The Importance of Flexibility for Functional Range of Motion

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The effectiveness of preexercise static stretching for performance enhancement and injury prevention has recently been questioned. The majority of relevant research has been focused on the short-term effects of static stretching\(^1\) rather than its long-term effects on functional range of motion (FROM). For example, the impact of inadequate dorsiflexion FROM on subtalar mechanics and tibial rotation and their influence on patellofemoral motion are well documented.\(^2,3\) The potential influence of joint hypomobility on dysfunction of the entire kinetic chain cannot be ignored. If one link of a kinetic chain is hypomobile, the proximal links must alter their function to preserve the overall “normal” function of the integrated kinetic chain.\(^4\) This compensatory alteration of proximal joint function leads to long-term changes in the flexibility of associated soft tissues (muscle, tendon, ligament, and fascia), as well as changes in neuromuscular activation patterns, as each component of the kinetic chain seeks the path of least resistance during performance of functional-movement patterns.\(^5\) This article presents a framework assessing FROM of the lower extremity and reviews contemporary techniques for restoring restricted FROM.

The Kinetic Chain

Gross movement of a multisegmental system (e.g., the spine or an extremity) is the result of numerous interdependent motions within each of the joints that make up the kinetic chain. For example, each spinal segment produces relatively little motion. The amount of forward flexion occurring between the first and second lumbar vertebrae is relatively small, but summation of the forward flexion occurring between all lumbar, thoracic, and cervical vertebrae can produce a large amplitude of overall spine flexion. An anatomic leg-length discrepancy will create pelvic obliquity in the frontal plane (i.e., the pelvis will be lower on the side of the shorter extremity), which induces lateral flexion of the lumbar spine toward the opposite side. A functional leg-length discrepancy, which is produced by excessive subtalar pronation during the stance phase of the gait cycle, is associated with a drop of both the navicular and the head of the talus and internal rotation of the tibia in relation to the foot. As internal-rotation torque is transferred through the knee joint, the tibia internally rotates in relation to the femur, which induces a valgus alignment of the lower extremity. Farther up the kinetic chain, the pelvis will also drop,

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**Key Points**

Loss of functional range of motion can alter the function of the various components of the kinetic chain, thereby increasing injury susceptibility.

Both the athlete and the athletic trainer or therapist must understand that time and effort are required to restore normal functional motion.

Loss of functional range of motion is readily identifiable by an athletic trainer or therapist.

Regular performance of stretching exercises, combined with self-mobilization of soft tissue, can facilitate restoration of normal functional motion.

Key Words: kinetic chain, stretching, self-mobilization of soft tissue
which induces the same effect on the spine as an anatomic leg-length discrepancy.

Clinicians should always assess movement of the entire kinetic chain when evaluating injuries. A goniometric measurement of straight-leg hip flexion to assess hamstring flexibility is certainly useful, but it is not the only means by which flexibility should be evaluated. A tight hamstring in a supine athlete does not necessarily limit FROM. Using inductive reasoning (i.e., a specific observation used as the basis for a generalized explanation), clinicians often assume that there is a relationship between hamstring tightness and lumbar pain. Although this assumption is widely accepted, it would seem to make more sense for the clinician to assess the athlete's flexibility while the athlete performs a controlled functional motion. This type of assessment will enable the clinician to see where the limitations in motion occur and where compensatory movement strategies are employed during the functional motion. The clinician can use deductive reasoning (i.e., a general observation used as the basis for identification of a specific problem) to relate FROM restrictions to alterations in the normal function of the components of the kinetic chain, thereby focusing attention on specific component motions that must be restored for resolution of symptoms.

