17

Functional Movement Assessment

Barbara J. Hoogenboom, Michael L. Voight, Gray Cook, and Greg Rose

OBJECTIVES

After completion of this chapter, the physical therapist should be able to do the following:

- Explain the benefits of a functional, comprehensive movement screening process versus the traditional impairment-based evaluation approach.
- Differentiate between movement, testing, and assessment.
- Explain how poor movement patterns and dysfunctional movement strategies can result in injury or reinjury.
- Explain the use and components of the Functional Movement Screen and the Selective Functional Movement Assessment.
- Describe, score, and interpret the movement patterns of the Functional Movement Screen and the Selective Functional Movement Assessment and how the results from each can have an impact on clinical interventions.
- Articulate the difference between movement screening and specific functional performance tests.
- Apply specific functional performance test to clinical practice.

Introduction

Movement is at the core of the human journey. It is foundational to the human experience and allows us to interact with our environment in ways different from other mammals. Movement, which begins in the womb, is the basis of early growth and development. It proceeds in a highly predictable manner in infants and young children and is known as the developmental sequence or traditional motor development. Once an individual reaches a certain age, full integration of reflexive behavior allows the development of purposive, highly developed, and unique mature motor programs. We continue to move functionally throughout a lifetime until the effects of aging alter the normalcy of movement.

Motion versus Movement

Because movement is complex, it must be differentiated from the simpler construct of motion. We believe that many professionals lack a true understanding of movement; they err on the side of quantitative assessment of motion and fail to understand the hierarchic progression from general, fundamental movement patterns to specific, highly specialized movements. These highly specialized movements have complex, fine-tuned motor programs that support their consistency and intricacy. Most rehabilitation and medical professionals have been trained to measure isolated joint motion with goniometers, inclinometers, linear measurements, and ligament laxity tests. These types of motion assessment are not wrong, but rather only a piece of a much bigger puzzle of "movement" and the inherent stability and mobility demands that are part of the synchronous, elegant, coordinated activities that make up activities of daily living, work tasks, and sport maneuvers. Mere motion measurements cannot capture the whole spectrum of human movement, nor the complexity of human function.

Systems Approach to Movement

The premise of this chapter and the chapter that follows is that impairment-based, highly specialized motion assessment is far too limiting, and predisposes practitioners to errors in professional judgment. It is too narrow an approach, which focuses on small, discrete pieces of an integrated functional task or movement. The alternative of a more functional, comprehensive movement screen is vitally important for understanding human function and identifying impairments and dysfunctional movement patterns that diminish the quality of function. In many cases, weakness or tightness of a muscle or group is often identified and then treated with isolated stretching or strengthening activities instead of using a standard movement pattern that could address several impairments at once. Likewise, many professionals often focus on a specific region of complaint instead of beginning by identifying a comprehensive movement profile and relating the profile to dysfunction.

"Fundamentals First"

Where does one start with the examination and assessment of something as complex as human function? Standard, frequently used, fundamental or general movements would seem the logical place to start. To prepare an athlete for the wide variety of activities needed to participate in the demands of sport, analysis of fundamental movements should be incorporated into preparticipation screening. Assessment of fundamental movements can help the rehabilitation professional determine who possesses or lacks the ability to perform a wide variety of essential movements. We believe that assessment of fundamental or composite movements is necessary before the assessment of highly specific or specialized motions or movements. Consider the following statements in the context of assessment of an athlete:

- What appears to be muscular weakness may be muscular inhibition.
- Identifiable weakness in a prime mover may be the result of a dysfunctional stabilizer or group of muscular stabilizers.
- Diminished function in an agonist may actually be dysfunction of the antagonist.
- What is described as muscular tightness may be protective muscle tone leading to guarding and inadequate muscle coordination during movement.
- "Bad" technique might be the only option for an individual performing poorly selected, "off-target" exercises.
- Diminished general fitness may be related to the increased metabolic demand required by patients who use inferior neuromuscular coordination and compensations.

It is vital that fundamental, essential movements be examined to develop a working hypothesis regarding the *source* of the dysfunction. This approach allows the rehabilitation professional to see "the big picture" and attempt to discern the cause of the dysfunction rather than just identifying and treating specific, isolated impairments. This fundamental first approach, typically used when teaching a motor skill, holds true for assessment and correction of movement.

The Mobility–Stability Continuum

Movement becomes less than optimal (dysfunctional) as a result of "breakdowns" in parts of the movement system. Typically, such breakdowns are described as mobility or stability dysfunction. Unfortunately, the terms *mobility* and *stability* are not universally defined and can imply different things to clinicians with different backgrounds. For this reason it is important to describe the approach of the authors regarding descriptions of mobility and stability.

Mobility dysfunction can be broken down into 2 unique subcategories:

- *Tissue extensibility dysfunction* involves tissues that are extraarticular. Examples include active or passive muscle insufficiency, neural tension, fascial tension, muscle shortening, scarring, and fibrosis.
- *Joint mobility dysfunction* involves structures that are articular or intraarticular. Examples include osteoarthritis, fusion, subluxation, adhesive capsulitis, and intraarticular loose bodies.

Stability dysfunction may include an isolated muscular weakness or joint laxity, but it is frequently more complex and refers to multiple systems that are involved in the complex construct known as motor control. To account for the complexity of a stability problem, the term *stability motor control dysfunction* is used. Stability motor control dysfunction is an encompassing, broad description of problems in movement pattern stability. Traditionally, stability dysfunction is often addressed by attempting to concentrically strengthen the muscle groups identified as stabilizers of a region or joint. This approach neglects the concept that true stabilization is reflex driven and relies on proprioception and timing rather than isolated, gross muscular strength. By using the term stability motor control dysfunction to distinguish stability problems, the clinician is forced to consider the central nervous system, peripheral nervous system, motor programs, movement organization, timing, coordination, proprioception, joint and postural alignment, structural instability, and muscular inhibition, as well as the absolute strength of the stabilizers. The concepts of mobility and stability are discussed further in the context of the Selective Functional Movement Assessment (SFMA) later in this chapter.

