A PERIODIZED APPROACH FOR CORE TRAINING

by Jeffrey M. Willardson, Ph.D.

LEARNING OBJECTIVES

- Understand the importance of core stability exercises for healthy individuals.
- Understand how to perform resistance exercises for the development of muscular endurance, muscular strength, and muscular power in the core musculature.
- Understand the potential advantages and disadvantages of performing resistance exercises on unstable equipment (*e.g.*, Swiss ball, wobble board, and balance disc).

Key words:
Resistance Training, Strength, Power, Muscular Endurance, Stability

During the past decade, core stability training has become one of the most widely promoted concepts within the fitness industry. Books and articles have been written that are entirely devoted to this topic (1,2). Much of what is currently known about core stability training originated from the rehabilitation literature and was intended for treating low back injuries in clinical-type settings (3).

However, core training methods are now being applied to healthy individuals in commercial-type settings. Core stability exercises have been recommended for healthy individuals with fitness goals that range from improvements in functional capacity to improvements in specific sports skills. Resistance exercises performed on unstable equipment (*e.g.,* Swiss ball, wobble board, and balance disc) have been widely promoted for core stability training (4). Resistance exercises that were traditionally performed on stable floors and benches are now commonly performed on unstable equipment.

For example, the squat is now commonly performed with each foot supported on a balance disc, and the chest press is now commonly performed while lying supine on a Swiss ball (5,6). The use of unstable equipment can make training fun and motivating and has been proven effective to increase core muscle activity. However, the use of this equipment does have limitations; for example, the lighter loads and lower movement velocities typical of exercises performed on unstable equipment make them best suited for development of core muscular endurance (7).

Development of this characteristic is beneficial for all individuals and may contribute to improvements in functional capacity, which allows for improved execution of most daily activities

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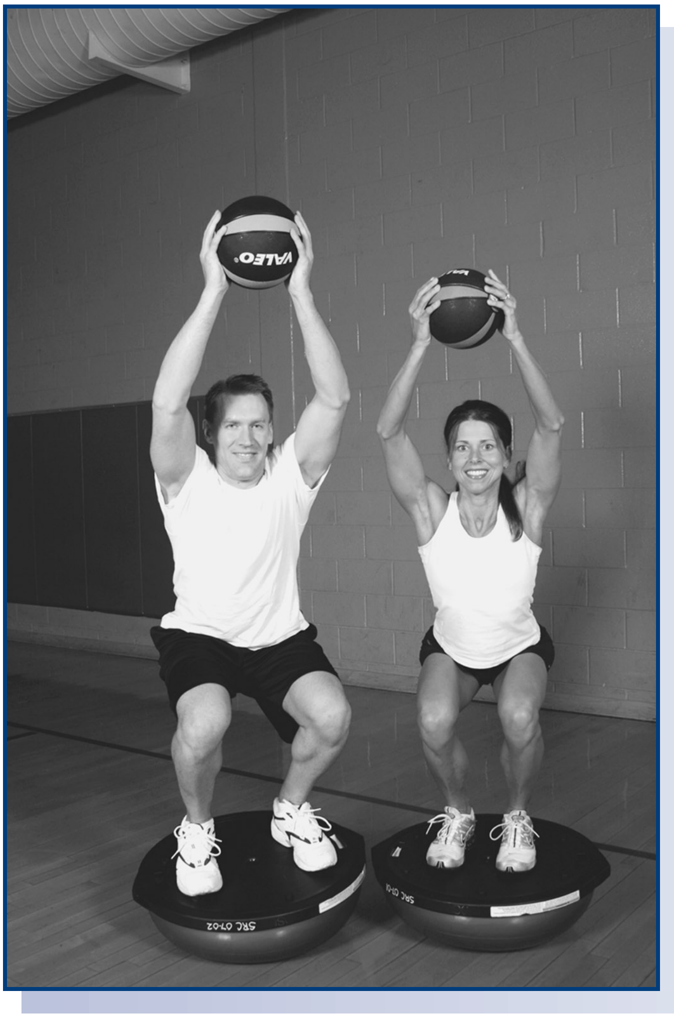

