Influence of Lower Extremity Biomechanics and Muscle Imbalances on the Lumbar Spine

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If an athlete presents with an apparent case of shin splints, a thorough evaluation should address the structure and function of the foot. However, if this same athlete came to you with low back pain, would you still be as inclined to look at his or her feet?

Overuse injuries such as shin splints are often caused by abnormal biomechanics in the lower extremity. While we as clinicians may feel more informed about the effect that lower extremity biomechanics can have on pathologies ranging from the foot to the hip, it is also important to consider the effect of lower extremity biomechanics on the pelvis and lumbar spine.

Causes of low back pain range from direct trauma to improper lifting techniques and poor posture. Muscle imbalances that contribute to postural problems are often associated with the onset of low back pain. However, other factors such as foot dysfunction can also play a role.

Key Points

- Abnormal biomechanics may cause compensatory movements that lead to microtrauma in the pelvis and lumbar spine.
- A comprehensive evaluation for low back pain should include assessment of the lower extremities for abnormal biomechanics.
- Muscle imbalances of the pelvis or lower extremities may contribute to the onset of low back pain.

A study by D'Amico (1976) has documented that over 50% of posture related low-back-pain patients may have foot dysfunction or deformity as a potential etiology. Clinically, both postural imbalances and lower extremity biomechanics should be considered when treating athletes with low back pain.

This article highlights the relationship between the lumbar spine, pelvis, muscle imbalances, and the lower extremities. We encourage clinicians to address this relationship when evaluating the athlete with low back pain.

Review of Closed Kinetic Chain Motion

Motion at the subtalar joint (STJ) consists of pronation and supination. Pronation is an important component of STJ range of motion because it provides shock absorption and allows the foot to adapt to changes in terrain. Supination is important because it allows the foot to become a rigid lever for propulsion. During gait, the STJ influences motion that occurs throughout the lower kinetic chain by transmitting forces between the foot and lower extremity.

Table 1 depicts how movements at the foot, such as STJ pronation, are associated with movements at the tibia, femur, hip, and low back. Likewise, forces originating in the low back
may result in compensatory movements that are transmitted down the lower extremity and into the foot. Abnormal biomechanics, whether due to acute injury, structural deformity (e.g., forefoot varus), or muscle imbalance, will cause the body to compensate and alter its normal function. For instance, an athlete with a tight gastrocnemius may lack sufficient dorsiflexion for gait and will compensate by toeing-out while walking. Often it is this compensatory motion that leads to microtrauma and injury.

While a certain amount of STJ pronation and supination is needed for normal gait, excessive or limited amounts of either motion may contribute to abnormal forces which are generated throughout the lower kinetic chain, pelvis, and lumbar spine. Hyperpronation, or pronation that occurs beyond the midstance period of the gait cycle, leads to a hypermobile foot and is commonly identified as a contributor to pathologies ranging from the foot to the sacroiliac joint. Conversely, the absence of normal STJ pronation during gait lowers the shock absorption ability in the lower extremity, pelvis, and lumbar spine. An athlete who presents with a supinated gait pattern will often present with a rigid foot which does not allow for optimal force attenuation and may cause low back pain.

### Influence of Muscle Imbalance on the Lumbar Spine

Identifying muscle imbalance is a key component in the evaluation of low back pain. This includes not only those muscles that attach to the spine and pelvis but the lower extremity muscles as well. When evaluating which muscles are tight or weak, it is important to remember that postural imbalances are often influenced by those muscles that function in the same plane of movement (Botte, 1981; D'Amico, 1976). For example, a posterior pelvic tilt is considered a sagittal plane deviation and is influenced by sagittal plane movers, such as the hamstrings.

However, analysis of deviations and imbalances in all three cardinal planes is essential because dysfunction in any one plane can cause dysfunction of the remaining two planes (D'Amico, 1976). The following sections will detail deviations and associated muscle imbalances in each of the body’s three cardinal planes.

### Sagittal Plane Dysfunctions

A sagittal plane deviation of the lumbar spine, such as increased lumbar lordosis, is influenced by sagittal plane movers, i.e., abdominals, hip flexors, gluteus maximus, quadriceps, hamstrings, anterior tibialis, and gastrocsoleus (Botte, 1981). Weakness or tightness in any of these muscles will contribute to an anterior or posterior pelvic tilt.

An anterior pelvic tilt is associated with hyperlordosis in the lumbar spine because it increases the extension moment at the lumbosacral region and flexion moment of the sacrum on the ilium (DeRosa & Porterfield, 1989). Muscle imbalances of the pelvis associated with an anterior pelvic tilt include tightness of the erector spinae, iliopsoas, and rectus femoris, and weakness of the abdominals, gluteus maximus, and hamstrings.

Due to the repetitive nature of running, runners often develop adaptive shortening of the hip flexors, hamstrings, or calf mus-

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**Table 1: Summary of Lower Kinetic Chain Joint Motions**

<table>
<thead>
<tr>
<th>Increased lumbosacral angle</th>
<th>Decreased lumbosacral angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior pelvic tilt</td>
<td>Posterior pelvic tilt</td>
</tr>
<tr>
<td>Hip flexes</td>
<td>Hip extends</td>
</tr>
<tr>
<td>Femoral IR, adduction</td>
<td>Femoral ER, abduction</td>
</tr>
<tr>
<td>Knee flexes; valgus stress</td>
<td>Knee extends; varus stress</td>
</tr>
<tr>
<td>Tibial IR, anterior migration</td>
<td>Tibial ER, posterior migration</td>
</tr>
<tr>
<td>STJ pronation</td>
<td>STJ supination</td>
</tr>
</tbody>
</table>

Note: The arrows show that movement originating at the foot may lead to movement and forces proximally, and that movements originating in the spine/pelvis may be transmitted distally as far down as the foot.

IR = internal rotation; ER = external rotation.