Integrated Core Training
Introduction

To stay on the cutting edge of research, science, and practical application, the health and fitness professional needs to follow a comprehensive, systematic, and integrated approach when training, reconditioning, or rehabilitating a client. In order to develop a comprehensive integrated training program, the health and fitness professional must fully understand the functional kinetic chain. An integrated training program is a comprehensive approach that strives to improve all the components necessary to achieve optimum performance (strength, balance, flexibility, endurance, and power). Since the core is where the human body’s center of gravity is located and where all movement begins, this chapter focuses on the fundamental concepts of core stabilization, and how the health and fitness professional can design an effective and dynamic core stabilization program.

Section I: Core Stabilization Concepts
Section II: Functional Anatomy of the Core
Section III: Scientific Rationale for Core Stabilization Training
Section IV: Guidelines for Core Stabilization Training
Section V: Core Stabilization Training Program Design
Section VI: Summary
References

Traditionally, training has focused on isolated, absolute strength gains in isolated muscles, utilizing single planes of motion. However, all functional activities are multi-planar and require acceleration, deceleration, and dynamic stabilization. Movement may appear to be single-plane dominant, but the other planes need to be dynamically stabilized to allow for optimum neuromuscular efficiency. Understanding that functional movements require a highly complex, integrated system enables the health and fitness professional to make a paradigm shift. The paradigm shift focuses on training the entire kinetic chain utilizing all planes of movement, while establishing high levels of functional strength and neuromuscular efficiency. The paradigm shift also dictates that the health and fitness professional train force reduction, force production, and dynamic stabilization during all kinetic chain activities.
A core stabilization training program (Figure 1) improves dynamic postural control, ensures appropriate muscular balance and joint arthrokinematics around the lumbo-pelvic-hip complex (LPHC), and allows for the expression of dynamic functional strength and improved neuromuscular efficiency throughout the entire kinetic chain.9,10,13,14,15,17,18,19,20,21,22,23,24,25

**Figure 1: Benefits of Core Training**

1. Improve dynamic postural control  
2. Ensure appropriate muscular balance and joint arthrokinematics  
3. Allow for the expression of functional strength  
4. Provide intrinsic stability to the LPHC, which allows for optimum neuromuscular efficiency of the rest of the kinetic chain
Section I: Core Stabilization Concepts

The core is defined as the LPHC. There are twenty-nine muscles that attach to the LPHC. An efficient core allows for the maintenance of optimum length-tension relationships of functional agonists and antagonists, which makes it possible for the body to maintain optimum force-couple relationships in the LPHC. Maintaining optimum length-tension relationships and force-couple relationships allows for the maintenance of optimum joint arthrokinematics in the LPHC during functional kinetic chain movements. This provides optimum neuromuscular efficiency in the entire kinetic chain, and allows for optimum acceleration, deceleration, and dynamic stabilization during integrated, dynamic movements.

The core operates as an integrated functional unit, enabling the entire kinetic chain to work synergistically to produce force, reduce force, and dynamically stabilize against abnormal force. In an efficient state, each structural component distributes weight, absorbs force, and transfers ground reaction forces. This integrated, interdependent system needs to be appropriately trained to enable it to function efficiently during dynamic activities.

Many individuals have developed functional strength, power, neuromuscular control, and muscular endurance in specific muscles that enable them to perform functional activities. However, few people develop the muscles required for spinal stabilization. The body’s stabilization system has to function optimally to effectively utilize the strength, power, neuromuscular control, and muscular endurance that it has developed in its prime movers. If the extremity muscles are strong and the core is weak, there will not be enough force created to produce efficient movements. A weak core is a fundamental problem inherent to inefficient movement that leads to predictable patterns of injury.

The core musculature is an integral component of the protective mechanism that relieves the spine of deleterious forces that are inherent during functional activities. A properly designed core stabilization training program helps an individual gain strength, neuromuscular control, power, and muscle endurance of the LPHC. This integrated approach facilitates balanced muscular functioning of the entire kinetic chain. Greater neuromuscular control and stabilization strength provides a more biomechanically efficient position for the entire kinetic chain, and thereby allows optimum neuromuscular efficiency throughout the kinetic chain.
Neuromuscular efficiency is established by the appropriate combination of postural alignment (static/dynamic) and stability strength, which enables the body to decelerate gravity, ground reaction forces, and momentum.\textsuperscript{10,15,19} If the neuromuscular system is not efficient, it will be unable to respond to the demands placed on it during functional activities.\textsuperscript{13} As the efficiency of the neuromuscular system decreases, the ability of the kinetic chain to maintain appropriate forces and dynamic stabilization decreases significantly. This decreased neuromuscular efficiency leads to compensation and substitution patterns (synergistic dominance, altered reciprocal inhibition, arthrokinetic inhibition), as well as poor posture during functional activities.\textsuperscript{18,20,25} This increases mechanical stress on the contractile and non-contractile tissue and leads to repetitive microtrauma, abnormal biomechanics, and injury.\textsuperscript{14,16,20,33}
Section II: Functional Anatomy of the Core