and occupational tasks (2,7). However, exclusive emphasis on development of core muscular endurance may not benefit healthy individuals with sports-specific performance goals that require development of core muscular strength and core muscular power (4). Additionally, some healthy nonathletic individuals may have training goals that are best addressed through development of core muscular strength and core muscular power. These characteristics require heavier loads in the case of core muscular strength and higher movement velocities in the case of core muscular power (4,8). Therefore, the best strategy for core training might be a periodized approach that emphasizes each muscular characteristic (*i.e.,* core muscular endurance, core muscular strength, and core muscular power) separately over time.

For example, core exercises for older adults might be structured primarily for development of core muscular endurance; however, occasional variation could involve performance of exercises structured for development of core muscular strength or core muscular power. This would be beneficial when carrying heavy household items for short distances or in developing the quick reactive muscle actions necessary to avoid falls. Conversely, core exercises for a recreational golfer might be structured primarily for development of core muscular strength and core muscular power; however, occasional variation could involve performance of exercises structured for core muscular endurance. This would be beneficial during golf outings that require carrying clubs throughout a course.

With these thoughts in mind, the purpose of this article will be threefold: to define the core and discuss the physiology of core stability, to discuss two common misconceptions regarding core stability training, and to address the periodized prescription of resistance exercises to emphasize each of the aforementioned muscular characteristics.

THE CORE: DEFINITION AND PHYSIOLOGY

The core can be defined as the trunk or the link between the upper and lower extremities. The trunk is made up of the spine, the pelvic girdle, and the rib cage. The spine attaches to the pelvic girdle posteriorly at the sacroiliac joints. The ribs attach to the sternum anteriorly at the costochondral joints and to the thoracic spine posteriorly at the costovertebral joints. The spine

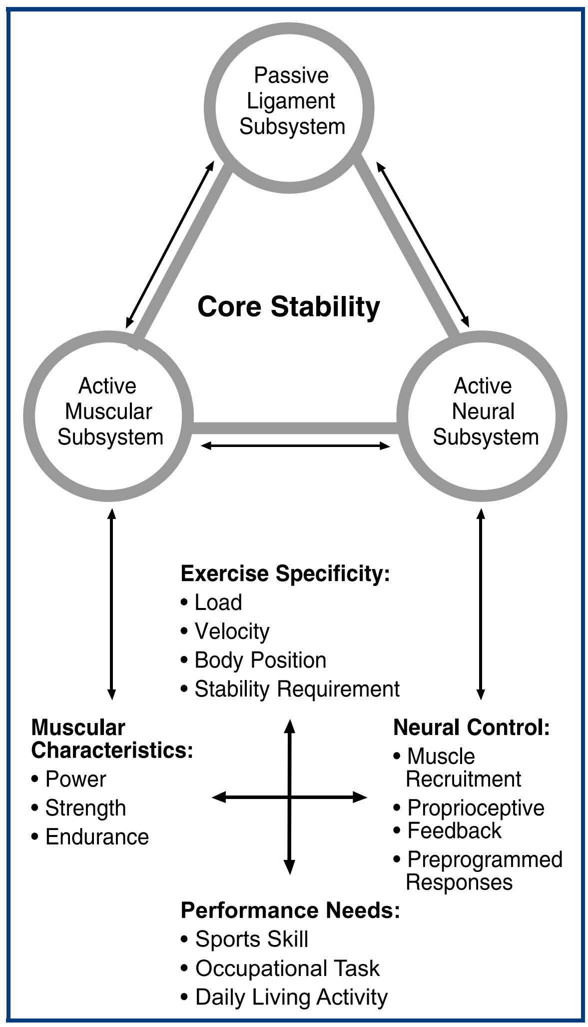

Figure 1. Conceptualization of core stability.

is made up of 33 articulating vertebrae that are held together by ligaments. However, the stability of the spine is largely dependent on the strength and flexibility of muscles on the anterior and posterior sides of the body (9–11).

