20:1; 25-37, 2005

Core stabilisation training for middle- and long-distance runners

By Michael Fredericson, Tammara Moore

ABSTRACT

A strong foundation of muscular balance and core stability is essential for middle- and long-distance runners. In their experience working with elite runners, even those at an Olympic level, the authors have found that weakness or lack of sufficient co-ordination in core musculature can lead to less efficient movements, compensatory movement patterns, strain, overuse, and injury. This article briefly discusses the theory behind core training for injury prevention and improving a distance runner's efficiency and performance. It then details a systematic progression of core exercises that can be easily incorporated into a runner's training programme. The programme starts with restoration of normal muscle length and mobility to correct any muscle imbalances. Next, fundamental lumbo-pelvic stability exercises are introduced, teaching the athlete to activate the deeper core musculature. When this has been mastered, advanced lumbo-pelvic stability exercises using the Physioball are added for greater challenge. As the athlete makes the transition to the standing position, sensory-motor training is used to stimulate the subcortex and provide a basis for more advanced functional movement exercises, which promote balance, co-ordination, precision, and skill acquisition.

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Introduction

For middle- and long-distance runners—whose events involve balanced and powerful movements of the body propelling itself forward and catching itself in complex motor patterns—a strong foundation of muscular balance is essential. In many runners, however, even those at an Olympic level, the core musculature is not fully developed. Weakness or lack of sufficient coordination in the core musculature can lead to less-efficient movements, compensatory movement patterns, strain, overuse, and injury. This article briefly discusses the theory behind core training for injury prevention as well as for improving a distance runner's efficiency and performance. It then details a systematic progression of core exercises that can be incorporated easily into every runner's training programme.

The role of the core

The core musculature is composed of 29 pairs of muscles that support the lumbo-pelvic-hip complex. These muscles help to stabilise the spine, pelvis, and kinetic chain during functional movements. When the system works efficiently, the result is appropriate distribution of forces; optimal control and efficiency of movement; adequate absorption of ground-impact forces; and an absence of excessive compressive, translation, or shearing forces on the joints of the kinetic chain.

The first stage in developing a stable core is to develop the abdominal muscles. Richardson et al[1] have discovered that there are two different types of muscles fibres (slow-twitch and fast-twitch) that make up the abdominal muscles, and that because of this different fibre composition, different exercise regimens are required to properly train these muscles. Slow-twitch fibres primarily make up the local muscle system—the muscles of the deeper abdominal muscle layers. These muscles are closer to the centre of rotation of the spinal segments and, with their shorter muscle lengths, are ideal for controlling intersegmental motion, maintaining mechanical stiffness of the spine, and are best suited to respond to changes in posture and extrinsic loads. The key muscles of this system include the *transversus abdominus, multifidi*, internal *oblique*, deep *transversospinalis*, and pelvic floor muscles. Co-contraction of these muscles produces force via the *thoracolumbar fascia* and the intra-abdominal pressure mechanism stabilises and resists forces acting on the lumbar spine.

Fast-twitch fibres, on the other hand, primarily make up the global muscle system, which includes the superficial or outer-layer muscles. These muscles possess long levers and large moment arms that are capable of producing high outputs of torque, with an emphasis on speed, power, and larger arcs of movement.[2] The main muscles in this layer are the *erector spinae*, external *oblique*, and *rectus abdominis* muscles—the muscles that are strengthened by traditional back and abdominal exercises and that assist with gross spinal movements.

Interestingly, Hodges and Richardson[3, 4] have shown that it is not simply that deep-layer abdominal muscles are recruited during stabilisation of the spine, but it is how they are recruited that is important. The transverse *abdominus* and the *multifidi* are considered "stabilising muscles" (muscles that are continually modulated by the central nervous system and provide feedback about joint position), while the global and larger torque-producing muscles control acceleration and deceleration. The authors found that the co-contraction of the deeper-layer transverse *abdominus* and *multifidi* muscle groups occurs prior to any movement of the limbs, and believe that this neuromuscular pre-activation is critical in stabilising the spine prior to any movement.

The core programme

Stability work should be started only after the athlete has achieved good mobility, as adequate muscle length and extensibility are crucial to proper joint function and efficiency. Although beyond the scope of this article, a

thorough evaluation of the muscular system should include an assessment of the muscles for over-activity, shortening, weakness, inhibition, and quality of motion. This is best accomplished by a skilled physician or therapist using muscle-length tests, strength tests, and tests for the efficiency of basic movement patterns and neuromuscular control. A thorough postural observation and video taping of the athlete's running gait will help in assessing and identifying any movement imbalances.

