A modern approach to abdominal training

Craig Liebenson*

L.A. Sports and Spine, 10474 Santa Monica Building, #202 Los Angeles, CA 90025, USA

Received 20 April 2007; accepted 23 April 2007

Introduction

Active care is a benchmark in the management of low back conditions. Unfortunately, voluntary exercise often perpetuates faulty movement patterns or abnormal motor control (AMC). This series of articles will describe how to train the abdominals and ensure that patients are performing their exercises without AMC.

The sit-up is a classic example of an exercise myth. The sit-up places high compressive load on the disc (McGill, 2006, 2007). It usually involves a posterior pelvic tilt which unnecessarily exacerbates disc load (Hickey and Hukins, 1980). Also, it is frequently performed early in the morning which is a time of high risk for annular injury (Adams and Hutton, 1985). Better and safer abdominal exercises exist which will be described in this series of papers.

Are specific patterns of muscle co-activation necessary?

Whether the goal is preventive, injury recovery, rehabilitation, or performance enhancement good “core” fitness is a must. Muscles stabilize joints by stiffening like rigging on a ship (Fig. 1). According to Cholewicki and McGill (1996) spine stability is greatly enhanced by co-contraction (or co-activation) of antagonistic trunk muscles. Co-contractions increase spinal compressive load, as much as 12–18% or 440 N, but they increase spinal stability even more by 36–64% or 2925 N (Granata and Marras, 2000). They have been shown to occur during most daily activities (Marras and Mirka, 1990). This mechanism is present to such an extent that without co-contractions the spinal column is unstable even in upright postures! (Gardner-Morse and Stokes, 1998).

Co-contractions are most obvious during reactions to unexpected or sudden loading (Lavender et al., 1989). Involuntary coordination of “core” muscles has been found to be correlated to back pain. Researchers at Yale University have shown that a specific motor control signature of delayed agonist-antagonistic muscle activation predicts which asymptomatic people will later develop low back pain (Cholewicki et al., 2005). In particular, what was found was longer muscle response latencies to perturbation in the “at risk” group than those in healthy control subjects.

Marras et al. (2005) have reported that there is a different pattern of antagonist muscle co-activation (kinematic ability) in LBP individuals than in asymptomatics. Patients were found to have greater spine load and greater kinematic compromise during lifting tasks. Altered kinematics were strongly related to spine load, being able to predict 87% of the variability in compression, 61% in...
anteroposterior shear, and 65% in lateral shear. The kinematic picture for the LBP individual showed excessive levels of antagonistic muscle co-activation which reduced trunk motion, but also increased spine loading. Ironically, when the spine is under load it is best stabilized, but when “surprised” by trivial load at a vulnerable time such as in the morning or after prolonged sitting the spine stability system is most dysfunctional (Adams and Dolan, 1995). Inappropriate muscle activation patterns during seemingly trivial tasks (only 60 N of force) such as bending over to pick up a pencil can compromise spine stability and potentiate buckling of the passive ligamentous restraints (Andersson and Winters, 1990). This motor control skill has also been shown to be more compromised under challenging aerobic circumstances (McGill et al., 1995).

Australian researchers have demonstrated that a delayed activation of the transverse abdominus muscle during arm or leg movements has been found to distinguish LBP patients from asymptomatic individuals (Hodges and Richardson, 1998, 1999). However, according to Canadian scientists focusing on a single muscle is like focusing on a single guy wire (Kavcic et al., 2004). Research from the University of Waterloo in Canada has found that while certain muscles such as multifidus and transverse abdominus may have special relevance in distinguishing LBP subjects from asymptomatic individuals that these muscles are part of a much bigger orchestra responsible for spinal stability (Kavcic et al., 2004). They demonstrated that different muscles played greater or lesser roles depending on the activity/exercise.

Sufficient stability, according to McGill, is defined as the amount of muscle stiffness necessary for stability along with a safety margin (McGill, 2006, 2007). Cholewicki et al. (1997) showed that modest levels of co-activation are necessary, but if a joint has lost its stiffness greater amounts of co-activation are needed.

How effective is abdominal training?

Specific spinal stabilization exercises have been shown to reduce future recurrences following an acute LBP episode (Hides et al., 2001). Specific spine stabilization exercises achieved superior outcomes to isotonic exercises in chronic patients with spondylolythesis (O’Sullivan et al., 1997). One study that compared McGill’s “general” stabilization exercise approach to the Australian “deep” local stabilization training demonstrated that the “general” approach was superior (Koumantakis et al., 2005).

Stuge et al. (2004) found that stabilizing exercises were superior to traditional physical therapy for pelvic girdle pain after pregnancy. The stabilization group had lower pain intensity, disability, higher quality of life, and less impairments. The results persisted at 1-year check post-partum.

Yilmaz et al. (2003) administered an 8-week stabilization program to post-operative lumbar microdiscectomy patients. It was compared to home exercise and to no exercise. At the 12th week superior results were achieved in pain, function, mobility, and lifting ability for the stabilization group. Supervised stabilization training was superior to home exercises which was superior to no exercise.