The spine is the most movable in the cervical and lumbar regions. The lumbar region is of particular interest with regard to core stability because these vertebrae are designed for weight bearing. Therefore, core stability might be considered synonymous with lumbar stability. The lumbar spine is able to move in all planes of motion, with flexion and extension occurring in the sagittal plane, lateral flexion and reduction occurring in the frontal plane, and right and left rotation occurring in the transverse plane.

Core stability has been defined as the capacity of the stabilizing system to maintain the intervertebral neutral zones within physiological limits. The stability of the lumbopelvic region is essential to provide a foundation for movement of the upper and lower extremities, to support loads, and to protect the spinal cord and nerve roots (9–11). The concept of core stability has been depicted in Figure 1.

Examination of Figure 1 indicates that core stability is achieved through the contribution of passive and active subsystems. These subsystems work together and are equally important in achieving core stability. Chronic low back problems are most likely to occur when one of the subsystems becomes deficient, which places greater stress on the other subsystems to take up the slack. This is especially true when weakness exists in one or more of the core muscles, which places greater stress on the spinal ligaments.

The passive subsystem consists of the spinal ligaments that hold the vertebrae together. The passive subsystem is especially important at the end points in spinal motion when the ligaments are stretched tight. This subsystem cannot be trained through exercise, so the other active subsystems become the focus of core stability training programs. The first active subsystem is the nervous system. The nervous system activates and controls the tension within the core muscles, based on sensory feedback received from proprioceptors such as muscle spindles and Golgi tendon organs (9–11).

Muscle spindles are located between the muscle fibers and respond to high rates of stretching that result in reflexive muscular actions. These sensory organs are important in situations that require corrective muscle actions, such as quickly regaining balance to avoid falling. Conversely, Golgi tendon organs are located at the junction between the muscle fibers and the tendons and respond to high levels of tension. These sensory organs provide a protective mechanism against muscle tears by sending inhibitory signals that allow for relaxation of agonist muscle groups and tension development within antagonist muscle groups (9–11). An advantage of core stability training is that the nervous system can be preprogramed to activate muscles, which increases balance and decreases the risk of injury associated with future postural disturbances (12,13).

The second active subsystem is the muscular system. Stability and movement of the lumbar spine is highly dependent on the tension developed within the core muscles that attach to the pelvic girdle, ribs, and lumbar vertebrae. This is illustrated by the finding that, when stripped of muscle and relying exclusively on passive (*i.e.,* ligament) support, the spine (first thoracic vertebrae through sacrum) will collapse under approximately 2 kg of load (9–11). Obviously, this does not occur in healthy individuals because of the tension developed within the core muscles.

The core muscles have been classified as local or global based on location and function. The local muscles include the multifidus, rotatores, intertransversalis, and interspinalis that attach directly to and run between adjacent vertebrae. These muscles contain high densities of muscle spindles and contract in response to sudden postural disturbances to maintain core stability (9–11).

Other local muscles include the transversus abdominis, internal oblique abdominis, and quadratus lumborum. The transversus abdominis and internal oblique abdominis attach to the transverse processes of the lumbar vertebrae via the thoracolumbar fascia. The quadratus lumborum attaches directly to the transverse processes of the lumbar vertebrae and the 12th rib on each side of the body. Contraction of the transversus abdominis draws in the umbilicus, whereas contraction of the internal oblique abdominis and quadratus lumborum increases compressive forces between the bodies of the lumbar vertebrae. Both of these actions have a stabilizing effect on the spine (9–11).