The traditional perception of muscles is that they work concentrically and predominantly in one plane of motion. However, in order to more effectively understand motion and design efficient training, reconditioning, and rehabilitation programs, it is imperative to view muscles functioning in all planes of motion and in the full contraction spectrum (eccentrically, stabilization, and concentrically). The following section will describe the isolated and integrated functions of the major muscles of the kinetic chain.\textsuperscript{27,28}

Lower Extremity Functional Anatomy

The lower extremity musculature functions synergistically to stabilize the entire kinetic chain during functional movement patterns. The lower extremity also works synergistically to eccentrically decelerate and concentrically accelerate the entire kinetic chain during functional movement patterns.\textsuperscript{27,34}
Hamstrings

The traditional view of the hamstring is that it assists with hip extension and knee flexion. The integrated view is that it eccentrically decelerates knee extension, hip flexion, and internal rotation at heel strike, eccentrically decelerates iliosacral anterior rotation during functional movements, and dynamically stabilizes the LPHC during functional movement patterns.

Figure 2: Hamstrings
**Hip Abductors**

These include the gluteus medius, gluteus minimus, and tensor fascia latae. The traditional view is that the hip abductors abduct the femur. The integrated view is that the gluteus medius decelerates hip adduction and hip internal rotation, and the gluteus minimus and tensor fascia latae decelerate hip adduction. The tensor fascia latae also assists in decelerating hip extension and hip external rotation. The entire abductor complex works synergistically as the primary frontal-plane stabilizing mechanism (lateral sub-system).

**Figure 3: Hip Abductor Complex**
Gluteus Maximus

The traditional view is that the gluteus maximus produces hip extension and external rotation. The integrated view is that it eccentrically decelerates hip flexion, hip adduction, and hip internal rotation during stance phase, decelerates tibial internal rotation via the iliotibial band (ITB), assists in stabilizing the sacroiliac joint (SIJ) via the sacrotuberous ligament and the lateral knee via the ITB.

Figure 4: Gluteus Maximus
**Iliopsoas**

This consists of the iliacus, psoas major, and psoas minor. The traditional view is that the Iliopsoas produces hip flexion. The integrated view is that it eccentrically decelerates femoral internal rotation at heel strike, eccentrically decelerates hip extension, and assists in stabilizing the lumbar spine during functional movements.

**Figure 5: Iliopsoas**
Core Functional Anatomy

The core musculature functions synergistically to stabilize, eccentrically decelerate, and concentrically accelerate the entire kinetic chain during functional movement patterns.

Erector Spinae

This muscle includes the iliocostalis, longissimus, and spinalis. The traditional view is that the erector spinae extends the trunk. The integrated view is that it eccentrically decelerates flexion, rotation, and lateral flexion of the lumbar spine, and dynamically stabilizes the lumbar spine during functional movements.
Abdominal Complex

This includes the rectus abdominus, external oblique, internal oblique, and transverse abdominus (TVA). The traditional view of the abdominal complex is that it flexes and rotates the trunk. The integrated view is that the rectus abdominus eccentrically decelerates extension and rotation, dynamically stabilizes the LPHC, and concentrically flexes the spine. The external oblique eccentrically decelerates extension and rotation, dynamically stabilizes the LPHC, and concentrically posteriorly rotates the pelvis, flexes the pelvis and produces contralateral rotation. The internal oblique eccentrically decelerates extension and rotation, dynamically stabilizes the LPHC, and concentrically produces flexion and ipsilateral rotation. And finally, the TVA works primarily to dynamically stabilize the LPHC during functional movement patterns.

Figure 7: Abdominal Complex
Upper Extremity Functional Anatomy

The upper extremity musculature functions synergistically to stabilize, eccentrically decelerate and concentrically accelerate the entire kinetic chain during functional movement patterns.

*Latissimus Dorsi*

The traditional view of the latissimus dorsi is that it adducts, extends, and internally rotates the humerus. The integrated view is that it eccentrically decelerates flexion, abduction, and external rotation of the upper extremity, assists in dynamic stabilization of the LPHC through the thoracolumbar fascia (TLF) mechanism, and functions as a bridge between the upper and lower extremity.

*Figure 8: Latissimus Dorsi*
Current Concepts in Functional Anatomy

It has been proposed that there are two distinct yet interdependent muscular systems that enable our bodies to maintain proper stabilization and ensure efficient distribution of forces for the production of movement. Crisco and Panjabi\(^2\) have suggested that muscles located more centrally to the spine provide intersegmental stability (support from vertebrae to vertebrae) while the more lateral muscles support the spine as a whole. Bergmark\(^3\) has categorized these different systems with relation to the trunk into local and global muscular systems.
**Joint Support System**

**The Inner Unit (Local Muscular System):** The local musculature or inner unit consists of muscles that are predominantly involved in joint support or stabilization.\(^{35,36}\) Thus we have chosen to refer to the local muscles as joint support systems. It is important to note, however, that joint support systems are not confined to the spine and are evident in the peripheral joints as well.