The purpose of this chapter, as part of a sports medicine rehabilitation text, is to provide the context for and convince the reader of the importance of a timely, accurate, and reproducible functional movement assessment. Although a part of examination, isolated measurements and quantitative assessments are not enough to capture the essence of functional movement in activities of life.

Movement Screening, Testing, and Assessment

Athletic trainers screen during the preseason. Physical therapists are involved in screening, prevention, and wellness initiatives. Physicians serve patients by medically or surgically "fixing problems" but also attempt to prevent repeat injury. The number 1 risk for injury is previous injury.[1-6] What contributes to this paradigm? Poor screening that does not identify athletes at risk for injury? Poor rehabilitation that does not "finish the job"? "Poor" or untested surgical or medical interventions that do not get to the "root" of the problem? Each is a possibility, and all disciplines may be responsible for unsuccessfully preparing or providing the building blocks for full return to movement normalcy. It is the "job" of all health professionals to adequately screen, test, assess, and identify movement dysfunction and offer solutions to restore movement efficiency and normalcy.

At this point it is important to distinguish between screening, testing, and assessment (Table 17-1). This chapter is written to enhance the reader's ability to comprehensively assess the "movement" (recall the previous discussion of movement versus motion) of patients, athletes, and clients. Many would argue that assessment of movement is important before embarking on a physical performance endeavor because the ability to move provides the foundation for the ability to perform physical fitness activities, work and athletic tasks, and basic activities of daily living. It is important to be able to distinguish dysfunctional movement from "normal" movement during preparticipation or preseason screening, as well as during postinjury or postoperative rehabilitation. It is also important to acknowledge that training through or despite "poor" movement patterns reinforces poor quality of movement and is likely to increase the risk for injury and predispose to greater

Table 17-1 Difference between Screening, Testing, and Assessment

Term	Definition	Meaning
Screening	A system for selecting suitable people; to protect somebody from something unpleasant or dangerous	To create grouping and classification; to check risk
Testing	A series of questions, problems, or practical tasks to gauge knowledge, experience, or ability; measurement with no interpretation needed	To gauge ability
Assessment	To examine something; to judge or evaluate it; to calculate a value based on various factors	To estimate inability

levels of dysfunction.[4-6] Even highly skilled athletes may have fundamental imperfections in movement.

We propose that the astute sports medicine professional combine the tasks of screening, testing, and assessment to systematically ascertain the risk, ability, or inability of each athlete, patient, or client. The outcome of such a logical and refined procedure would provide the caregiver the best possible information to formulate opinions regarding readiness for participation or return to activities.

Therefore, screening might come first in the assessment process, and the outcome of a useful, practical movement screening tool or approach would allow the provider to do the following:

- Demonstrate movement patterns that produce pain within expected ranges of movement.
- Identify individuals with nonpainful but limited movement patterns who are likely to demonstrate higher potential risk for injury with exercise and activity.
- Identify specific exercises and activities to avoid until competency in the required movement is achieved.
- Identify and logically link screening movements to the most effective and efficient corrective exercise path to restore movement competency.
- Build a description of standardized, fundamental movement patterns against which broader movement can be compared.

Sahrmann, Kendall, and Janda have each offered valuable perspectives regarding human movement, posture, and function.[7-9] They have been instrumental in describing examination of structural, as well as functional, symmetry or lack thereof. Rehabilitation professionals have progressed from examination of isolated muscles and posture[7] to appreciation of the necessity of examining complex movement patterns.[9]

> There are numerous ways in which slight subtleties in movement patterns contribute to specific muscle weaknesses. The relationship between altered movement patterns and specific muscle weaknesses requires that remediation address the changes to the movement pattern; the performance of strengthening exercises alone will not likely affect the timing and manner of recruitment during functional performance.
>
> —Dr. Shirley Sahrmann

The transition from analysis of motion to analysis of functional movement and movement patterns helps rehabilitation providers discern the underlying cause of the dysfunction or imbalance. This paradigm shift propels rehabilitation providers toward the big picture, cause-and-effect, and regional interdependence thinking necessary for success in the 21st century.

Most would agree that it is difficult to qualitatively discern the quality of movement unless provided with a framework for making a judgment. Systematic screening, testing, and assessment of movement require not only a framework, but also benchmarks or criteria that define the proper method of performing a movement. We propose 3 possible general outcomes of movement assessment (Table 17-2) as determined by comparison between the movement performed by the athlete and predetermined descriptors of success.

Training through or despite identified “poor” movement patterns reinforces poor quality and increases the risk for injury, even during low-stress activities, and the possibility of progression to greater movement dysfunction. Training and functional exercise techniques and strategies are covered in Chapter 20; however, it is important to note here that that poor movement patterns must be identified and addressed before embarking on high-level functional training.

Table 17-2 **Outcomes of Movement Assessment**

Outcome	Description
Acceptable	Movement is good enough to allow the individual to be cleared for activity without an increase in risk for injury.
Unacceptable	Movements are dysfunctional and the individual may be at risk for injury unless movement patterns are improved.
Painful	Screening movements produce pain. Currently injured regions require additional, more advanced movement and physical assessment, including imaging, by a qualified health care provider.