The global muscles include the rectus abdominis, external oblique abdominis, erector spinae, and latissimus dorsi that attach directly to the pelvic girdle and rib cage. These muscles are capable of high levels of force production and are important to maintain core stability when performing heavy ground-based free free-weight movements such as the squat and dead lift. Other less acknowledged global muscles that originate on the pelvis or lumbar vertebrae and insert on the proximal portion of the femur, tibia, or fibula include the hip flexors (*e.g.,* rectus femoris, sartorius, iliacus, and psoas major and minor), hip extensors (*e.g.,* gluteus maximus, semimembranosus, semitendinosus, and long head of the biceps femoris), hip adductors (*e.g.,* adductor magnus, adductor brevis, adductor longus, gracilis, and pectineus), and hip abductors (*e.g.,* tensor fasciae latae, gluteus medius, and gluteus minimus) (9–11).

The hip muscles act on the pelvis or lumbar spine during close chain movements when the feet are planted on the ground. Because the spine is attached to the pelvis posteriorly at the sacroiliac joints, the tilting of the pelvis results in simultaneous movement of the lumbar spine. Therefore, the actions of the hip muscles can affect pelvic positioning and core stability.

CORE STABILITY TRAINING COMMON MISCONCEPTIONS

The first misconception is that the local (*e.g.,* multifidus) muscles can be trained independently from the global (*e.g.,* erector spinae) muscles. The truth is that all trunk exercises involve activation of both local and global muscle groups. The specific combination of muscles activated is dependent on body positioning and the force of gravity. Arokoski et al. (14) compared rectus abdominis, external oblique abdominis, longissimus thoracis, and multifidus muscle activity during 16 core exercises performed in prone, supine, seated, and standing body positions. The key finding was that the multifidus (local muscle) and longissimus thoracis (global muscle) demonstrated similar activity patterns and simultaneous function.

The second misconception is that there are certain muscles that are more important for core stability than others. Such has been the case with promotion of training strategies designed to emphasize the transversus abdominis muscle. This muscle is unique in that the horizontal alignment of the fibers acts as a physiological weight belt. Contraction of the transversus abdominis draws in the umbilicus, which increases intra-abdominal pressure and lumbar stability. Studies have demonstrated that the transversus abdominis was the first muscle activated during unexpected loading of the trunk and during upper and lower extremity movements, regardless of the direction of limb movement (12,13).

The abdominal hallowing exercise, performed in the quadruped position, has been recommended to emphasize the function of the transversus abdominis. However, this exercise cannot be considered functional because core stability is achieved through the coordinated activation of several core muscles. Stuart M. McGill, professor in the Department of Applied Health Sciences at the University of Waterloo stated, "The relative contributions of each core muscle continually changes throughout a task, such that discussion of the most important stabilizing muscle is restricted to a transient instant in time" (11[p355]).

This statement was supported by Cholewicki and VanVliet (15) when they compared the relative contribution of local and global muscles during seated and standing core exercises. The key finding was that no single muscle group contributed more than 30% to core stability, irrespective of the exercise. However, removal of the lumbar erector spinae, a global muscle, resulted in the largest reduction in core stability. The bottom line message was that core stability is a dynamic concept, with both local and global muscular contributions continually changing to meet postural adjustments or external loads supported by the body.

PERIODIZATION IN CORE EXERCISE PRESCRIPTION

Several factors determine the prescription of resistance exercises. The specificity of an exercise relative to a given sport skill, daily activity, or occupational task is determined by more than just visual similarity. Some of the many factors that should be considered include the following: force production (*i.e.,* percentage of maximum strength being lifted), rate of force development, velocity (*i.e.,* controlled vs. explosive), range of motion, joint action (*i.e.,* flexion, extension, abduction, adduction, internal rotation, and external rotation), muscle action (*i.e.,* concentric, eccentric, and isometric), and body position (*i.e.,* seated, standing, and lying).

