

Running Injuries and Core Stability

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Objective: To present a biomechanical examination of trunk and pelvic rotation in the sagittal and frontal planes during running and to demonstrate how dysfunction in the core and pelvic-hip complex muscles may affect the running cycle and increase the risk of injury during running. **Background:** Injuries pertaining to the back, pelvis, hip and thigh account for approximately 25 – 30% of injuries sustained by runners. Lumbo-pelvic support during running comes from the four key stabilizing mechanisms of the core: thoracolumbar fascia; intra-abdominal pressure; the paraspinal muscles (interspinales and intertransversarii) and the deep lumbar musculature (multifidus, lower longissimus and iliocostalis). Contraction of these muscles produces trunk and pelvic rotation in both the sagittal and frontal planes during running. Weakness of core and pelvic-hip musculature may result in poor coordination of lumbo-pelvic force couples, faulty trunk and pelvic rotational mechanics, inadequate transfer of forces up the kinetic chain and increased risk of injuries. **Recommendations:** Clinicians and coaches should appreciate how to effectively include exercises that promote correct coordination and recruitment pattern of core muscles. Exercises should include spinal stabilization and integrated core exercise patterns. **Conclusion:** Adequate stabilization during running allows the trunk musculature to effectively respond to external forces and teaches the athlete to better brace the trunk while initiating powerful movements. Adequate stabilization may also resist shear and compressive forces during sporting activities and allow for optimal rotational mechanics and a reduced risk of lumbar and lower-extremity injuries during running. **Key Words:** core stabilization, lumbo-pelvic-hip complex, injury risk

There are a variety of joint actions, compressive forces and rotational movements that occur during running, placing great stress on connective tissues throughout the body.¹ Runners are aware of these risks and train to decrease the likelihood of injury by progressively increasing exercise intensity and performing resistance training exercises. However, the saying “what you don’t know can hurt you” holds true when it comes to considering what runners understand about the effects of weak core and pelvic stability on the running cycle and what type of training is needed to create functional strength in this area.

We will refer to the term ‘core’ as the muscles of the abdominal wall and lumbar musculature as well as the associated hip and pelvic musculature. We will present the functional anatomy of the core musculature (as it relates to core support and control), examine the rotational biomechanics between the trunk and pelvis in the sagittal and frontal planes during running, and demonstrate how muscle dysfunction in the core can affect the running cycle, decrease athletic performance, and increase the risk of injury during running.

Injuries pertaining to the back, pelvis, hip and thigh account for approximately 25 – 30% of injuries sustained by runners.^{1,2} Other common pathologies affect the foot, ankle, knees and shins. Most of these injuries tend to become recurrent, which creates a challenge for both the clinician and coach.¹

Background

We will describe lumbo-pelvic-hip complex motion with respect to the phases of the running cycle. A complete running cycle is made up of stance and swing phases.¹⁻⁴ The stance phase can be subdivided into periods of propulsion and absorption. Absorption begins at foot strike and finishes at midstance, while propulsion begins at mid stance and finishes at toe off.¹ The swing phase can be subdivided into periods of initial and terminal swing. Initial swing commences after toe off and finishes at midswing, whilst terminal swing commences at midswing and finishes at foot strike.^{1,2} The various phases of stance and swing make up approximately 40 and 60% of the running cycle respectively.^{1,3,4}

Lumbo-pelvic support during running comes from key stabilizing mechanisms of the core: thoracolumbar fascia; intra-abdominal pressure; the paraspinal muscles (interspinales and intertransversarii) and the deep lumbar musculature (multifidus, lower longissimus and iliocostalis).⁵ The thoracolumbar fascia (TLF) can provide a tensile support ('hoop tension') to the lumbar spine by way of internal oblique (IO) and transversus abdominis (TVA) activation.^{4,5} The TVA and IO inserts into the thoracolumbar fascia. This fascia encircles the spine creating an indirect link between the TVA, IO and TLF.⁴ Contraction of the TVA and IO increases tension in the TLF, which in turn creates an extension force on the spine, thereby enhancing its stability.⁴ Intra-abdominal pressure (IAP) provides a stabilizing effect for the entire lumbar area.^{4,5,9} Synergistic contraction of all abdominal muscles, which occurs during running, creates tension on the rectus sheet in the abdomen.^{4,5,9} This sheet encloses the rectus abdominis (RA) and attaches to the IO and TVA.^{4,5,9,11} Tension within the sheet increases abdominal air pressure through movement of the viscera and diaphragm. This results in decompression of the lower lumbar spine, and may reduce compression and shear forces acting on the spine by as much as 30%.¹²

Zatsiorsky¹² argues that IAP is active during running along with TVA activation. Additionally, the deep lumbar muscles are active throughout full lumbar spine motion and during movements of the lower and upper limbs.^{4,11} The external oblique (EO) has clinical significance in an unstable pelvis as well as in lumbo-pelvic positioning during running since it has the ability to both stabilize and rotate the pelvis posteriorly.⁴

It is evident that the TVA, multifidus, IO, EO, paraspinals, and pelvic floor musculature play an important role in stability of the pelvis and lumbar spine during running. Richardson and Jull have demonstrated that with quick movements of legs or arms the TVA fires 30 ms before shoulder movements and 110 ms before leg movements.⁴ They suggested that the TVA anticipates dynamic forces acting on the spine and it should be specifically trained to coordinate with muscles of the lower and upper extremity.