Movement Related to Injury Potential and Return from Injury

The greatest risk for injury is a history of previous injury,[1-6] and this fact has been demonstrated in a wide variety of populations and athletes. Yet how might this relate to an uninjured athlete or worker? Are there certain "markers" or performance measures that could separate high-quality, proper or correct movement from low-quality, improper or incorrect movements? Conceptually, if movement is dysfunctional, all activities, including activities of daily living, work tasks, and athletic performance built on that dysfunction, may be flawed and predispose the individual to increased risk for the development of even greater dysfunction. This statement is true even when dysfunctional base movements are masked by apparently acceptable, age-appropriate, and even highly skilled performance. It is possible to move poorly and not experience pain, and, conversely, to move well and yet experience pain. Over time, poor movement patterns and dysfunctional movement strategies are likely to produce pain. An example might be a gymnast with an exaggerated lordosis that is "functional" for her sport but is likely, over time, to result in facet joint compression in the lumbar spine and decreased flexibility of the hip flexors. It is important to note that although poor movement patterns may increase risk for injury with activity, good movement patterns do not guarantee decreased risk for injury. It is the job of the astute health care professional to target and address identifiable risk factors, such as tight muscles, weak muscles, or poor balance or coordination, during movement and their biomechanical influences on movement. Once poor movement patterns are addressed, proper movement must be enhanced with appropriate strength, endurance, coordination, and skill development, but proper movement comes *first!*

The Functional Movement Screen and the Selective Functional Movement Assessment

The 2 movement assessment systems described in this chapter work together and use some common patterns of movement, but each possesses unique aspects. They serve to provide common language and "thinking" between a wide variety of health and fitness professions. Both are about the assessment of *quality* and not so much about the assessment of *quantity* of movement. Both stress the clinician's ability to rate performance quality, rank and describe the greatest dysfunction, and measure, if necessary, within the context of foundational, general movements.

The Functional Movement Screen

The Functional Movement Screen (FMS) is a predictive, but *not* diagnostic, functional screening system. The FMS is an evaluation or screening tool created for use by professionals who work with patients and clients for whom movement is a key part of exercise, recreation, fitness, and athletics. It may also be used for screening within the military, fire service, public safety, industrial laborers, and other highly active workers. This screening tool fills the void between preparticipation/preplacement screening and specific performance tests by examining individuals in a more general dynamic and functional capacity. Research suggests that tests that assess multiple facets of function such as balance, strength, range of motion (ROM), and motor control simultaneously may assist professionals in identifying athletes at risk for injury.[10-12]

The FMS, described by Cook et al,[13,14] is composed of 7 fundamental movement patterns that require a balance of mobility and stability for successful completion. These functional movement patterns were designed to provide observable performance tasks that relate to basic locomotive, manipulative, and stabilizing movements. The tests use a variety of common positions and movements appropriate for providing sufficient challenge to illuminate weakness, imbalance, or poor motor control. It has been observed that even individuals who perform at high functional levels during normal activities may be unable to perform these simple movements if appropriate mobility or stability is not present.[10,11] An important aspect of this assessment system is its foundation on principles of proprioception and kinesthesia. Proprioceptors must function in each segment of the kinetic chain and associated neuromuscular control must be present for efficient movement patterns to occur.

The FMS is not intended for use in individuals displaying pain during basic movement patterns or in those with documented musculoskeletal injuries. Painful movement is covered subsequently in the section on the SFMA. The FMS is for healthy, active people and for healthy, inactive people who want to increase their physical activity. Interrater reliability of the FMS has been reported by Minick et al[15] to be high, which means that the assessment protocol can be applied and reliable scores obtained by trained individuals when there is adherence to standard procedures.

The FMS consists of 7 movement patterns that serve as a comprehensive sample of functional movement (Box 17-1). Additionally, 3 clearing tests, each associated with one of the FMS movement patterns, assess for pain with shoulder rotation motions, trunk extension, or trunk flexion.

A kit for FMS testing is available commercially (www.performbetter.com); however, simple tools such as a dowel, 2 × 6 board, tape, tape measure, a piece of string or rope, and a measuring stick are enough to complete the testing procedures. When conducting the screening tests, athletes should not be bombarded with multiple instructions about how to perform the tests; rather, they should be positioned in the start position and offered simple commands to allow achievement of the test movement while observing their performance. The FMS is scored on an ordinal scale, with 4 possible scores ranging from 0 to 3 (Table 17-3). The clearing tests mentioned earlier consider only pain, which would indicate a "positive" clearing test and requires a score of 0 for the test with which it is associated.

Box 17-1 Seven Movement Patterns of the Functional Movement Screen

- Deep squat
- Hurdle step
- In-line lunge
- Shoulder mobility test
- Active straight-leg raise
- Trunk stability pushup
- Rotatory stability test

Table 17-3 **Scoring System for the Functional Movement Screen**

A Score of . . .	Is Given if . . .
0	At any time during testing the athlete has pain anywhere in the body. *Note:* The clearing tests consider only pain, which would indicate a "positive" clearing test and requires a score of 0 for the test with which it is associated.
1	The person is unable to complete the movement pattern or is unable to assume the position to perform the movement.
2	The person is able to complete the movement but must compensate in some way to complete the task.
3	The person performs the movement correctly, without any compensation.

Three is the highest or best score that can be achieved on any single test, and 21 is the best total score that can be achieved.

The majority of the movements test both the right and left sides, and it is important that the sides be scored independently. The lower score of the 2 sides is recorded and used for the total FMS score, with note made of any imbalances or asymmetry occurring during performance of the task (Figure 17-1). The creators of the FMS suggest that when in doubt, the athlete should be scored low.

Seven Movement Patterns of the Functional Movement Assessment

The Deep Squat (Figure 17-2) The squat is a movement needed in most athletic events; it is the "ready position" that is required for many power movements such as jumping and landing. The deep squat assesses bilateral, symmetric mobility and stability of the hips, knees, ankles, and core. The overhead position of the arms (holding the dowel) also assesses the mobility and symmetry of the shoulders and thoracic spine. To perform a deep squat, the athlete starts with the feet at approximately shoulder width apart in the sagittal plane. The dowel is grasped with both hands, and the arms are pressed overhead while keeping the dowel in line with the trunk and the elbows extended. The athlete is instructed to descend slowly and fully into a squat position while keeping the heels on the ground and the hands above the head.