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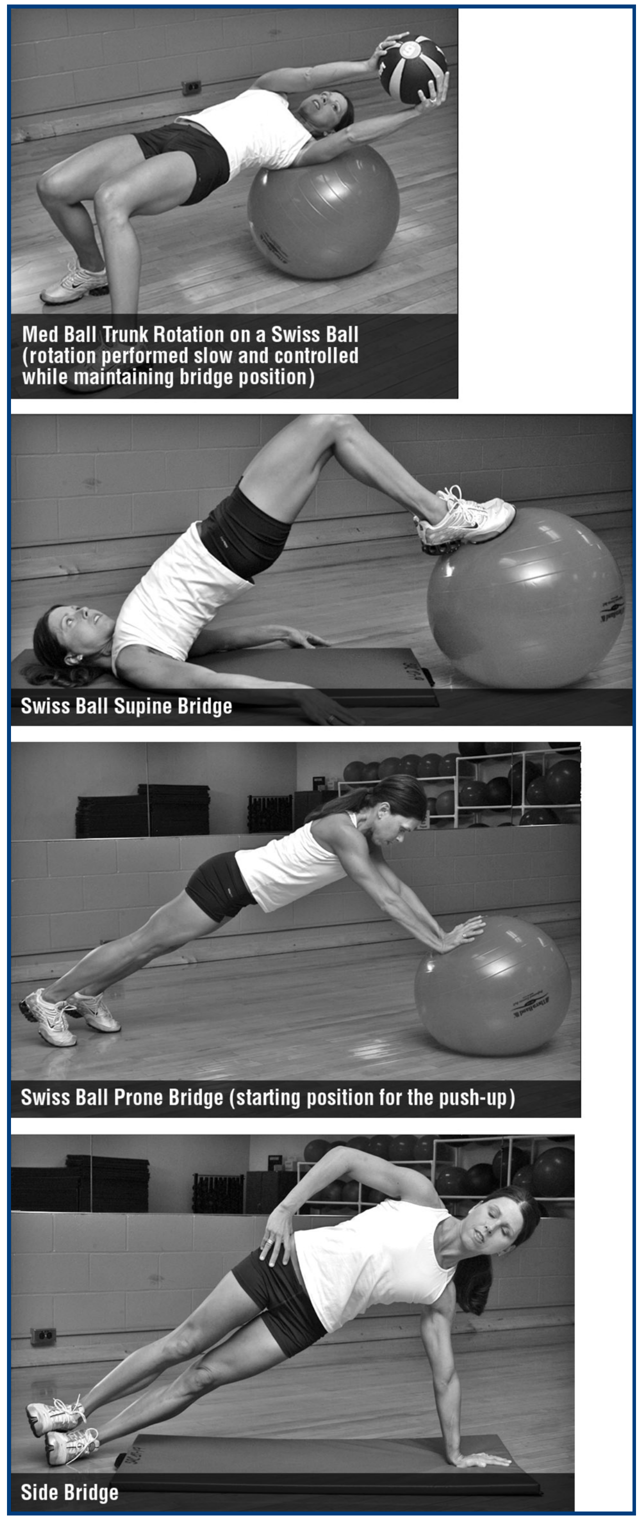

Figure 2. Sample core muscular endurance exercises.

Examination of Figure 1 indicates that resistance exercises should be selected that match the core stability requirements of