Joint support systems consist of muscles that are not movement specific, but provide stability to allow movement of a joint. They usually are located in proximity to the joint. They also have a broad spectrum of attachments to the joint's passive elements that make them ideal for increasing joint stiffness and thus stability.\(^{36}\) A common example of a peripheral joint support system is the rotator cuff for the glenohumeral joint that provides dynamic stabilization for the humeral head in relation to the glenoid fossa during movement.\(^{37,38}\) Other joint support systems include the posterior fibers of the gluteus medius and the external rotators of the hip that perform pelvo-femoral stabilization,\(^{39}\) and the vastus medialis obliquus that provides patellar stabilization at the knee.\(^{40}\) The joint support system of the core (LPHC) consists of muscles that either originate or insert (or both) into the lumbar spine.\(^{4}\) The major muscles include the TVA, lumbar multifidus, internal oblique, diaphragm and the muscles of the pelvic floor.\(^{35,36,41}\) This joint support system has also been referred to as the inner unit.\(^{41}\)

![Figure 9: Inner Unit](image-url)
The **Outer Unit (Global Muscular Systems)**: The global muscles (outer unit) are predominantly responsible for movement and consist of more superficial musculature that attaches from the pelvis to the rib cage and/or the lower extremities. The major muscles include the rectus abdominis, external obliques, erector spinae, hamstrings, gluteus maximus, latissimus dorsi, adductors, hamstrings, and quadriceps. The outer unit muscles are predominantly larger and are associated with movement of the trunk and limbs and equalize external loads placed upon the body. They also are important because they transfer and absorb forces from the upper and lower extremities to the pelvis. The outer unit musculature has been broken down and described as force couples working in four sub-systems. These sub-systems include the deep longitudinal, posterior oblique, anterior oblique, and lateral sub-systems. This distinction allows for an easier description and review of functional anatomy. It’s crucial for health and fitness professionals to think of these sub-systems operating as an integrated functional unit. Remember, the central nervous system is designed to optimize the selection of muscle synergies, not isolated muscles.

![Figure 10: Outer Unit](image-url)
**The Deep Longitudinal Sub-System (DLS):** The major contributors to the DLS are the erector spinae, TLF, sacrotuberous ligament, and biceps femoris. Some experts suggest that the DLS provides one means of a reciprocal force transmission longitudinally from the trunk to the ground. As illustrated in Figure 11, the long head of the biceps femoris attaches to the sacrotuberous ligament at the ischium. The sacrotuberous ligament in turn attaches from the ischium to the sacrum. The erector spinae attaches from the sacrum and ilium up to the ribs and cervical spine. Activation of the biceps femoris increases tension in the sacrotuberous ligament, which transmits force across the sacrum stabilizing the SIJ, and allows force transference up through the erector spinae to the upper body.

![Figure 11: Deep Longitudinal Sub-System](image)

This transference of force is apparent during the normal gait. Prior to heel strike, the biceps femoris activates to eccentrically decelerate hip flexion and knee extension. Just after heel strike, the biceps femoris is further loaded through the lower leg via inferior movement of the fibula. This tension from the lower leg, up through the biceps femoris, into the sacrotuberous ligament and up the erector spinae creates a force that assists in stabilizing the SIJ.

Another force couple not mentioned in the DLS consists of the superficial erector spinae, the psoas and the inner unit. While the erector spinae and psoas create lumbar extension and an anterior shear force at L4–S1, the inner unit provides inter-segmental stabilization and a posterior shear force (neutralizer).
Integrated Core Training

during functional movement.\textsuperscript{28,36,41} Dysfunction in any of these structures can lead to SIJ instability and low back pain (LBP),\textsuperscript{45} demonstrating the importance of training these structures as a functional unit.

\textbf{The Posterior Oblique Sub-System (POS):} The POS works synergistically with the DLS. As illustrated in Figure 1, the gluteus maximus and latissimus dorsi attach to the TLF, which connects to the sacrum. The fiber arrangements of these muscles run perpendicular to the SIJ. Thus, when the contralateral gluteus maximus and latissimus dorsi contract, they create a stabilizing force for the SIJ.\textsuperscript{45} Just prior to heel strike, the latissimus dorsi and the contralateral gluteus maximus are eccentrically loaded. At heel strike, each muscle accelerates (concentric action) its respective limb and creates tension in the TLF. This tension assists in the stability of the SIJ. In addition, the POS transfers forces that are summated from the transverse plane orientation of these muscles to propulsion in the sagittal plane when we walk or run. The POS is also of prime importance for other rotational activities such as swinging a golf club, swinging a baseball bat, and/or throwing a ball.\textsuperscript{42,44,45} Dysfunction of any structure in the POS can lead to SIJ instability and LBP. The weakening of the gluteus maximus and/or latissimus dorsi may also lead to increased tension in the hamstring and therefore cause reoccurring hamstring strains.\textsuperscript{41,45,53}