FMS™ Test	Right	Left	Score	(for bilateral tests, eboose lowest score to record)
Overhead deep squat	X	X		
Trunk stability push-up	X	X		
Hurdle step (droped by among LE)				
In-line lunge (droped by forward LE)				
Shoulder mobility (droped by upper UE)				
Active straight leg raise				
Rotary stability (droped by among LE)				
Total Score ______/21				

Figure 17-1 **Functional Movement Screen scoring sheet**

LE, Lower extremity; UE, upper extremity

The Hurdle Step (Figure 17-3) The hurdle step is designed to challenge the ability to stride, balance, and perform a single-limb stance during coordinated movement of the lower extremity (LE). The athlete assumes the start position by placing the feet together and aligning the toes just in contact with the base of the hurdle or 2 × 6 board. The height of the hurdle or string should be equal to the height of the tibial tubercle of the athlete. The dowel is place across the shoulders below the neck, and the athlete

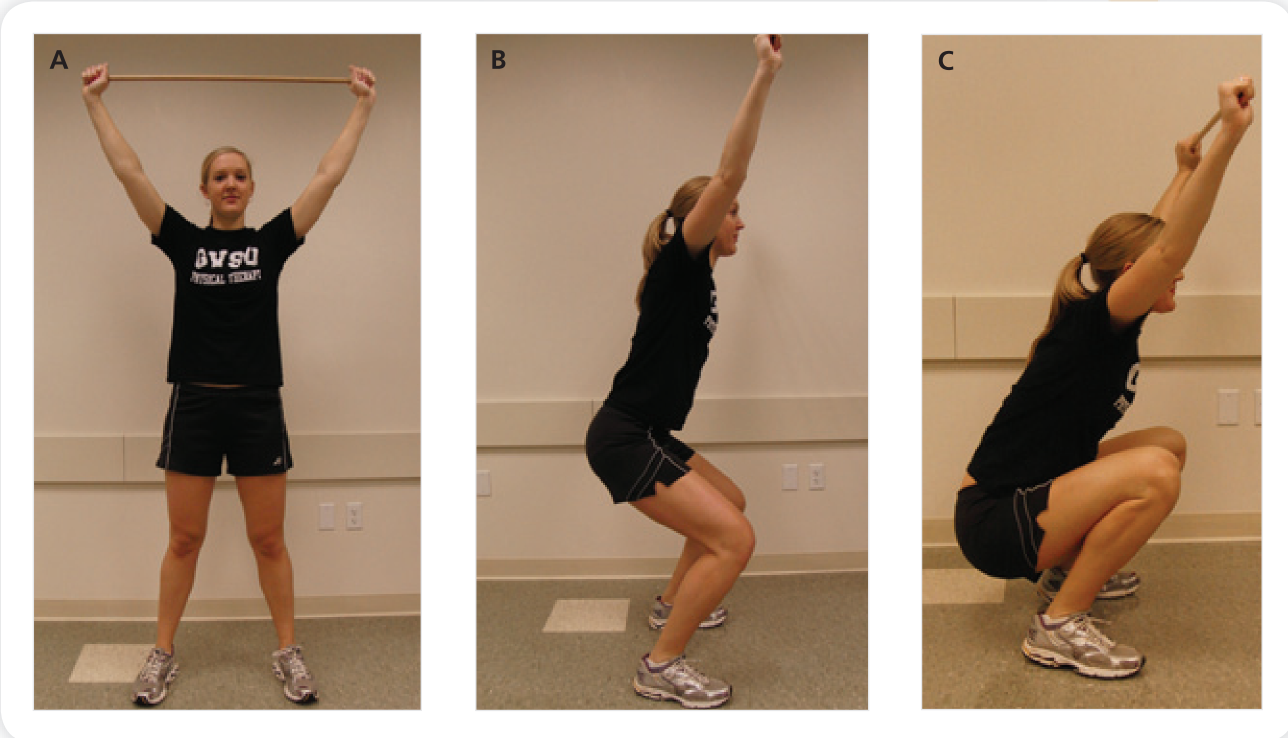


Figure 17-2 **Overhead deep squat maneuver**

Beginning (**A**) and end (**B**) of movement, frontal view, and midrange, side view (**C**).

Figure 17-3 **Hurdle step maneuver**

Midmotion (**A**) and end motion (**B**) before return.

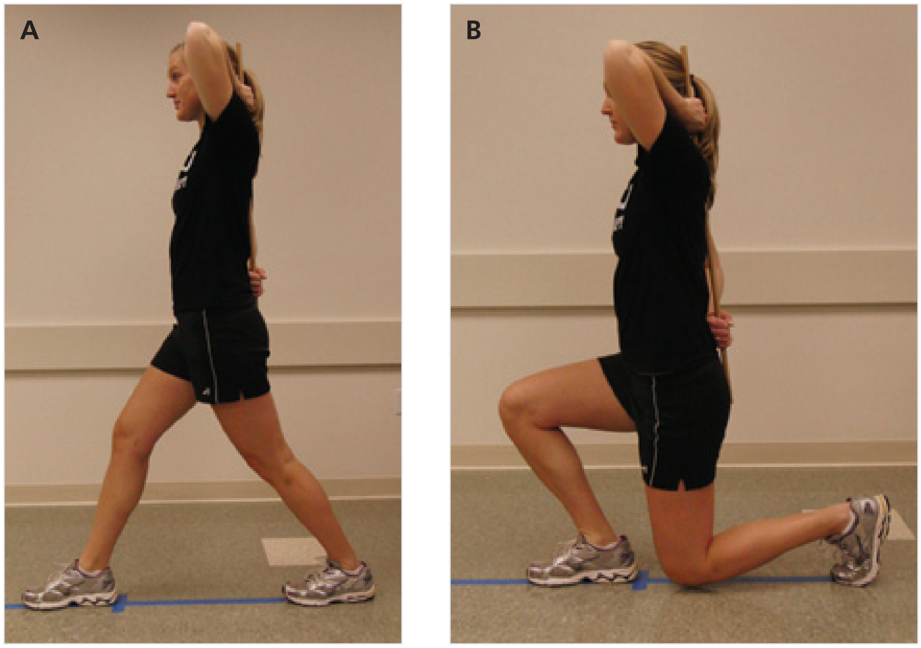


Figure 17-4 **In-line lunge**

Beginning (**A**) and end (**B**) of maneuver.

is asked to step up and over the hurdle, touch the heel to the floor (without accepting weight) while maintaining the stance leg in an extended position, and return to the start position. The leg that is stepping over the hurdle is scored.