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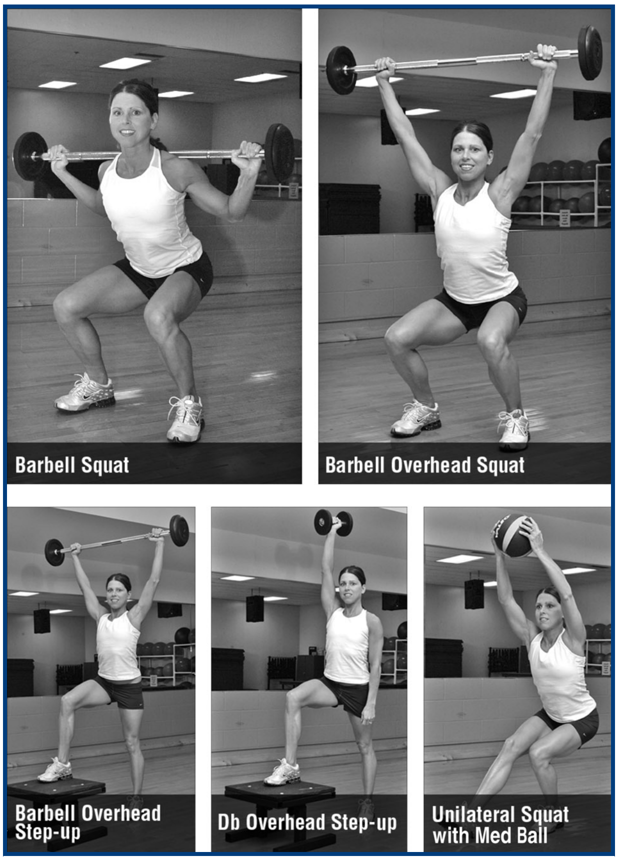

Figure 3. Sample core muscular strength exercises—progressions ground-based squat.

a given sport skill, daily activity, or occupational task. Two key factors that determine core stability requirements include the support surface and whether the movement is performed with a single limb independently (unilateral) or with both limbs simultaneously (bilateral). Research has demonstrated the need for increased core muscle activity when movements were performed on increasingly unstable surfaces or with a single limb independently (16).

Neural and muscular adaptations that result from performance of resistance exercises are expressed through increases in power, strength, or muscular endurance. Development of each of these muscular characteristics can potentially contribute to increased core stability. The goals of the client should dictate the primary selection of exercises for core training. However, regardless of the training goal, all clients may benefit from periodic variation that allows for development of all three muscular characteristics. The following sections will discuss development of core muscular endurance, core muscular strength, and core muscular power.

CORE MUSCULAR ENDURANCE

This characteristic can be defined as the ability to produce submaximal muscle actions over extended periods. Development of this characteristic is beneficial for all individuals, regardless of the primary training goal. Stuart M. McGill, professor in the Department of Applied Health Sciences at the University of Waterloo, recommended that the development of core muscular endurance take precedence over the development of core muscular strength for preventing and rehabilitating low-back injuries (3). In agreement with this perspective, Arokoski et al. (14[p1096]) stated, "Because the lumbar stabilizing multifidus muscles are mainly composed of type I fibers, only relatively low loads are needed to improve their performance."

Research has indicated that the most effective method for increasing core muscular endurance might be through performance of resistance exercises on unstable equipment (*i.e.,* Swiss ball, wobble board, and balance disc) (Figure 2). For example, Vera-Garcia et al. (17) evaluated muscle activity in the upper and lower regions of the rectus abdominis during curl-ups performed on a Swiss ball versus a stable bench. The results demonstrated that performing the curl-up on a Swiss ball resulted in significantly greater abdominal muscle activity (50% vs. 21% of maximal activity).

Marshall and Murphy (18) compared muscle activity in the rectus abdominis, transversus/internal oblique abdominis, external oblique abdominis, and erector spinae when push-ups were performed on a Swiss ball versus a stable floor. The results demonstrated that at the top portion of the push-up, with the hands positioned on a Swiss ball, there was significantly greater activity in the rectus abdominis (35% vs. 9% of maximal activity) and transversus/internal oblique abdominis (33% vs. 13% of maximal activity). Research also has demonstrated similar findings for the dumbbell chest press when performed on a Swiss ball and for the barbell back squat when performed with each foot supported on a balance disc (5,6).