\textbf{Figure 12: Posterior Oblique Sub-System Image}

\textbf{The Anterior Oblique Sub-System (AOS):} The AOS also functions in a transverse plane orientation very similarly to the POS only from the anterior portion (front) of the body. Its prime contributors are the oblique muscles (internal and external) adductor complex, and hip external rotators. Viewing electromyography (EMG) data on the obliques, adductors, and hip external rotators, it is apparent that they
function to aid in the stability and rotation of the pelvis, as well as contributing to leg swing.\textsuperscript{27,50} The AOS is also implicated in the stabilization of the SIJ.\textsuperscript{54} As illustrated in Figure 13, when we walk, our pelvis must rotate in the transverse plane in order to create a swinging motion for the legs.\textsuperscript{42} This rotation comes in part from the POS posteriorly and the AOS anteriorly. One only needs to look at the fiber arrangements of the muscles involved (latissimus dorsi, gluteus maximus, internal and external obliques, adductors, and hip rotators) to realize this point. The AOS is also necessary for functional activities involving the trunk, upper and lower extremities. The obliques, in concert with the adductor complex, not only produce rotational and flexion movements, but also are instrumental in stabilizing the LPHC.\textsuperscript{44,54}

**Figure 13: Anterior Oblique Sub-System Image**

*The Lateral Sub-System (LS):* The LS is comprised of the gluteus medius, tensor fascia latae, adductor complex, and quadratus lumborum. The LS has been implicated in frontal plane stability.\textsuperscript{28,53} This system is responsible for pelvo-femoral stability. Figure 14 illustrates how, during single-leg functional movements such as in gait, lunges, or stair climbing, the ipsilateral gluteus medius, tensor fascia latae, and adductors combine with the contralateral quadratus lumborum to control the pelvis and femur in the frontal plane.\textsuperscript{28,53} Dysfunction in the LS is evident by increased pronation (flexion, internal rotation and adduction) of the knee, hip and/or feet during walking, squats, lunges or climbing stairs. Accessory frontal plane movement during gait is characterized by decreased strength and neuromuscular control in the LS.\textsuperscript{55,56} Keep in mind that for reasons of explanation, these four sub-systems have been oversimplified and that the human body simultaneously utilizes all four of these sub-systems during activity. Each sub-system individually and interdependently contributes to the production of efficient movement by accelerating, decelerating, and dynamically stabilizing the kinetic chain during motion.
All of these muscles play an integral role in the kinetic chain because they provide dynamic stabilization and optimum neuromuscular control of the entire LPHC. When isolated, these muscles do not effectively achieve stabilization of the LPHC. It is the synergistic, interdependent functioning of the entire LPHC that enhances the stability and neuromuscular control throughout the entire kinetic chain.

**Stabilization Mechanisms**

The LPHC is stabilized during integrated multi-planar movement by two primary systems, the thoracolumbar stabilization mechanism and the intra-abdominal pressure stabilization mechanism (IAP) (Figure 15).¹ ² ³ ⁴ ¹⁰ ³¹ ³² ³⁷ ⁵⁸ ⁵⁹ ⁶⁰ ⁶¹

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**Figure 14: Lateral Sub-System**

**Figure 15: Stabilization Mechanisms**

- Thoracolumbar Stabilization
- Intra-abdominal Pressure
Thoracolumbar Stabilization Mechanism

The TLF is a fascial network of non-contractile tissue that plays an essential role in the functional stability of the lumbar spine. The TLF is divided into three layers, the posterior, anterior, and middle. Although the TLF is non-contractile, it can be engaged dynamically because of the contractile tissue that attaches to it. The muscles that attach to the TLF include deep erector spinae, multifidus, TA, internal oblique, gluteus maximus, latissimus dorsi, and quadratus lumborum. The TA and the internal oblique are particularly important for stabilization. They attach to the middle layer of the TLF via the lateral raphe. Contraction of the TA and the internal oblique creates a traction and tension force on the TLF, which enhances the regional inter-segmental stability in the LPHC. This preferential contraction decreases translational and rotational stress at the lumbosacral junction.30,31,32,60,62,63,64

Figure 16: Thoracolumbar Stabilization Mechanism
**Intra-abdominal Pressure Mechanism**

The second stabilization mechanism is the IAP. Increased IAP decreases compressive forces in the LPHC. As the abdominal muscles contract against the viscera, they push superiorly into the diaphragm and inferiorly into the pelvic floor. This results in elevation of the diaphragm and contraction of pelvic floor musculature. This will assist in providing intrinsic stabilization to the LPHC.