In-Line Lunge (Figure 17-4) The in-line lunge attempts to challenge the athlete with a movement that simulates dynamic deceleration with balance and lateral challenge. Lunge length is determined by the tester by measuring the distance to the tibial tubercle. A piece of tape or a tape measure is placed on the floor at the determined lunge distance. The arms are used to grasp the dowel behind the back with the top arm externally rotated, the bottom arm internally rotated, and the fists in contact with the neck and low back region. The hand opposite the front or lunging foot should be on top. The dowel must begin in contact with the thoracic spine, back of the head, and sacrum. The athlete is instructed to lunge out and place the heel of the front/lunge foot on the tape mark. The athlete is then instructed to slowly lower the back knee enough to touch the floor while keeping the trunk erect and return to the start position. The front leg identifies the side being scored.

Shoulder Mobility (Figure 17-5) This mobility screen assesses bilateral shoulder ROM by combining rotation and abduction/adduction motions. It also requires normal scapular and thoracic mobility. Begin by determining the length of the hand of the athlete by measuring from the distal wrist crease to the tip of the third digit. This distance is used during scoring of the test. The athlete is instructed to make a fist with each hand with the thumb placed inside the fist. The athlete is then asked to place both hands behind the back in a smooth motion (without walking or creeping them upward)—the upper arm in an externally rotated, abducted position (with a flexed elbow) and the bottom arm in an internally rotated, extended, adducted position (also with a flexed elbow). The tester

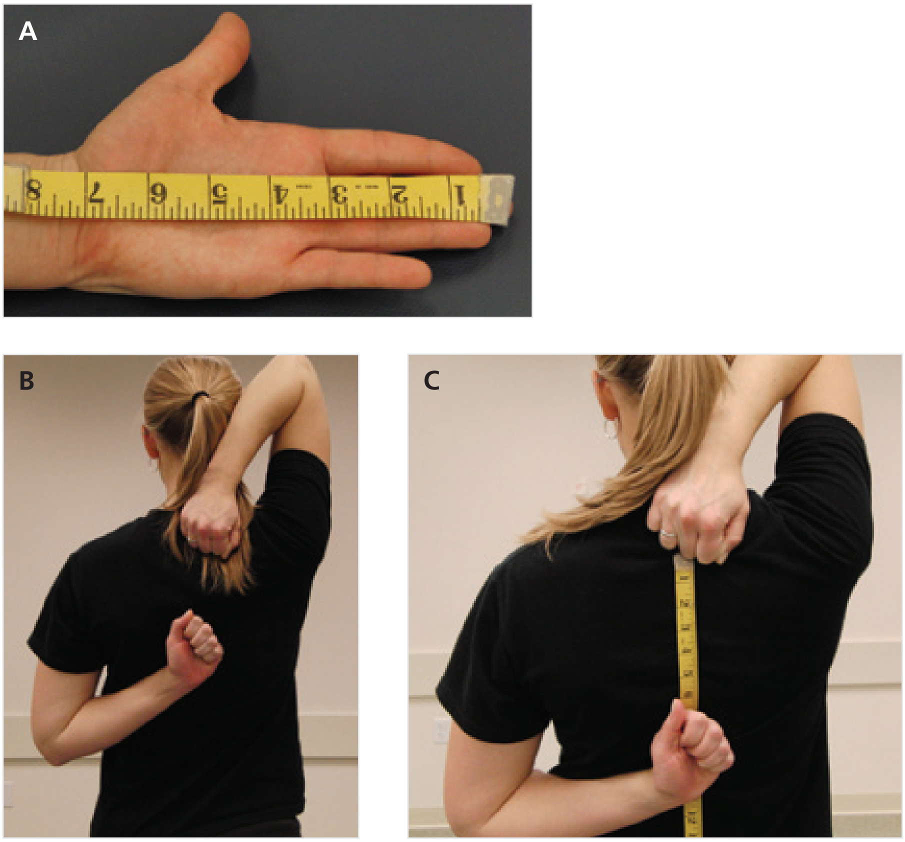


Figure 17-5 **Shoulder mobility test**

Hand measurement (**A**), at end of motion (**B**), and how motion is related to hand measurement (**C**).

measures the distance between the 2 fists. The flexed (uppermost) arm identifies the side being scored.

Shoulder Clearing Test (Figure 17-6) After the previous test is performed, the athlete places a hand on the opposite shoulder and attempt to point the elbow upward and touch the forehead (Yocum test). If painful, this clearing test is considered positive and the previous test must be scored as 0.

Active Straight-Leg Raise (Figure 17-7) This test assesses the ability to move the LE separately from the trunk, as well as tests for flexibility of the hamstring and gastrocnemius. The athlete begins in a supine position, arms at the side. The tester identifies the midpoint between the anterior superior iliac spine and the middle of the patella and places a dowel on the ground, held perpendicular to the ground. The athlete is instructed to slowly lift the test leg with a dorsiflexed ankle and a straight knee as far as possible while keeping the opposite leg extended and in contact with the ground. Make note to see where the LE ends at its maximal excursion. If the heel clears the dowel, a score of 3 is given; if the lower part of the leg (between the foot and the knee) lines up with the dowel, a score of 2 is given; and if the patient is only able to have the

Figure 17-6

Screening test for shoulder, also known as the Yocum test. If positive for pain, the athlete scores 0 on the shoulder mobility test.

Figure 17-7

Active straight-leg raise test, end of motion.