Preliminary stretches for shortened muscles should include proprioceptive neuromuscular facilitation (PNF) type or contract-relax stretches that strive for isometric contraction, followed by end-range stretching. These are effective techniques for maintaining muscle length and joint mobility. Active Release Techniques® (a specialised method for soft tissue mobilisation) when used in conjunction with stretching techniques, have shown great promise in restoring muscle length and soft-tissue extensibility. Athletes can also do their own self-mobilisation with use of a foam roll.

Proprioceptive: *Relating to stimuli that are produced and perceived by the body, especially those connected with position and movement.*

Specific exercises for the runner should progress from mobility to stability, to reflexive motor patterning, to acquiring the skills of fundamental movement patterns, and finally, to progressive strengthening. These sequences may not be applicable to all athletes; therefore, the key is to analyse the individual in each exercise category and then to tailor an exercise regimen that will best suit that runner's needs. For example, it has been shown that runners prone to *iliotibial* band syndrome often have weakness in their hip abductors that predisposes them to increased stress on the *iliotibial* band.[5] Thus, a preventative training programme for runners with this syndrome must target the hip abductors, particularly the posterior aspect of the *gluteus medius* that assists external rotation or in decelerating internal rotation of the hip. Other muscles that prove weak or inhibited on evaluation should also be strengthened on a case-by-case basis.

The purpose of basic core stabilisation exercises is not only to increase stability, but more importantly— it is to gain co-ordination and timing of the deep abdominal-wall musculature. *It is extremely important to do these basic exercises correctly, as they are the foundation of all other core exercises and movement patterns.* These basic exercises emphasise maintaining the lumbar spine in a neutral position (which is the midrange position between lumbar extension and flexion.), allowing for the natural curvature of the spine.

This first stage of core stability training begins with the athlete learning to stabilise the abdominal wall. Proper activation of these muscles is considered crucial in the first stages of a core stability programme, before progressing to more dynamic and multi-planar activities.

We recommend the technique as described by McGill.[6] This involves a sub-maximal isometric contraction of the three layers of the abdominal wall (*rectus*, obliques, and transverse) producing a true muscular girdle around the spine to buttress against buckling and shear instability.

Fundamental lumbo-pelvic stability

The exercise programme should progress sequentially through the fundamental movements as detailed below. The following exercises are to be performed three times per week to maximise results. The athlete begins with one to two sets of 15 repetitions and progresses to three sets of 15-20 reptitions. These exercises are taught initially in either a supine, hook-lying position, or all-fours quadruped position. The athlete can progress to the more functional standing exercises, as control is developed. Important concepts taught at this stage include not tilting the pelvis or flattening the spine. We also emphasise normal rhythmic breathing.

SUPINE BENT-KNEE RAISES

This is a fundamental exercise for recruiting the deep abdominal muscles and for lumbo-pelvic control.

The athlete lies on her back, with knees bent and feet flat on the floor. She then braces the abdominal wall, holding the lumbar spine in a neutral position, and slowly raises one foot 15-30cm off the ground with alternate legs. Common errors when performing this exercise include rocking the pelvis, abdominal protrusion, or an inability to maintain the neutral (midrange) lumbar curve. If this happens, discontinue the exercise for a rest period. Quality more than quantity is stressed.

Progression: The exercise can progress to alternately extending the legs and lowering to the ground. Once the athlete can maintain stability with alternate leg lifts. She can add alternate, overhead arm raises for greater challenge. The arm raises should be performed slowly, while maintaining lower abdominal bracing.

Figure 1: Supine Bent-Knee Raises

QUADRUPED WITH ALTERNATE ARM/LEG RAISES

This exercise prepares the athlete for the proprioceptively more challenging, more dynamic exercises of the trunk. It specifically engages the *multifidi*—the deep transverse spine stabiliser and extensor of the lumbar spine.

The athlete should position herself on all fours. She then braces the abdominal wall as described above. While maintaining a midrange/neutral curve of the lumbar spine, the athlete should raise the right arm and the left leg (opposite upper and lower limbs) into a line with the trunk, while preventing any rocking of the pelvis or spine (excessive transverse- or coronal-plane motion). If it helps to maintain alignment, the athlete may use an object, such as a foam roller or wooden dowel, placed along the spine, for added tactile feedback. The leg should be raised only to the height at which athlete can control any excessive motion of the lumbo-pelvic region. She then performs the exercise raising the left arm with the right leg.