![Figure 17: Intra-abdominal Pressure Mechanism](image)

**Postural Considerations**

The core maintains postural alignment and dynamic postural equilibrium during functional activities. Optimum alignment of each body part is a cornerstone of an integrated training and rehabilitation program. Optimum posture and alignment allow for optimum neuromuscular efficiency because the normal length-tension relationship, force-couple relationship, and arthrokinematics are maintained during functional movement patterns. A comprehensive core stabilization program prevents the development of serial distortion patterns and provides optimum dynamic postural control during functional movements.
Neuromuscular Considerations

A strong and stable core can improve optimum neuromuscular efficiency by improving dynamic postural control.\textsuperscript{18,25,30,32,63,70,71} Several authors have demonstrated kinetic chain imbalances in individuals with altered neuromuscular control.\textsuperscript{14,15,16,17,18,21,22,23,24,30,31,32,33,60,62,63,67,68,72,73,74,75,76} Research has demonstrated that people with LBP have an abnormal neuromotor response of the trunk stabilizers accompanying limb movement.\textsuperscript{31,32,76} Additionally, individuals with LBP had significantly greater postural sway and decreased limits of stability. Research also demonstrates that approximately 75 to 90\% of all individuals suffer from recurrent episodes of back pain. Furthermore, it has been demonstrated that individuals have decreased dynamic postural stability in the proximal stabilizers of the LPHC following lower extremity ligamentous injuries.\textsuperscript{14,72,73,74} It has also been demonstrated that joint and ligamentous injury can lead to decreased muscle activity.\textsuperscript{20,29,77,78} Joint and ligament injury can lead to joint effusion, which in turn leads to muscle inhibition.\textsuperscript{77} This alters neuromuscular control in other segments of the kinetic chain secondary to altered proprioception and kinesthesia.\textsuperscript{72,73} Therefore, when an individual has pain and swelling, all of the muscles that cross that joint can be inhibited.

Research has also demonstrated that muscles can be inhibited from an arthrokinetic reflex.\textsuperscript{14,22,29,78} This is referred to as arthrogenic muscle inhibition. Arthrokinetic reflexes are reflexes that are mediated by joint receptor activity. If an individual has abnormal arthokinematics, the muscles that move the joint will be inhibited. For example, if an individual has a sacral torsion, the multifidus and the gluteus medius can be inhibited.\textsuperscript{79} This leads to abnormal movement in the kinetic chain. The tensor fascia latae become synergistically dominant and become the primary frontal plane stabilizer.\textsuperscript{28} This often leads to tightness in the iliotibial band, which decreases frontal and transverse plane control at the knee. Furthermore, if the multifidus is inhibited,\textsuperscript{79} the erector spinae and the psoas become facilitated. This will further inhibit the inner unit stabilization mechanism (internal oblique and TVA) and the gluteus maximus,\textsuperscript{31,32} which also decreases frontal and transverse plane stability at the knee. As previously mentioned, an efficient core improves neuromuscular efficiency of the entire kinetic chain because it dynamically stabilizes the LPHC and therefore improves pelvo-femoral biomechanics. This is yet another reason that training programs should include a comprehensive core stabilization-training program to prevent injury as well as the chain reactions that are initiated secondary to injury in the kinetic chain.
Section III: Scientific Rationale for Core Stabilization Training

Most individuals train their core stabilizers inadequately compared to other muscle groups. Although adequate strength, power, muscle endurance, and neuromuscular control are important for lumbo-pelvic-hip stabilization, it is detrimental to perform exercises incorrectly or that are too advanced. Several authors have found decreased firing of the TVA, internal oblique, multifidus, and deep erector spinae in individuals with chronic LBP. Research has shown decreased stabilization endurance in individuals with chronic LBP. The core stabilizers are primarily type I slow-twitch muscle fibers. These muscles respond best to time under tension. Time under tension is a method of contraction that lasts for 6–20 seconds and emphasizes hyper-contractions at end ranges of motion. This method improves intramuscular coordination, which improves static and dynamic stabilization. To get the appropriate training stimulus, you must prescribe the appropriate speed of movement for all aspects of exercises. Core strength endurance must be trained appropriately to allow an individual to maintain dynamic postural control for prolonged periods of time.

Performing core training with inhibition of these key stabilizers leads to the development of muscle imbalances and inefficient neuromuscular control in the kinetic chain. Research demonstrates that abdominal training without proper pelvic stabilization increases intradiscal pressure and compressive forces in the lumbar spine. In fact, maintaining the cervical spine in a neutral position during core training will improve posture, muscle balance, and stabilization. If, for instance, the head protracts during movement, the sternocleidomastoid is preferentially recruited. This increases the compressive forces at the C0–C1 vertebral junction. This can also lead to pelvic instability and muscle imbalances secondary to the pelvo-ocular reflex. This reflex is important to maintain the eyes level. If the sternocleidomastoid muscle is hyperactive and extends the upper cervical spine, then the pelvis will rotate anteriorly to realign the eyes. This can lead to muscle imbalances and decreased pelvic stabilization.

Additional research demonstrates that hyperextension training without proper pelvic stabilization can increase intradiscal pressure to dangerous levels, cause buckling of the ligamentum flavum, and lead to narrowing of the intervertebral foramen. Moreover, the traditional curl-up increases intradiscal pressure and increases compressive forces at L2–L3.