These muscle activation levels (*i.e.,* <50% of maximal) when combined with longer tension times and lower movement velocities represent an ideal stimulus for development of core muscular endurance (7). Resistance exercises performed on unstable

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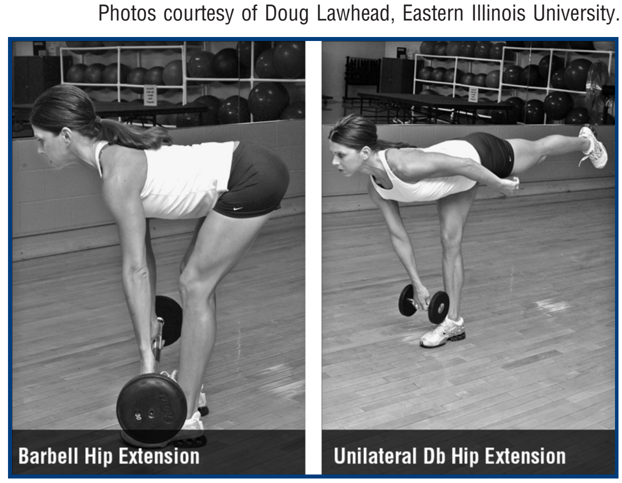

Figure 4. Sample core muscular strength exercises—progressions ground-based dead lift.

equipment should always be performed at a slow and controlled tempo with body mass or additional light resistance. The focus of such exercises should be on sustaining constant tension within the core musculature either isometrically (*e.g.,* side bridge, prone bridge, and supine bridge) or dynamically (*e.g.,* curl-ups).

CORE MUSCULAR STRENGTH

This characteristic can be defined as the ability to produce maximal force. This characteristic may be most beneficial for athletes (*e.g.,* recreational, collegiate, and professional) but also may have application to other individuals, depending on their daily activities or occupational tasks. This characteristic is best developed through performance of ground-based free-weight exercises. Performing resistance exercises in this manner allows for heavier loads to be used and is specific to most sports skills, daily activities, and occupational tasks that are typically executed on a stable surface (4,8).

Many times, an individual must execute a sports skill, daily activity, or occupational task while supported on a single leg. Research has demonstrated greater core muscle activity when free-weight exercises were performed unilaterally rather than bilaterally (16). Therefore, ground-based free-weight exercises should be modified progressively to focus on unilateral strength development. Specifically, the squat and dead lift can be modified to progressively stimulate greater core muscle activity, without losing force production and the potential for strength development (Figures 3, 4). Because of the heavier loads used, these exercises are recommended for healthy individuals without low-back pain. Perfect technique (as shown in the examples) should be practiced with light weights before lifting heavy weights.

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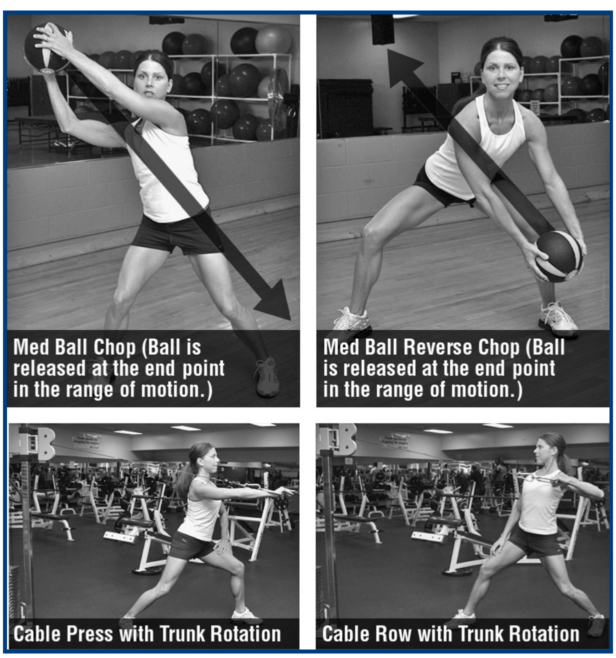


Figure 5. Sample core muscular power exercises (concentric phase performance as quickly as possible)

CORE MUSCULAR POWER

This characteristic can be defined as the ability to produce force rapidly. Here again, this characteristic might be most beneficial for athletes (*e.g.,* recreational, collegiate, and professional) but also may have application to other individuals, depending on their daily activities or occupational tasks. Muscular power represents a combination of muscular strength and the velocity of muscle action. Increases in either of these components may increase power output. Because core muscular strength was covered previously, this section will focus on the velocity of muscle action.