Progression: A Physioball underneath the trunk can provide significantly more proprioceptive challenge owing to its unstable surface. The goal once again is for the athlete to maintain lumbar stability while the opposite arm and leg are raised slowly.

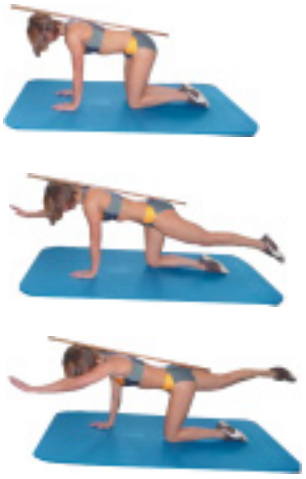


Figure 2: Quadruped with Alternate Arm/Leg Raises

BRIDGING

Bridging is a fundamental core-stability and *gluteal*-strengthening exercise.

The athlete begins the exercise on her back, in a hook-lying position, with arms resting at her sides. She activates the abdominals and

squeezes the gluteal cheeks prior to initiating the movement. The athlete lifts the pelvis and hips off the ground while maintaining neutral lumbar alignment. There should be no rotation of the pelvis. The hips should be aligned with the knees and shoulders in a straight line. The athlete should hold the position for 10sec and then slowly lower the pelvis to the floor.

Progression: In the lifted-bridge position, while maintaining neutral lumbar and pelvic alignment, the athlete can lift one foot off the ground and extend the leg. By placing her arms across her chest, she can increase the challenge of stabilising the lumbo-pelvic region. To progress further, the athlete can raise both arms up to the ceiling and then move one arm out to the side. She should bring the arm back to the centre and repeat with the other side.

Figure 3: Bridging

PRONE PLANK

This is a fundamental, static core-stability exercise.

The athlete supports herself with her forearms resting on the mat, elbows bent at 90°, and the toes resting on the mat. The athlete maintains the spine in a neutral position, recruits the *gluteal* muscles, and keeps the head level with the floor. She is instructed to breath normally throughout the exercise, while maintaining the abdominal brace. We suggest holding the position for 20sec, working up to one minute for two to three repetitions. No compensatory motion, such as increased lumbar lordosis or sag, should be seen.

Progression: In this position, the athlete can add leg lifts for more difficulty: one leg can be lifted off the mat, held for five seconds, and then repeated on the opposite side.
Figure 4: Prone Plank

SIDE PLANK

This is a fundamental, static core-stability exercise designed to challenge the athlete's body against gravity in the coronal/frontal plane and is an ideal exercise to train the *quadratus lumborum*.

The athlete is lying on her right side with the right arm extended in a straight line up from the shoulder, with the forearm resting on the mat. She then raises the pelvis from the floor and holds it in a straight-line "plank" position. The hips should not be allowed to sag toward the floor. We suggest holding the position for 20sec, working up to one minute holds for two to three repetitions.

Progression: The top foot can be raised to increasingly challenge the core and gluteal musculature.

Figure 5: Side Plank

Advanced lumbo-pelvic stability

Once the athlete demonstrates good stability with all static core exercises, they can be replaced with more advanced exercises on the Physioball detailed below. These exercises should be performed at least two times per week to maximise results. The athlete progresses to two sets of 10-15 repetitions. Quality is more important than quantitiy; the athlete must maintain lumbar neutral and keep the spine in perfect alignment throughout the exercises.

SEATED MARCHING ON A PHYSIOBALL

This exercise is more difficult because the athlete positions her body against gravity in a seated position on an unstable surface.

The athlete begins by sitting upright on a Physioball, with the lumbar spine in a neutral position (midrange). She places her feet hip-width apart. While bracing the abdominal muscles, she lifts one leg and foot off the ground. (The limb does not need to be lifted very high, just enough to be off the ground—approximately 5cm to start.) The athlete should focus on controlling the weight shifting to the weight-bearing limb while maintaining lumbo-pelvic stability.

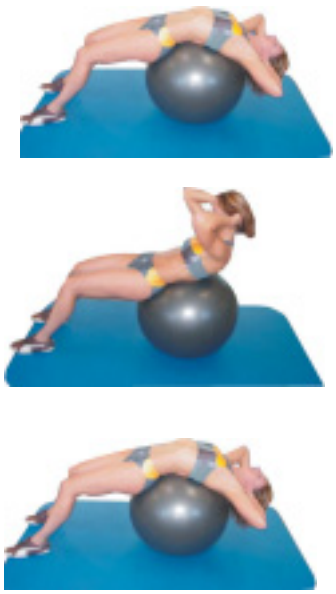
Progression: Once lumbo-pelvic stability can be maintained with alternate leg lifts, the athlete can add opposite arm lifts.