Assessment Framework

For the kinetic chain to function optimally, each component of the chain must make specific motion contributions that are coordinated with those of the other components. Inadequate flexibility can adversely affect the component motions of the kinetic chain, which can contribute to injury susceptibility. If there is not an optimal length–tension relationship in the musculotendinous units crossing any of the component joints of the kinetic chain, compensatory motion at other joints must occur. Muscle weakness, antagonist strength imbalances, altered neuromuscular control, and excessive loading of tissues can result. A functional-movement screen (FMS) might identify compensatory joint motions during performance of general functional-movement patterns (e.g., walking gait, overhead-squat test, single-leg-squat test) or sport-specific movement patterns.5,6

One of the most commonly used procedures for assessing lower extremity FROM is the overhead double-leg squat (ODLS). The ODLS is a multijoint and multiplane exercise that involves large and small muscle groups. The procedure for assessing lower extremity FROM with the ODLS is outlined in Table 1. It is imperative for the clinician to ensure the athlete's safety during performance of the functional-movement pattern. The ODLS should only be performed when an athlete is capable of full weight bearing in both extremities.

An athlete with a unilaterally tight gastrocnemius-soleus complex that limits dorsiflexion of the left ankle might exhibit a variety of alterations in the kinetic-chain movement pattern while performing the ODLS (Figures 1–3). From an anterior viewpoint, pronation of the subtalar joint might be observed, which is associated with navicular drop and internal rotation of the tibia in relation to the foot. Farther up the kinetic chain, the pelvis might be observed to descend to a greater extent on the involved side. From a lateral viewpoint, the athlete's heel might lift off the floor during the movement, which will be associated with a rate of hip descent faster than the rate of knee descent. Ideally, the athletic trainer or therapist would videotape the performance of 5–10 repetitions of each exercise, and check for repeated compensatory motions or apparent motion restrictions. Figure 1 illustrates the starting position for the ODLS, and the final position is illustrated in Figure 2 (lateral viewpoint) and Figure 3 (anterior viewpoint). Lacking normal dorsiflexion of the left ankle, the athlete exhibits abduction of the long axis of the left foot (Figure 3[a]) and lateral movement of the left knee (Figure 3[b]). Hamstring tightness and iliopsoas weakness are made evident by flexion of the lumbar spine, which is caused by a combination of hamstring tension acting on the ischial tuberosity and failure of the iliopsoas to generate downward rotation of the pelvis (Figure 2[b]). Tightness of the contralateral latissimus dorsi is indicated by asymmetrical elevation of the arms (Figure 3[c]). The athlete whose ODLS performance is illustrated had difficulty in repetitively performing this functional-movement pattern. His ODLS findings were consistent with the results of an orthopedic clinical assessment and his chief complaints. The FMS findings also provide the basis for the rehabilitation plan: to increase ankle dorsiflexion, increase hamstring flexibility, and increase iliobial-band flexibility.

The FMS procedures focus on soft-tissue restrictions affecting FROM, which are difficult to quantify and are not indicated by empirical evidence. The loss
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<thead>
<tr>
<th>Table 1. Procedures for Assessing Functional Range of Motion of the Lower Extremities During an Overhead Double-Leg Squat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Positioning of the athlete</strong></td>
</tr>
<tr>
<td><strong>Demonstration of the exercise</strong></td>
</tr>
<tr>
<td><strong>Performance of the overhead double-leg squat</strong></td>
</tr>
<tr>
<td><strong>Positioning of the clinician for viewing the exercise</strong></td>
</tr>
</tbody>
</table>
| **Review of the exercise by the clinician** | Review by the clinician must be systematic: a top-down or bottom-up approach.  
Anteroposterior view: Watch for symmetry of motion and weight shift to one side; watch the position of the foot and the navicular tubercle, tibial rotation, and alignment in relation to the patella; patellar orientation/motion; and symmetry of iliac crests. Facial expression should not indicate pain.  
Lateral view: Watch for the heels to remain on the floor, ankle-dorsiflexion angle, knee position with respect to the feet, and knee-flexion angle; anterior thigh drops to a level parallel to floor; knee and hip should move in unison at the same rate; lumbar-flexion angle remains constant with no rounding of the spine; head and chest remain upright facing forward, with the acromion process maintained in a position over the arch of the foot. |

![Figure 1](image1.png) Overhead double-leg squat: midposition lateral view.  
![Figure 2](image2.png) Overhead double-leg squat: end-position lateral view.  
![Figure 3](image3.png) Overhead double-leg squat: end-position anteroposterior view.
of FROM can be related to a variety of etiologic factors, including bony or ligamentous pathology, pain, poor kinesthetic awareness of body position, sport-specific adaptations (e.g., greater than normal external rotation of the dominant shoulder of a tennis player, spine hypermobility in a gymnast), muscle weakness attributable to a neurologic condition, or a combination of these factors. Therefore, the FMS must be viewed as one part of the overall assessment of the athlete (i.e., a tool in the “assessment toolbox”), rather than the only means of assessment. The FMS can help the clinician identify and address the cause of symptoms, rather than simply treating symptoms.