Rotational Mechanics of the Trunk during Running

Sagittal trunk rotation during running, termed flexion and extension, ranges between 2.3 to 23 degrees for speeds of 2-7 m/s.¹ Kinematic three-dimensional (3D) analysis suggests two full oscillations of flexion and extension, with respect to vertical, during a running cycle.^{2,3} Researchers have demonstrated that the position of minimal trunk flexion tends to occur at or just prior to foot strike.¹⁻³ The trunk then flexes during stance phase with maximum trunk flexion occurring during mid to late stance.¹⁻³ Investigators have also demonstrated that as speed increases, the position of minimal trunk flexion occurs during the air-borne period preceding stance, so that by foot strike the trunk has already commenced flexion.^{2,3} Since flexion occurs during moments of stance, the core muscles should demonstrate sufficient strength to stabilize

the spine and minimize unnecessary flexion loads. This may allow for optimal flexion and extension during the running cycle.

The trunk also rotates side to side during running in the frontal plane.¹⁻³ Maximal internal bending of the trunk to the left occurs just prior to foot strike, whereas maximal overall tilting to the left of the trunk segment with respect to the vertical occurs during early stance phase on the left. Thorstensson et al. found that as running speed increased from 2 to 6 m/s, the net angular displacements of the internal bending of the trunk increased from 11 - 20 degrees to 5 - 11 degrees respectively.^{2,3} This may suggest that as speed increases, there is an increased demand for the obliques and other stabilizing core muscles to synergistically control and allow for optimal frontal plane mechanics of the trunk.^{2,3}

Rotational Mechanics of the Pelvis during Running

Rotation of the pelvis occurs in the frontal plane and is termed pelvic obliquity.^{6-9,11} Pelvic obliquity plays a role in shock absorption and in controlling descent and ascent of the body's center of gravity.^{1,11} At midstance the pelvis becomes horizontal, then continues to elevate on the opposite side, reaching a maximum downward obliquity on the stance side during toe off. During the swing phase periods, the pelvis then begins to rise on the initial swing (same) side and lower on the terminal swing (opposite) side as it approaches foot strike. The rotational movements occurring at the trunk and pelvis are thought to play an important role in decoupling intense lower extremity motion from shoulder and head motion.^{8,5} This minimizes head and shoulder movement allowing lateral balance to be maintained.⁸ Muscle weakness/dysfunction in the core such as facilitated iliopsoas or tight quadratus lumborum and weak oblique muscles can negatively impact pelvic obliquity and shock absorption. A facilitated muscle is one that biases the motor neuron pool and therefore becomes overactive during activities that require synergistic use.⁴ This would reduce the efficiency of the running cycle and possibly increase the risk of lumbar, pelvic and lower extremity injuries.⁵

Discussion and Conclusions

Poor lumbo-pelvic stability during running has been cited as being a contributor to lower back pain in athletes.^{5,10} Researchers have demonstrated that the lumbar spine is the pivotal point of the lower extremity lever system during running^{11,12} and that there is a coordinated motor pattern between the movements of the trunk and hip during the propulsion period of stance.^{11,12}

The ground reaction forces and inertial forces acting on the body during running need to be controlled and dispersed by muscles tendons, ligaments and joint capsules. Many authors have reported a relationship between disturbances to the normal kinematic pattern of the hip and lumbar spine during running.^{1-5,12} Weak TVA and RA muscles coupled with a tight iliopsoas may increase hip flexion angle at foot strike, which may lead to excessive stress placed on the hamstrings with an increase risk of hamstring injuries.^{1,4,10} It has been argued that there is a biomechanical link between poor core stabilization and injuries such as posterior tibial tendonitis, medial shin splints, chondromalacia patellae, plantar fasciitis, hamstring tears and other musculoskeletal injuries (especially during functional lower extremity movements).^{1-5,11} Many such pathologies share a common risk factor, overpronation, which can be the result of dysfunction in the kinetic chain emanating from the core.^{4,5,8,11}

Since motor patterns are centrally generated, evaluation of recurring lower extremity injuries may also warrant an evaluation of the strength and stabilizing ability of the core musculature. Clinicians and coaches should be encouraged to think outside the box and understand how dysfunction in any part of the kinetic chain can lead to a variety of

musculoskeletal problems. Many of these problems can be reduced by simply learning to coordinate the muscles of the deep abdominal wall during functional movements.⁴

To reduce the likelihood of lower extremity injuries, runners and other athletes need to include exercises that emphasize core stability during dynamic movements. This would teach them to maintain neutral alignment of the vertebrae with muscular control, and allow for force dissipation throughout the axial skeleton.⁴ Maintaining neutral spinal alignment during dynamic lower extremity movement provides the ideal biomechanical advantage for the trunk musculature to effectively respond to external forces as it trains the athlete to resist shear and compressive forces during sporting activities. Therefore, clinicians and coaches should understand how to include exercises that effectively train the coordination and recruitment pattern of core muscles. Exercises should include spinal stabilization and functional open-and closed-chain integrated core exercise patterns. This may help to maintain adequate lumbo-pelvic-hip stability, allow for optimal rotational mechanics, and reduce the risk of running injuries.

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