Increasingly, research has uncovered decreased cross sectional area of the multifidi in subjects with LBP. Researchers found that there was not spontaneous recovery of the multifidi following resolution of
symptoms. Hence the need for adequate reconditioning of local, intrinsic core musculature. This need can be addressed through implementing a training regimen that focuses on first creating core stabilization (increasing the endurance capacity of local core muscles) by retraining the local muscles with a drawing-in maneuver. Additional research demonstrates increased EMG activity and increased pelvic stabilization when an abdominal drawing-in maneuver was performed prior to initiating core training. In fact, recent research by Hides et al. has shown that the technique of drawing-in significantly increased in the thickness of the TVA as well as decreased cross-sectional area, theorized to bilaterally contract and form a “corset” which will most likely increase the stability of the lumbar spine. A study by Richardson et al. published in 2002 uncovered decreased joint laxity of the SIJ when a drawing-in maneuver (activating the TVA with co-contraction of the multifidi) was performed. This further supports the notion of increased core stability when the local core musculature is successfully engaged.

The NASM Stance on Core Training Based on the Research

It seems that much of the debate surrounding core training centers on theories of motor learning and muscle capacity, not on whether a core training program can help decrease LBP. In fact, many researchers agree on the integration of some aspect of core training to alleviate LBP in patients. A review of current core concepts and literature addressing the core revealed a shift in thought about the exercise and applications of a lumbar stability program (LSP). A review published in the American Journal of Physical Medicine and Rehabilitation provided some insight into the highly debated and increasingly interesting research of LSPs. Despite every view, the review found a universal acceptance that exercise may be a vital part of treatment of nonspecific LBP. The question most researchers are currently fixated on is what program implementation will work best.

There are various approaches to training the core. The rationale behind core training seems to fall into two main categories: the muscle capacity model, which states that exercises are performed because the demands of trunk control require a restoration of strength and endurance; and the control model, which states that exercises are performed to gain control and coordination of the trunk musculature.

The first rationale of muscle capacity is based on the Euler model of spinal stability. Euler’s model equates the forces acting on a flexible column in order to control buckling forces. This model proposes that the musculature that surrounds the spine acts as guy wires to help support and stabilize the spine (i.e., stability is dependent on muscles acting to limit trunk motion). As Euler’s theory suggests, devoid of musculature to stiffen the spine, compressive forces of as little as 90 Newtons (20.23 lbs) could cause the lumbar spine to buckle. This mode of thought asserts that these muscles keep the spine in a mechanically stable equilibrium (i.e., neutral spine). These muscles are proposed to control and restrict movement and maintain
a stable lumbo-pelvic position (bracing). However, this is a very static analysis of the spine, and theories have not been tested on a dynamic model. This exercise strategy would require a stable or stiff spine, with force and load being applied through movement of the extremities.

In the control model of core stability, theorists claim that “lumbo-pelvic function and health are dependent on the accurate interplay of the trunk musculature.” In other words, the nervous system must be able to determine how much stability the spine needs to meet the internal or external demands and recruit the proper muscles to handle those needs. Feed-forward control dictates that the nervous system can plan muscle-activation strategies in advance to prepare the spine to handle forces and loads resulting from movement of an extremity. If the forces are unexpected, the nervous system must be able to respond accurately and recruit the correct muscles to protect the spine from deleterious forces. Therefore, theorists claim that control of the lumbar spine and pelvis are dependent not only on muscle capacity, but also on the sensory system that communicates spinal stability, which allows the nervous system to respond accurately by choosing and implementing the correct muscle strategy.

Studies have shown that people with LBP have changes in motor control. Research has found in LBP sufferers a delayed activity of the TVA and lumbar multifidi with quick movements of the extremities. Independent of force direction, the local musculature has been shown to be active and activated prior to movement in healthy participants. Hodges noted in his research that the TVA, when properly activated, creates tension in the TLF, contributing to spinal stiffness, and compresses the SIJ, increasing stability. The lumbar multifidus, in conjunction with the TVA, can help control movement and translation of vertebrae by generating an intervertebral compressive force. The global system was found to have little ability to control the movement of the spine, yet it contributes spinal orientation and helps counter forces. Based on these findings, exercise recommendations or program considerations can vary, depending on whether the individual focus is on control or muscle capacity.

Both strategies should be implemented in a core training program, as research has shown the need for both retraining motor control of local and global musculature as well as retraining the strength and endurance of these muscles. Research has upheld the hypothesis that proper function of both the local and global musculature is needed to maintain efficacy of the spine. For retraining control of core stability, retraining recruitment strategies of the Central Nervous System would be appropriate. In these cases, the intrinsic musculature is not functioning appropriately and is often inhibited by the superficial musculature that has become synergistically dominant or hyperactive.

A core program that incorporates skilled activation of the deep muscles and then progressive integration of the intrinsic musculature with the superficial musculature is necessary. Once the coordinated activation
Integrated Core Training

is accomplished, training in varying environments, at differing speeds, forces, and intensities, is needed to shift an individual into activities of daily living. The muscle capacity model of core stability exercise tends to overlap the control model. The muscle capacity model is more aggressive in utilizing superficial trunk musculature right away, claiming the need for coordination of both groups of muscles to work together synergistically. In essence, this is a correct observation; however, devoid of proper initial training of the intrinsic musculature, continual dominance of the superficial muscles could result.