**Stretching Suggestions**

Flexibility exercises can be categorized as corrective, active, or functional. The remainder of this article will be limited to corrective flexibility exercise, which can be used during the initial phase of rehabilitation for restoring FROM. Two types of corrective flexibility exercise are static stretching and self-mobilization of soft tissue (or self-administered myofascial release). Although evidence supporting the effectiveness of preactivity static stretching for injury prevention and performance enhancement is lacking, static stretching can be useful for maintaining or restoring FROM. When combined with appropriate strengthening exercises, core-stabilization exercises, and activities designed to enhance neuromuscular coordination, stretching exercises can make a meaningful contribution to successful rehabilitation.

Static stretching consists of passively elongating musculotendinous units to the point of tension development and holding the stretch in a static position for approximately 15–30 s. The athlete should not experience pain or excessive discomfort. If the muscle is stretched slowly, activation of the Golgi tendon organ can facilitate relaxation of active tension within the muscle (autogenic inhibition). Stretching should be performed at least one time per day, after exercise, but twice per day is preferred (morning and postexercise). It is extremely important to educate athletes to ensure compliance with a stretching-exercise regimen. The more the athlete understands about his or her injury and contributing etiologic factors, the more likely it is that he or she will recognize the importance of regularly performing the stretching exercises. We have found that athletes who are compliant with a prescribed stretching regimen report improvement in approximately 4 weeks.

Stretching by means of self-mobilization of soft tissue can be very beneficial. A technique commonly used for iliotibial-band tightness involves using a foam roller to improve soft-tissue extensibility (Figure 4). Because muscle fascia is less elastic than the muscle’s contractile elements, its degree of extensibility plays an important role in either limiting or allowing motion. Scar tissue and contractures can decrease the elasticity in the muscle fascia, which can result in focal areas of reduced soft-tissue mobility, referred to as fascial tension. Fascial tension might present as a highly localized point of tenderness, or trigger point. Foam rollers are useful in two ways: They can be used to assist the athlete in static stretching, and as the body weight compresses the tissue associated with a trigger point under the foam roller it can relieve its hypertonicity and hypersensitivity. Once instructed on the correct use of a foam roller, the athlete can use it to find and release the trigger points and stretch the involved tissue.

The importance of compliance with a stretching regimen cannot be overemphasized. Restoring FROM to an optimal level might take more time than what is necessary to relieve symptoms As an athlete begins to feel better, he or she often becomes less compliant with a prescribed stretching program, especially unsupervised self-care programs. The athlete must understand the underlying cause of the condition and the need for continued compliance to prevent recurrence of symptoms.

![Figure 4](image.png)  
Foam-roller exercise for iliotibial-band flexibility.
Summary

The current discussion about the lack of available research evidence to support the effectiveness of preactivity stretching for injury prevention and performance enhancement seems to detract from the widely accepted idea that stretching exercises are important for long-term maintenance of FROM. Despite questions about the validity of long-held assumptions pertaining to the relationship between preactivity stretching exercises and subsequent short-term susceptibility to injury, flexibility is clearly an important aspect of optimal function. All flexibility-assessment techniques (e.g., goniometric measurement of isolated joint mobility and FMS) and all stretching methods (e.g., active, passive, contract–relax, spray and stretch, etc.) should be used as tools in your professional “toolbox.” Remember the old saying, “If the only tool in your toolbox is a hammer, then everything you are fixing starts to look like a nail.” Understanding how, when, and why to use each tool will maximize the benefits an athlete will ultimately realize from the treatments he or she is provided.

References


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