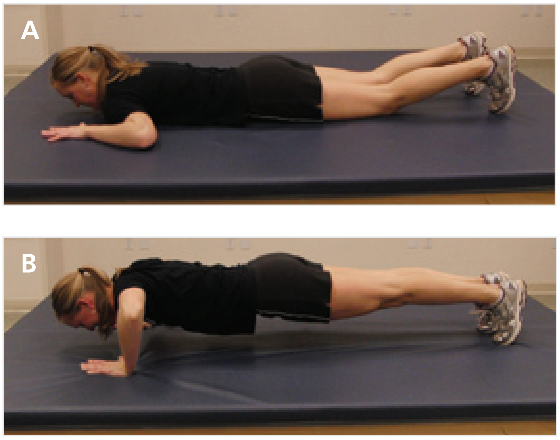


Figure 17-8 **Trunk stability pushup test**

Beginning of motion (**A**) and midmotion (**B**). Note that the hand position is for a score of 3 for females (thumbs at chin); to score a 2, females start with the thumbs at clavicular height. In males, a score of 3 is achieved with the thumbs at forehead level and a 2 with the thumbs at chin level.

thigh (between the knee and the hip) line up with the dowel, a score of 1 is given.

Trunk Stability Pushup (Figure 17-8) This test assesses the ability to stabilize the spine in anterior/posterior and sagittal planes during a closed-chain upper-body movement. The athlete assumes a prone position with the feet together, toes in contact with the floor, and hands placed shoulder width apart (level determined by gender per criteria described later) (Table 17-4), as though ready to perform a pushup from the ground. The athlete is instructed to perform a single pushup in this position with the body lifted as a unit. If the athlete is unable to do this, the hands should be moved to a less-challenging position per criteria and a pushup attempted again. The chest and stomach should come off the floor at the same instance, and no "lag" should occur in the lumbar spine.

A clearing examination is performed at the end of the trunk stability pushup test and graded as pass or fail, failure occurring when pain is experienced during the test. Spinal extension is cleared by using a full-range prone press-up maneuver from the beginning pushup position (Figure 17-9); if pain is associated with this motion, a score of 0 is given.

Rotary Stability (Figure 17-10) The rotary stability test is a complex movement that requires neuromuscular control of the trunk and extremities and the ability to transfer energy between segments of the body. It assesses multiplane stability during a combined upper extremity (UE) and LE motion. The athlete assumes the staring position of quadruped with the shoulders and hips at 90 degrees of flexion. The athlete is instructed to lift a hand off the ground and extend the same-side shoulder (allowing the elbow to flex) while concurrently lifting the knee off the ground and flexing the hip and knee. The athlete needs to raise the extremities only approximately 6 inches from the floor while bringing the elbow and knee together (see Figure 17-10*A* and *B*) until they touch and then return them to the ground. The test is repeated on the opposite side. The UE that moves during testing is scored. Completion of this task allows a score of 3. If unable to perform, the athlete is cued to perform the same maneuver with

Table 17-4 **Alignment Criteria for a Trunk Stability Pushup by Gender**

Position Level	Male	Female
III	Thumbs aligned with the forehead	Thumbs aligned with the chin
II	Thumbs aligned with the chin	Thumbs aligned with the clavicle

The athlete receives a score of 1 if unable to perform a pushup at level II.

the opposite LE and UE (see Figure 17-10*C* and *D*), which allows a score of 2 to be awarded. Inability to perform a diagonal (level II) stability results in a score of 1.

A clearing examination is performed at the end of this test and again is scored as positive if pain is reproduced. From the beginning position for this test, the athlete rocks back into spinal flexion and touches the buttocks to the heels and the chest to the thighs (Figure 17-11). The hands should remain in contact with the ground. Pain on this clearing test overrides any score for the rotary stability test and causes the athlete to receive a score of 0.

A total score of 21 is the highest possible score on the FMS, which implies excellent and symmetric (in tests that are performed bilaterally) performance of the variety of screening maneuvers. Total FMS scores have been investigated in relation to injury in National Football League football players[11] and in female collegiate soccer, basketball, and volleyball players.[10] Kiesel et al[11]

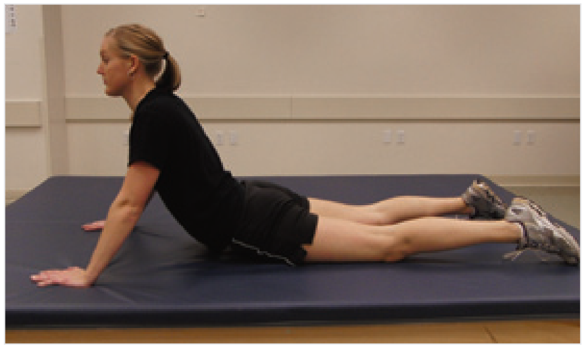


Figure 17-9 **Screening (clearing) test for spinal extension**

If positive for pain, the athlete scores 0 on the trunk stability pushup.