For advanced clients that already possess high levels of core muscular strength, the most effective strategy to increase core muscular power might be to focus on ground-based resistance exercises that involve lighter loads and higher movement velocities. Several equipment options are available including medicine balls, cables, and traditional barbells and dumbbells. Use of medicine balls can be especially effective for development of rotational power in the core musculature. Specifically, athletes that perform throwing-type actions (*e.g.,* baseball throw and volleyball serve) or swing implements (*e.g.,* golf club, tennis racquet, and baseball bat) could benefit. Medicine ball and cable exercises that involve core rotation combined with coordinated joint actions of the upper and lower extremities are recommended (Figure 5).

Resistance exercises designed for the development of core muscular power should always be performed while standing on a stable surface to allow for higher movement velocities and rates of force production. Research has demonstrated reductions in these variables when the squat was performed with each foot supported on a balance disc (19,20). This may have been caused by a stiffening strategy that involved cocontraction of agonist and antagonist muscle groups. Although increased antagonist activity may contribute positively to balance development and joint protective responses, it also could contribute negatively to core muscular power development by opposing the intended direction of motion. Therefore, resistance exercises performed on unstable equipment may not provide the optimal stimulus for core muscular power development.

CONCLUSIONS

Core stability exercises have become mainstream, with rehabilitative methodologies now being applied to healthy individuals. A popular trend has been to modify traditional free-weight resistance exercises by performing them while standing or lying on unstable equipment. For example, the squat is now commonly performed with each foot supported on a balance disc, and the chest press is now commonly performed while lying on a Swiss ball.

Resistance exercises performed on unstable equipment are ideal for development of core muscular endurance because of the lighter loads, longer tension times, and lower movement velocities typically used. Development of this characteristic is beneficial for all individuals and may contribute to improvements in functional capacity, which allows for improved execution of most daily activities and occupational tasks. Furthermore, some individuals may have a physical limitation (*e.g.,* low-back pain) that prevents them from performing heavy ground-based free free-weight movements. In such cases, the use of unstable equipment is ideal to allow for greater core muscle activity without lifting heavy loads.

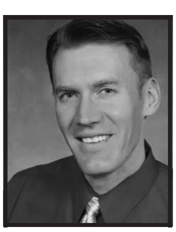
However, exclusive emphasis on development of core muscular endurance may not benefit healthy individuals with sports-specific performance goals that require development of core muscular strength and core muscular power. Additionally, some healthy nonathletic individuals may have training goals that are best addressed through development of core muscular strength and core muscular power. Development of these characteristics is best addressed through performance of ground-based free-weight exercises (*e.g.,* squat, dead lift, Olympic lifts, and medicine ball throws). These exercises are characterized by higher forces, movement velocities, and rates of force production.

The goals of the client should dictate the primary selection of exercises for core training. However, regardless of the training goal, the best strategy might be a periodized approach that emphasizes each muscular characteristic (*i.e.,* core muscular endurance, core strength, and core power) separately over time. Development of each of these muscular characteristics can potentially contribute to increased core stability. Personal trainers are encouraged to use the ideas and concepts presented in this article to select resistance exercises that best meet the needs of each of their clients.

Photo credits:

Jennifer Carter is a certified personal trainer and served as the model for all pictures in this article.

Doug Lawhead teaches journalism at Eastern Illinois University and photographed all exercises demonstrated in this article.



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CONDENSED VERSION AND BOTTOM LINE

The goals of the client should dictate the primary selection of exercises for core training. However, regardless of the training goal, the best strategy might be a periodized approach that emphasizes each muscular characteristic (*i.e.,* core muscular endurance, core muscular strength, and core muscular power) separately over time.