In the end, both theories aim to re-establish the trunk muscles’ ability to meet the higher demands or forces placed on them for spinal stability, and the theories, used together, can be a significant approach to core stability training.

NASM is continually stressing the integration of both theories of motor relearning and increased capacity of core muscles. The core stabilization training guidelines require activation and skilled learning of proper intrinsic muscle recruitment before integration of the superficial musculature.

One starts with what is termed core stabilization training, where the neutral spine is located and retraining of the inner unit is accomplished. This creates increased lumbo-pelvic-hip stability through the co-contraction of the TVA and the lumbar multifidi, as well as the TLF that is dynamically engaged through muscle insertions such as the TVA, deep erector spinae, internal obliques, and lumbar multifidi. This retraining also increases neuromuscular efficiency, leading to increased muscle capacity as the superficial muscles are introduced later in training. Performing exercises without proper firing of the inner unit musculature can lead to muscle imbalances and inefficient neuromuscular control of the entire kinetic chain. This, in turn, can lead to or propagate already existing injuries, such as LBP.

As mentioned earlier, research has found that lack of proper stabilization leads to increased intradiscal pressure and compressive forces in the lumbar spine. Once skilled activation is accomplished, movement of the extremities is added while the client maintains a neutral spine, retraining muscle capacity as the extremities pose substantial force requirements on the spine. These exercises should be done without noticeable compensation before integration of superficial muscles into the exercises.

The next level of core training integrates and coordinates activation of the deep musculature with the superficial muscles of the core. The core strength level of training in NASM’s model is intended to enhance neuromuscular efficiency, create a multi-dimensional progression and teach control of eccentric, isometric, and concentric phases of core activity. Specificity, speed and neural demand are also increased in this phase. This coincides with both the motor control theory and the muscle capacity theory of core training. In the NASM core training continuum, both theories are utilized as progressions of one another and not as differing approaches.
Lastly, in the core power stage of training, core stabilization and strength are integrated into the specific activity, as are speed and neural demand. The speed and forces utilized in this phase are comparable to those encountered in a client’s return to his or her environment. This phase places a high demand on the coordinated activity of the core musculature as a whole. Each level of core training treats both theories of core training as valid, and integrates each approach into a systematic progression to restore and increase function of the core, while avoiding injury.
Section IV: Guidelines for Core Stabilization Training

Focusing on assessing the local musculature and incorporating exercises that teach proper muscle activation of the TVA and multifidi in patients lacking proper activation may help clinicians begin the process of rehabilitation. An important key to success in a core training program is the understanding of flexibility and muscle imbalances. Activation of local stabilization musculature is important; however, activation of these muscles alone may not bridge the gap into functional living. Integration of core stabilization and strength training is important in keeping clients functioning properly. Teaching proper activation patterns and increasing the endurance capabilities of both local and global musculature may transition a client safely from training into everyday movements and activities.

Prior to performing a comprehensive core stabilization program, each individual must undergo a comprehensive kinetic chain assessment. All muscle imbalances and arthrokinematic deficits need to be corrected prior to initiating an aggressive core training program. A team approach is the best way to thoroughly assess each client. Find a competent health care professional in your community with whom you can establish a referral basis for comprehensive evaluations.

As outlined in Figure 18, a comprehensive core stabilization training program should adhere to specific guidelines. It should be systematic, progressive, and functional. The program should emphasize the entire muscle contraction spectrum, focusing on force production (concentric contractions), force reduction (eccentric contractions), and dynamic stabilization (isometric contractions). The core stabilization program should begin in the most challenging environment the individual can control.
Figure 18: Core Training Guidelines and Program Variables

<table>
<thead>
<tr>
<th>CORE STABILIZATION TRAINING GUIDELINES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Progressive</td>
</tr>
<tr>
<td>2. Systematic</td>
</tr>
<tr>
<td>3. Activity Specific</td>
</tr>
<tr>
<td>4. Integrated</td>
</tr>
<tr>
<td>5. Proprioceptively Challenging</td>
</tr>
<tr>
<td>6. Based on Current Science</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PROGRAM VARIABLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Plane of motion</td>
</tr>
<tr>
<td>2. Range of motion</td>
</tr>
<tr>
<td>3. Loading parameters (physioball, ball, Bodyblades, power sports trainer, weight vest, dumbbell, tubing, etc.)</td>
</tr>
<tr>
<td>4. Body position</td>
</tr>
<tr>
<td>5. Amount of control</td>
</tr>
<tr>
<td>6. Speed of execution</td>
</tr>
<tr>
<td>7. Amount of feedback</td>
</tr>
<tr>
<td>8. Duration (sets, reps, tempo, time under tension)</td>
</tr>
<tr>
<td>9. Frequency</td>
</tr>
</tbody>
</table>

