to stand for 30 seconds with eyes open or closed)
2. Single leg stand, eyes open (target: average of 29-30 seconds for subjects 20-59 years old; 22 seconds for those 60-69; 14 or those 70-79)
3. Single-leg stand, eyes closed (target for young people is about 30 sec; average of 21-28 seconds for subjects 20-59 years old; 10 seconds for those 60-69; 4 for those 70-79)
4. Forward lean
5. Half step forward
6. Half step back
7. Bilateral asymmetrical trunk diagonals.

Note: Progress to lunges. (See Lunge Track.)



Make sure patients...

- Maintain neutral pelvis. _____ repetitions (3-10)
- Maintain abdominal bracing/hollowing. _____ sets (1-3)
- Maintain small foot (if used) or "3 point" foot. _____ minutes (2-3)
- Maintain knees slightly bent with knee turned toward little toe. _____ times per day/week (1-5 dy/5-7 wk)
- Avoid chin poking.
- Sternum lifted up and out.
- Breathe properly.

Prescription

STOP if patient shakes, loses form or back pain is aggravated (a muscle burn is okay).

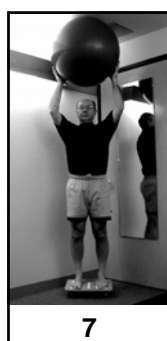
Standing Track

Unstable Surface

Exercises can be done on any labile surface (pads, rocker board, wobble board, cylinders). Do exercises barefoot, with the balance board on carpet, perhaps facing a corner if the patient feels unsure. A piece of foam rubber can be placed under the rocker board to slow it down if necessary.

Warm up: Slowly rock the board back and forth in a controlled manner

1. Double leg stance (DLS) eyes open/closed (board turned at different angles, see 1A -1C).
2. Lean forward.
3. Single leg stance (SLS), eyes open/closed (board turned at different angles, see 3A - 3B).
4. DLS with challenge, eyes open/closed.
5. SLS with challenge, eyes open/closed.
6. DLS raise arms above head (to raise the center of gravity) or elevate in various work positions, with and without resistance.
7. Balancing, tossing/passing ball from hand to hand or with the doctor.
8. Step from rocker board to rocker board (advanced).
9. Lunge onto board (advanced).



Make sure patients...

- Distribute weight evenly over both feet.
- Maintain neutral pelvis.
- Maintain abdominal bracing/hollowing.
- Maintain small foot (if used) or "3 point" foot.
- Maintain knees slightly bent with thigh externally rotated.
- Avoid chin poking.
- Sternum lifted up and out.
- Breathe properly.

Prescription

- _____ repetitions (3-10)
- _____ sets (1-3)
- _____ minutes (2-3)
- _____ times per day/week
(1-5 dy/5-7 wk)

STOP if patient shakes, loses form or back pain is aggravated (a muscle burn is okay).



Practitioner Tips

Standing Track

Indications

- Part of the Basic Program.
- Patients who have work demands requiring a lot of standing and/or walking.
- Patients with poor balance.

Application

- In cases of sciatica, the rocker board activities should be delayed until the leg pain subsides. In chronic cases, this track should be done very carefully.
- In patients with poor balance it can be performed in the corner of a room so that the walls can help prevent falling.
- These activities are sometimes referred to as sensory motor exercises. As an option, they can be performed with the “short foot”[‡] or “three point” foot.
- Like the sitting ball exercises, the rocker board steps of this track are very useful to introduce as *soon as possible* in most cases. It rapidly adds a component of automatic reflex training.
- Treatment may include stimulating the skin receptors with a soft brush for 30 seconds, adjusting joint restrictions throughout the foot and knee up to the proximal fibula, and stimulating the foot by having the patient walk in place on an uneven surface such as a small bag of pebbles. (The pebble bag may be used by the patient as a tactile stimulus throughout the program.)
- When mounting the device, the patient should practice distributing his/her weight equally.
- The patient can adopt a modified Brüegger posture.
- The patient should progress to more difficult balance demands. Introduce a sequence of unstable environments (e.g., lengthwise rocker board, then widthwise, then diagonal, then wobble board; double leg, then single leg stance). Increase the challenge (first *slow* pushes from multiple directions allowing the nervous system to program the demand, then rapid pushes, eyes open then closed).
- Introduce more complex demands (balancing while performing upper extremity activities, eventually mimicking daily living activities which tend to bother the patient).
- Rocker shoes, Styrofoam cylinders, or a small trampoline may also be very effective.
- Exercise parameters vary, but should be of high frequency and short duration. One formula is 5-20 reps, 5-10 seconds on the board, 3-6 times a day. Stop when tired or shaking.

Check for

- small foot (if being used) or weight evenly balanced over heel and the first and fifth metatarsal-phalangeal joints
- feet shoulder distance apart
- thighs slightly externally rotated and knee slightly flexed
- neutral pelvis with abdominal bracing/hollowing (palpate)
- sternal lift or slight scapular contraction
- chin in neutral or slightly retracted
- during step forward or step back maneuvers, check for pelvic rotation

[‡] The short foot is a particular drawn up position of the foot that the patient maintains which emphasizes a deep arch with minimal inversion or toe curling. It may serve to amplify the training effect of upright and balance exercises, but an inordinate amount of time should not be spent teaching patients who cannot master it (unless, perhaps, the patient also has a pronation problem.) If a patient must wear special orthotics, some initial work with the small foot may be beneficial in arousing afferents, but otherwise the standing track should be performed with the orthotic.