Assessment of motor control during abdominal training

There are a few fundamental components necessary to optimize motor control during abdominal stabilization training. They are the abdominal brace (AB), neutral spine posture, normal respiration, and the sternal crunch. Avoiding AMC during abdominal stabilization training is crucial to maintaining “sufficient stability”.

The abdominal brace

In assessing AMC the first criteria is achieving stiffness via pre-contraction or performing an AB.
Co-contractions have been shown to occur automatically in response to unexpected or sudden loading (Lavender et al., 1989; Marras et al., 1987). Stokes et al. (2000) has described how there are basically two mechanisms by which this co-activation occurs. One is a voluntary pre-contraction to stiffen and thus dampen the spinal column when faced with unexpected perturbations. The second is an involuntary, reflex contraction of the muscles quick enough to prevent excessive motion that would lead to buckling following either expected or unexpected perturbations (Cresswell et al., 1994; Lavender et al., 1989; Marras et al., 1987; Stokes et al., 2000; Wilder et al., 1996).

This can be achieved by having a patient perform a dead bug or bird dog and then “brace”. While the patient performs an AB the clinician offers slow and then quick perturbations in different planes while asking the patient to maintain their posture. The patient can pretend they are about to be pushed or hit and they will “automatically’ brace (see Fig. 2).

Neutral spine posture

The second criteria for spine stability is maintenance of a “neutral spine” or normal lumbar lordosis. Many patients perform posterior pelvic tilts which actually places the lumbo-sacral spine in flexion and thus can potentially harm the disc via end-range loading in flexion. The “neutral zone is the inner region of a joint’s range of motion (ROM) where minimal resistance to motion is encountered (Panjabi, 1992).

Disc herniation has been shown to be related to repeated flexion motion, especially (Callaghan and McGill, 2001) if coupled with lateral bending and twisting (Adams and Hutton, 1985). This was supported by the work of Hickey and Hukins (1980) who demonstrated the protective function of lumbar lordosis on the disc. According to McGill (2006) “Because ligaments are not recruited when lordosis is preserved, nor is the disc bent, it appears that the annulus is at low risk for failure.”

Normal respiration

When performing the AB with neutral spine posture (e.g. slight lumbar lordosis) it is important that the normal respiration is maintained. The tendency when performing an AB and resisting perturbations is to hold the breath or chest breathe. Simple cueing to continue breathing normally is usually all that is required. The best cue is to say “breathe and brace”.

Practice-based problem

Wont abdominal bracing encourage chest breathing?

Yes, it can. However, the patient is encouraged to breathe horizontally in 360° around the abdomen and rib cage rather than vertically by lifting the chest to breathe in. A valuable cue is to open the ribs laterally like an accordion.

McGill et al. (1995) recommends that patients AB during both phases of respiration rather than only during exhalation. Typical gym training advice to exhale with exertion does not make sense in sports or work demands since stability must be ensured as endurance challenges are faced.

Sternal crunch

A novel approach to achieving stronger co-activation of all abdominal wall muscles is to observe the position of the anterior chest wall (Kolar, 2007). A cephalad position which can be thought of as an “inhalation” position is inhibitory of the normal diaphragmatic function. It is noted that the thoraco-lumbar (T/L) junction is hyperlordotic and the diaphragm is oblique in this position (see Fig. 3). Ideally, a caudal anterior chest position is
facilitated which is the "exhalation" position. In this case, the T/L junction is more neutral and the diaphragm is "centrated" in a horizontal position (see Fig. 4). The "exhalation" position is believed to be facilitory of the abdominal wall since active exhalation is produced by the abdominal muscles.

Practice-based problem

Won't the sternal crunch remove the lumbar lordosis?

Yes it can. However, it should not since the key is to mobilize the rib cage inferiorly and posteriorly WITHOUT altering the lumbo-sacral posture (e.g. lordosis). If the patient combines the sternal crunch with a posterior pelvic tilt this should be discouraged (see Fig. 5).

The overhead arm reach on a foam roll is an excellent training exercise for the abdominal wall. The patient should be able to maintain a sternal crunch while moving the arms overhead (see Fig. 6). This should be performed without T/L hyperlordosis and without a posterior pelvic tilt. The clinician would initially cue the patient for spinal stiffness, and thus an AB, by offering light perturbations of the torso in a transverse plane twisting direction. Last but not least, the patient should be reminded to maintain normal respiration throughout the duration of the exercise.

Conclusion

In a nutshell, abdominal exercises are commonly prescribed to prevent and treat lower back pain as well as to build overall fitness. Certain myths should be dispelled about this subject regarding sit-ups, morning exercise, the posterior pelvic tilt, the transverse abdominis, exhaling with exertion, etc. The role of maintaining a "neutral spine" and performing an AB should be understood. The next
two articles in this series will review more detail about the basics of assessment and training of the abdominal wall.

References