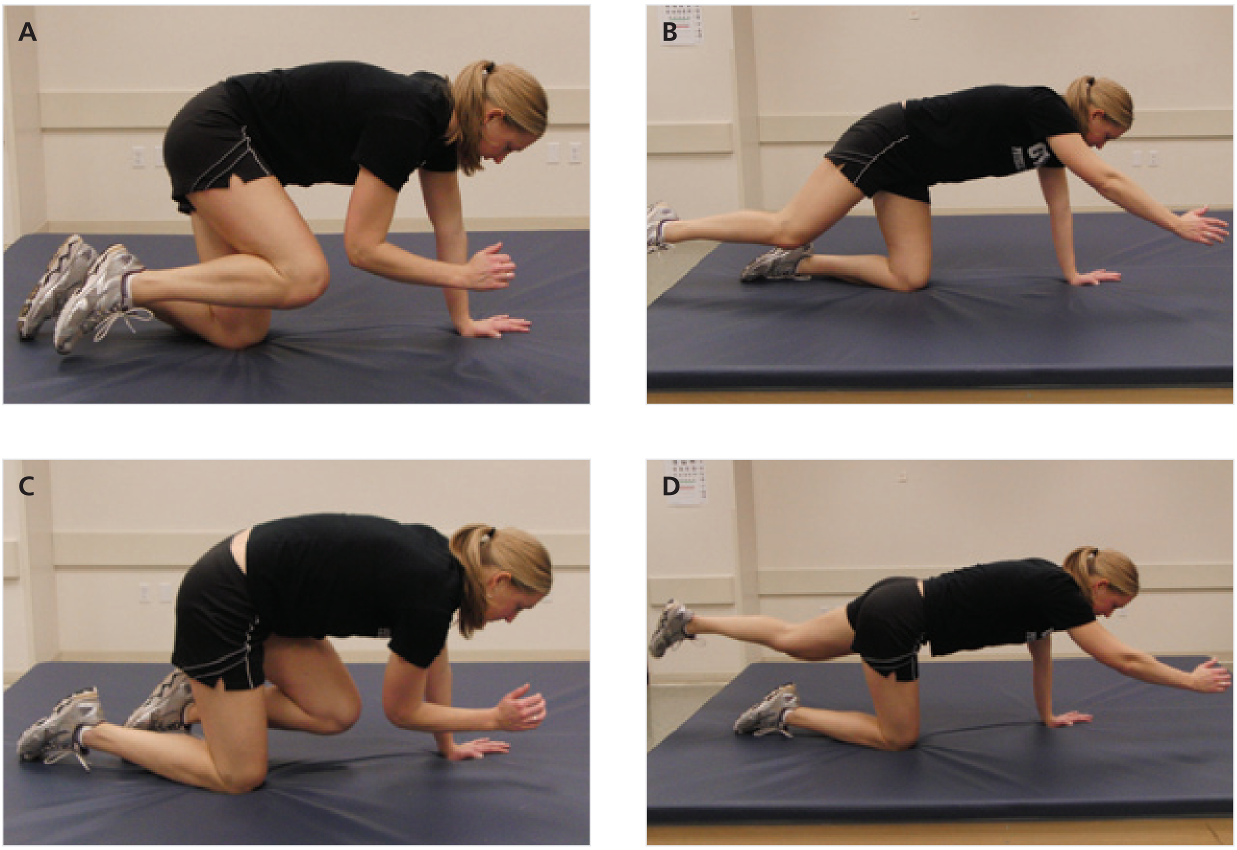


Figure 17-10 **Rotary stability test**

Flexed position for a score of 3 (**A**), extended position for a score of 3 (**B**), flexed position for a score of 2 (**C**), and extended position for a score of 2 (**D**).

Figure 17-11 **Screening test for spinal flexion**

If positive for pain, the athlete scores 0 on the rotary stability test.

reported a 51% probability of football players sustaining a serious injury over the course of 1 season, and Chorba et al[10] found a significant correlation between low FMS scores (<14) in female athletes and injury. Furthermore, a score of 14 or less on the FMS resulted in an 11-fold increase in the chance of sustaining injury in professional football players and a 4-fold increase in the risk for LE injury in female collegiate athletes.[10,11] Okada et al[16] investigated the relationship between the FMS and tests of core stability and functional performance. Significant correlations between some of the FMS screening tests and performance tests of the upper and lower quarter were reported, but these correlations were not consistent among all screening maneuvers. No significant correlations were found between measures of core stability and FMS variables.

The Selective Functional Movement Assessment

Musculoskeletal pain is the reason that most patients seek medical attention. The contemporary understanding of pain has moved beyond the traditional tissue damage model to include the cognitive and behavioral facets. Most scientists accept that pain alters motor function, although the mechanism of these changes has not been clearly identified. The central nervous system response to painful stimuli is complex, but motor changes have consistently been demonstrated and seem to be influenced by higher centers, consistent with a change in transmission of the motor command. The human body migrates to predictable patterns of movement in response to injury and in the presence of weakness, tightness, or structural abnormality. Richardson et al[17] summarized the evidence that pain alters motor control at higher levels of the central nervous system than previously thought by stating,

> Consistent with the identification of changes in motors planning, there is compelling evidence that pain has strong effects at the supraspinal level. Both short- and long-term changes are thought to occur with pain in the activity of the supraspinal structures including the cortex. One area that has been consistently found to be affected is the anterior cingulated cortex, which has long thought to be important in motor responses with its direct projections to motor and supplementary motor areas.[17]

The SFMA is a movement-based diagnostic system for clinical use. This system is used by professionals working with patients experiencing pain on movement. The goal of the SFMA is to observe and capture the patterns of posture and function for comparison against a baseline. It uses movement to provoke symptoms, demonstrate limitations, and offer information regarding movement pattern deficiency related to the patient's primary complaint. The SFMA uses a series of movements with a specific organizational method to rank the quality of functional movements and, when suboptimal, identify the source of provocation of symptoms during movement. The SFMA has been refined and expanded to help the health care professional in musculoskeletal examination, diagnosis, and treatment geared toward choosing the optimal rehabilitative and therapeutic interventions. It helps the clinician identify the most dysfunctional movement patterns, which are then assessed in detail. By identifying all facets of dysfunction within multiple patterns, specific targeted therapeutic interventions designed to capture or illuminate tightness, weakness, poor mobility, or poor stability can be chosen. Thus, the facets of movement identified to most represent or define the dysfunction and thereby affect movement can be addressed. Manual therapy and corrective exercises are focused on movement dysfunction, not pain.

The SFMA is one way of quantifying the qualitative assessment of functional movement and is not a substitute for the traditional examination process. Rather, the SFMA is the first step in a functional orthopedic examination process that serves to focus and direct choices made during the remaining portions of the examination that are pertinent to the functional needs of the patient. The approach taken with the SFMA places less emphasis on identifying the source of the symptoms and more on identifying the cause. An example of this assessment scheme is illustrated by a runner with low back pain. Frequently, the symptoms associated with low back pain are not examined in light of other secondary causes such as hip mobility. Lack of mobility at the hip may be compensated for by increased mobility or instability of the spine. The global approach taken by the SFMA would identify the cause of the low back dysfunction.