Figure 6: Seated Marching on a Physioball

SPINAL FLEXION ON PHYSIOBALL

The athlete pre-activates her abdominal brace in the starting position and maintains this as she rolls back into spinal extension. She then slowly raises the body, focusing the rotation in the thoracic spine. Picture the head and neck as a rigid block on the thoracic spine to prevent flexing the cervical spine. The athlete concentrates on attempting to touch the bottom of her ribs to her pelvis (ASIS). The hands can be placed over the ears to eliminate pulling on the neck.

Progression: The athlete holds a 2.0 to 4.0kg medicine ball in front of the chest with the arms extended (see Figure 7b).



(a)

(b)

Figure 7: Spinal Flexion on Physioball

ALTERNATE LEG BRIDGE WITH SHOULDERS ON BALL

The athlete starts this exercise by sitting on the Physioball and walking forward with his feet on the ground, slowly leaning back until his back rests on the ball. This is called the *bridge position*. The head, neck, and shoulder

blades should be supported on the ball. Knees should be bent at a 90° angle, with feet on the ground. While bracing the abdominal muscles, the athlete raises the foot and extends the leg off the ground. The weight will be shifted to one side, and the athlete should focus on maintaining stability of the lumbo-pelvic region. The athlete should strive for stability and balance, while holding this position for 10sec and alternating lower limbs.

Progression: The athlete lifts the arms up in the air or out to the sides.

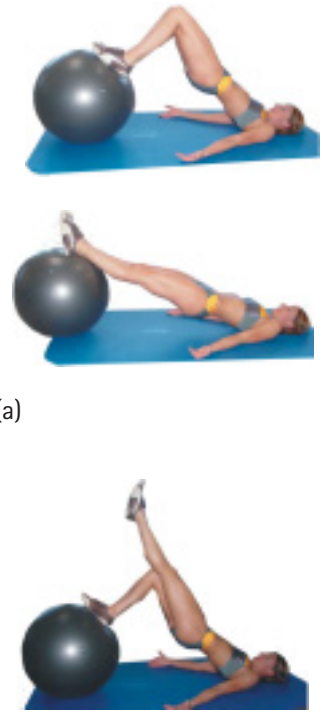
Figure 8: Alternate Leg Bridge with Shoulders on Ball

LEG CURLS ON A PHYSIOBALL

The purpose of this dynamic exercise is to recruit both actions of the hamstrings—hip extension and knee flexion—while maintaining dynamic stability of the lumbar spine.

In a supine position on the floor, the athlete places both feet on the Physioball. (Shoes should be removed to allow increased proprioception from the exteroceptors of the feet.) The athlete keeps her arms on the floor at the sides of the body for balance and raises the hips off the ground until the knees, hips, and shoulders create a straight line. She should focus on holding the spine in a neutral midrange position. In this position, the athlete then pushes the ball forward with the feet while maintaining the bridge. The goal is to keep the pelvis elevated (hip extension) as both legs extend and flex at the knees. While the knees extend and flex from this elevated bridge position, the athlete focuses on maintaining lumbo-pelvic stability.

Progression: The athlete can continue with single leg hamstring curls in the same position (see Figure 9b).



(a)

(b)

Figure 9: Leg Curls on a Physioball

Exteroceptor: *A sensory receptor that receives external stiumuli.*

ABDOMINAL ROLLOUT

The athlete kneels behind the ball, with both hands on the ball. Keeping the abdominal muscles braced and lower back in a neu-

tral position, she then rolls the ball away from her body a short distance until there is a straight line from the shoulder to hips. While maintaining alignment, she pulls the ball back ta short distance, then pushes it away again. The movement should occur only at the shoulders, not the back.

Progression: The athlete can gradually straighten the body until she is up on her toes. There should be a straight line from the back of the head to the knees. Now she can again move the ball away and back toward the body a short distance with the arms.

Figure 10: Abdominal Rollout

SQUAT BALL THRUST

Keeping the abdominal muscles braced and lower back and shoulder blades in a neutral position, he athlete uses her abdominal contraction to move the ball forward and back. Keep the spine in neutral alignment throughout the movement. If the exercise shown is too challenging, start with the shins instead of the toes on the ball.