As outlined in Figures 19 and 20, a progressive continuum of function that adheres to multi-modal loading parameters should be followed to systematically train the individual. The program should be manipulated regularly by changing any of the following variables: plane of motion, range of motion, loading parameters (physioball, ball, bodyblades, power sports trainer, weight vest, dumbbell, tubing, etc.), body position, amount of control, speed of execution, amount of feedback, duration (sets, reps, tempo, time under tension), and frequency. 5, 6, 7, 8, 9, 10, 11, 13, 15, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100.
When designing a core stabilization training program, the health and fitness professional should create a proprioceptively enriched environment and select the appropriate exercises to elicit a maximal training response. As outlined in Figure 21, the exercises must be safe, be challenging, stress multiple planes, incorporate a multi-sensory environment, be derived from fundamental movement skills, and be activity specific.
Figure 21: Exercise Selection Criteria

1. Safe
2. Challenging
3. Progressive
4. Systematic (Integrated Functional Continuum)
5. Proprioceptively Enriched
6. Activity Specific

The health and fitness professional should follow a progressive and integrated functional continuum like the one illustrated in Figure 22 to allow optimum adaptations.9,10,11,84

Figure 22: Integrated Functional Continuum

In addition, the health and fitness professional should follow an exercise progression continuum similar to the one outlined in Figure 23.
These concepts are critical for a proper exercise progression: slow to fast, simple to complex, known to unknown, low force to high force, static to dynamic, correct execution to increased reps/sets/intensity.⁷,⁸,⁹,¹⁰,¹¹,¹⁴

The goal of core training is to develop optimal levels of functional strength and dynamic stabilization.⁵,¹³ Neural adaptations become the focus of the program instead of striving for absolute strength gains.⁹,¹⁴,¹⁵,¹⁰,¹⁶ Increasing proprioceptive demand by utilizing a multi-sensory, multi-modal environment becomes more important than increasing the external resistance. Quality of movement is stressed over quantity. The focus of the program must be on function.⁹,¹⁰,¹¹
Section V: Core Stabilization Training Program

The following is an example of an integrated core training program. As mentioned earlier, the individual begins at the highest level at which he or she is able to maintain stability and optimum neuromuscular control. He/she is progressed through the program when he/she achieves mastery of the exercises in the previous level. 

Figure 24: OPT™ Model
Core Stabilization

In core stabilization (phase 1 of the OPT™ model), exercises involve little motion through the spine and pelvis. These exercises are designed to improve the functional capacity of the stabilization system.

- Marching
- Prone Iso-Abs
- Side Iso Abs
- Iso Abs w/Hip Extension
- Floor Bridge 1
- Floor Bridge 2
- Floor Cobra 1
- Floor Cobra 2
- Arm/Opposite Leg Raise
Core Strength

In core strength training (phases 2, 3, and 4 of the OPT™ model), the exercises involve more dynamic eccentric and concentric movements of the spine through a full range of motion. The specificity, speed, and neural demand are also progressed in this level. These exercises are designed to improve dynamic stabilization, concentric strength, eccentric strength, and neuromuscular efficiency of the entire kinetic chain.

- Ball Crunch 1
- Ball Crunch 2
- Ball Crunch w/Rotation 1
- Ball Crunch w/Rotation 2
- Back Extension 1
- Back Extension 2
- Reverse Crunch 1
- Reverse Crunch 2
- Knee Ups 1
- Knee Ups 2
Core Power

In core power training (phase 5 of the OPT™ model), exercises are designed to improve the rate of force production of the core musculature. These forms of exercise prepare an individual to dynamically stabilize and generate force at more functionally applicable speeds.
### Integrated Core Training Program Design

<table>
<thead>
<tr>
<th>OPT™ Level</th>
<th>Phase</th>
<th>Example Core Exercises</th>
<th>Sets/Reps</th>
<th>Rest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stabilization</td>
<td>1</td>
<td>1–4 Core Stabilization</td>
<td>1–3 x 12–20</td>
<td>0 – 90 s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2–Leg Floor Bridge</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Prone Iso-Abs</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prone Cobra</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strength</td>
<td>2, 3, 4</td>
<td>*0–4 Core Strength</td>
<td>2–3 x 8–10</td>
<td>0 – 60 s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Back Extensions</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ball Crunches</td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>Cable PNF</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knee-ups</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>5</td>
<td>**0–2 Core Power</td>
<td>2–4 x 5–10</td>
<td>0 – 60 s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medicine Ball Rotational Chest Pass</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Ball Medicine Ball Pullover</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 1 – Integrated Core Training Program Design*

*For the goal of muscle hypertrophy and maximal strength, it may be optional (although recommended) for individuals.*

**Because core exercises are performed in the dynamic warm-up portion of this program and core power exercises are included in the resistance training portion of the program, separate core training may not be necessary in this phase of training.*
Section VI: Summary

This type of training should be included in all integrated training programs. A core training program enables an individual to gain optimum neuromuscular control of the LPHC and to achieve optimum performance. To choose the proper exercises when designing a program, follow the progression of the OPT™ model. In the stabilization level, choose one to four core stabilization exercises. In the strength level, select from zero to four core strength exercises. In the power level, pick from zero to two core power exercises.
References


Integrated Core Training


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Integrated Core Training


102 Chek P: *Dynamic Medicine Ball Training. Correspondence Course*. La Jolla, CA: Paul Chek Seminars. 1996.