Progression: The athlete can perform the exercise with only one foot on the ball (see Figure 11b).

(a)

(b)

Figure 11: Squat Ball Thrust

Development of balance and motor control

The following movements require reflexive control. The athlete can establish this control using an unstable surface and taking advantage of the numerous proprioceptors in the soles of the feet, and by activating the neck muscles, which contribute greatly to postural regulation. This sensory-motor training is an attempt to provide the sub-cortex with a basis for movement that is progressively more challenging. It involves exercises that stimulate balance, coordination, precision and skill acquisition.

Various devices are useful to progressively challenge balance, including a balance board with a whole sphere underneath the board (which creates multi-planar instability) or a rocker-board with a curved surface underneath the board (which allows single-plane motion). Dynamic foam rollers are an inexpensive alter-

native to the boards that also can be used to challenge balance, proprioception, and stability. These include half-rollers and full-sized rollers. Two other items that are invaluable to challenge balance and core stability and aid proprioceptive training in the standing position are the Bosu Balance Trainer and the Dyna Disk (these can be used interchangeably.) The Bosu has two functional surfaces that integrate dynamic balance with sports-specific or functional training: the domed surface is convex, the other side is flat and can be used for less challenge. The Dyna Disk is an air-filled plastic disc that can be firmly inflated. It has a smaller diameter than the Bosu and can be used like the Bosu Trainer, as it creates an increased proprioceptive challenge to the athlete while standing on it. The Dyna Disk is unstable and does not have a base like the Bosu trainer.

FORWARD/BACKWARD ROCKING

In this exercise, a rocker-board is used to challenge balance in the frontal plane of motion. Standing on the rocker-board with both feet in perfect postural alignment, the athlete gently rocks forward and backward. (To maintain ideal posture, the athlete can create an imaginary line through the joints of the ankle, knee, hip, and shoulder. The ear should align in a straight line with these joints, with no excessive extension [swayback] of the lumbar spine or anterior pelvic rotation.) While rocking, there should be no excess body movement in the coronal or transverse planes. This exercise should be performed for several minutes. The goal is to optimally align the spinal curves and lower extremities.

Progression: The athlete can progress to a slight flexed-knee position, with fast and slow movements to stimulate the righting reflexes and balance reactions. She also can progress the stepping motion to the three axes of motion.

Figure 12: Forward/Backward Rocking

SINGLE-LEG BALANCE—3 PLANES

This next exercise progresses the athlete to a single-leg stance. The rocker-board is used in the three planes of motion. This exercise also can be performed with a balance board, which is more demanding as it incorporates all planes of motion simultaneously.

The athlete takes one step forward while maintaining alignment and balance, controlling aberrant motion, mimicking a forward running motion. The goal is to maintain lumbo-pelvic alignment. The athlete controls movement in the three planes of motions by placing her feet in various positions on the board. The athlete then alternately steps forward and backward onto the rocker-board.

Progression: Once the athlete achieves static stability and can remain stable while standing on the rocker board, she can add an accessory motion. The athlete can swing the arm and the non-weight-bearing opposite leg (as though mimicking running). No excessive motion in the pelvis or lumbar spine should occur during the swing phase.

Figure 13: Single-leg Balance—3 Planes

WEIGHT TRANSFERS WITH PROPER ALIGNMENT

The preceding exercise progresses to "falling" onto an unstable surface. Figure 14 shows a rocker-board and "falling" onto a circular balance board. Again, the emphasis is on spinal alignment from the head to the sacrum. The athlete steps forward quickly

and catches herself from falling over with a quick forward movement of the leg onto the board.

Figure 14: Weight Transfers with Proper Alignment

Functional Movement Training

Functional movements require acceleration, deceleration, and dynamic stabilisation. A functional exercise regimen specific to the demands of running includes single-leg drills, three-dimensional lunges, resistive diagonal patterns of the upper and lower extremities, and tri-planar movement sequences. Athletes can progress through the three planes of motion by performing similar exercises on balance boards, the Dyna Disk or Bosu type trainers, as static trunk and core stability have been mastered. Once these exercises are performed at a high level, the coach can be assured the athlete has the necessary core stability to start plyometric drills.

SINGLE-LEG BALANCE WITH HIP FLEXION

This exercise provides a functional movement pattern that is similar to running. The exercise seeks to increase stability of the lower abdominal muscles while using a forward motion at the hip. The exercise is designed to develop sagittal-plane control.

While balancing on one leg, the athlete imitates a running motion. As the upper thigh is lifted forward in a running motion, she concentrates on maintaining the abdominal brace and lumbo-pelvic stability while avoiding excessive anterior or posterior pelvic rotation. The athlete raises the opposite arm simultaneously into flexion, while maintaining postural alignment with an erect spine, allowing only the extremities to move.

Progression: Once the athlete can maintain lumbar spine stability without effort, she can attach a pulley or resistive cord to the ankle to increase the challenge to the hip flexors

Figure 15: Single-leg Balance with Hip Flexion

MULTI-DIRECTIONAL LUNGES

The athlete begins this exercise with a forward lunge. Again, the emphasis is on maintaining a neutral spine position and abdominal brace throughout the entire movement. As the athlete steps forward, knee flexion of the forward leg is limited to 90°. The knee joint should be over the ankle joint and the patella aligned with the second toe. The lower part of the leg should be perpendicular to the ground, as shown in Figure 16.

Progression: Once strength and stability in the forward (sagittal) plane have been achieved, the athlete can begin stepping out at oblique angles, creating a narrower lunge or a wider lunge in the coronal or transverse

Figure 16: Multi-directional Lunges

planes. The athlete can also step out onto an unstable surface such as a Bosu Trainer or Dyna Disk, which vastly increase the proprioceptive and dynamic core-stability challenge.

RESISTED ALTERNATE ARM/LEG STEP-UPS

This exercise is a continued progression of multi-directional lunges and must not be started until strength and stability in that exercise has been achieved.

This exercise utilises a sports cord to resist shoulder and hip flexion while doing Step-ups. The movement pattern is similar to the running gait. The athlete's opposite arm and leg are resisted simultaneously to increase the strength and co-ordination of this movement pattern.

Figure 17: Resisted Alternate Arm/Leg Step-ups

MULTI-DIRECTIONAL RESISTED ALTERNATE ARM/LEG STEP-UPS

This is a continued progression of the previous exercise. Once strength and stability is achieved in the frontal plane of motion, the athlete can begin stepping up at a 45°.

Figure 18: Multi-directional Resisted Alternate Arm/Leg Step-ups

STANDING PULLEY OR MEDICINE BALL ROTATION

This resistive, dynamic trunk pattern challenges the core with a rotational movement pattern while the athlete maintains stability in the hips and pelvis. It requires strict bracing of the abdominal muscles and locking the rib cage and pelvis together to avoid unnecessary stress from torsion on the spine.

The athlete stands with feet about shoulder-width apart and knees slightly bent. She activates the abdominal brace prior to the movement. It is important to emphasise postural alignment, with the scapulae retracted and depressed. The athlete should maintain neutral spinal angles throughout the movement. Holding a straight-arm position (elbows extended) while grasping the pulley handle or medicine ball with both hands, the athlete rotates the trunk by activating the abdominal obliques and spinal rotators. She concentrates on keeping the arms extended in front of the chest. It is important that the pelvis remains stable in the movement. Resistance is perpendicular to the body.

This exercise can be done in the same manner using a 2.0 to 4.0kg medicine ball.

Progression: The athlete can add diagonal motions with the pulley or medicine ball.

Figure 19: Standing Pulley or Medicine Ball Rotation

FORWARD LUNGE WITH A MEDICINE BALL WITH TRUNK ROTATION

The purpose of this exercise is to challenge the trunk muscles with appropriate weight shift, balance, and control on one leg. It uses a resistive movement of the trunk with a lunge that demands a high level of lumbo-pelvic and lower extremity stability as the athlete moves the ball in a diagonal pattern across the body.

The athlete will need approximately 30m to complete this exercise. She stands

moves the ball from a lower position at the hip, raising it across the body to the opposite shoulder, simulating a wood-chopping motion. The motion is then reversed by starting at the lower knee position and bringing the ball diagonally across the body, ending overhead at the opposite shoulder. This exercise also can be performed with resistive cords or a pulley system simulating the same motions.

Progression: The athlete can progress to standing on one leg, using the opposite arm to complete the motion.

Figure 21: Standing Reverse Wood-chop with a Medicine Ball

Conclusion

This article is intended to provide an understanding of the importance of core musculature to middle- and long-distance runners and to offer exercises that will help them achieve desired stability, balance, and neuromuscular control. It is highly recommended, however, that athletes consult a skilled practitioner to address individual needs and maximise results from a programme of this nature.

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