We believe it is important to start with a whole-body functional approach, such as the SFMA, before specific impairment assessments, to direct the evaluation in a systematic and constructive manner. Unfortunately, a functional orthopedic examination often involves provocation of symptoms. Provocation of symptoms may occur during the interplay of posture tests, movement in transition, and specific movement tests. Production of these symptoms creates the road map that the clinician will follow to a more specific diagnosis:

- Once symptoms have been provoked, the clinician should work backwards to a more specific breakdown of the component parts of the movement.
- Inconsistencies observed between provocation of symptoms that are not the result of symptom magnification may suggest a stability problem.
- Consistent limitations and provocation of symptoms can be indicative of a mobility problem.

The functional assessment process emphasizes analysis of function to restore proper movement for specific physical tasks. Use of movement patterns and the application of specific stress and overpressure assist in determining whether dysfunction or pain (or both) are present. The movement patterns will reaffirm hypotheses or redirect the clinician to the cause of the musculoskeletal problem. As an example, the SFMA standing rotation test (Figure 17-12) is performed with the patient's feet planted side-by-side and stationary. The subject makes a complete rotation with segments of the entire body first in one direction and then in the other. When consistent production of pain in the left thoracic spine is noted during standing left rotation, the same maneuver can be repeated in the seated posture (Figure 17-13). The 2 motions, although similar in demands for spinal rotation, have several differences; with the hips and lower extremities removed from the movement, an entirely different level of postural control may result.

When nearly the same provocation of symptoms and limitations at the same degree of left rotation are noted during both standing and seated, the cause may be an underlying mobility problem somewhere in the spine. Alternatively, if the seated rotation does not produce a consistent limitation and provocation of symptoms in the same direction and to the same degree, a stability problem might be present. This change in position results in a different degree of postural alignment, muscle tone, proprioception, muscle activation or inhibition, and reflex stabilization. The clinician must investigate the lower body component of this problem. Once consistency or inconsistency is observed with respect to limitation of movement or provocation of symptoms, the clinician should continue to look for other instances that support the suspicion.

Maintaining or restoring proper movement of specific segments is key to preventing or correcting musculoskeletal pain. The SFMA also identifies where

Figure 17-12 Total-body rotation test while standing

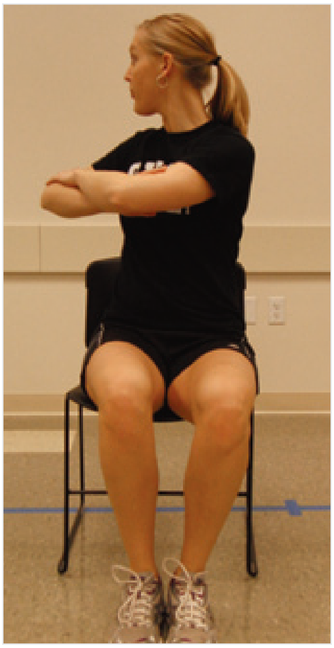


Figure 17-13 Spinal rotation in the sitting, unloaded position

functional exercise may be beneficial and provides feedback regarding the effectiveness of such exercise. A functional approach to exercise uses key specific movements that are common to the patient regardless of the specific activity or sport. Exercise that uses repeated movement patterns required for desired function is not only realistic but also practical and time efficient. Such functional exercises are discussed in Chapter 18.

Scoring System for the Selective Functional Movement Assessment

The hallmark of the SFMA is the use of simple, basic movements to reveal natural reactions and responses by the patient. These movements should be viewed in both loaded and unloaded conditions whenever possible and bilaterally to examine functional symmetry. The SFMA uses seven basic movement patterns (Box 17-2) to rate and rank the 2 variables of pain and function. In addition, 4 optional tests can be used to further refine movement dysfunction.

The term *functional* describes any unlimited or unrestricted movement. The term *dysfunctional* describes movements that are limited or restricted in some way because of lack of mobility, stability, or symmetry within a given movement pattern. *Painful* denotes a situation in which the selective functional movement reproduces symptoms, increases symptoms, or brings about secondary symptoms that need to be noted. Therefore, by combining the words *functional, dysfunctional, painful,* and *nonpainful,* each pattern of the SFMA must be scored with one of 4 possible outcomes (Table 17-5).

Basic Movements in the Selective Functional Movement Assessment

The 7 basic movements or motions included in the SFMA screen look simple but require good flexibility and control. They are referred to as "top-tier" tests or patterns. A patient who is (a) unable to perform a movement correctly, (b) shows a major limitation in 1 or more of the movement patterns, or (c) demonstrates an obvious difference between the left and right sides of the body has exposed a significant finding that may be the key to correcting the problem. The 7 basic movements of the SFMA are described in the following sections.

Cervical Spine Assessment (Figure 17-14)

- The cervical spine is cleared for pain and dysfunction by the patient actively demonstrating three patterns of motion: flexion (both upper and lower cervical), extension, and cervical rotation with side bending.

Box 17-2 Movement Patterns of the Selective Functional Movement Assessment

Seven Basic Movements	Four Optional Movements
Cervical spine assessment	Plank with a twist
Upper-extremity movement pattern assessment	Single-leg squat
Multisegmental flexion assessment	In-line lunge with lean, press, and lift
Multisegmental extension assessment	Single-leg hop for distance
Multisegmental rotation assessment	
Single-leg stance (standing knee lift) assessment	
Overhead deep squat assessment	

Table 17-5 **Scoring System for the Selective Functional Movement Assessment Based on Function and Pain Reproduction**

Label of Outcome of Pattern Performance	Description of Outcome
Functional nonpainful (FN)	Unlimited, unrestricted movement that is performed without pain or increased symptoms
Functional painful (FP)	Unlimited, unrestricted movement that reproduces or increases symptoms or brings on secondary symptoms
Dysfunctional painful (DP)	Movement that is limited or restricted in some way because of lack of mobility, stability, or symmetry; reproduces or increases symptoms; or brings on secondary symptoms
Dysfunctional nonpainful	Movement that is limited or restricted in some way because of lack of mobility, stability, or symmetry and is performed without pain or increased symptoms

Figure 17-14 **Cervical spine assessment**

Flexion (**A**), extension (**B**), and combined side bending/rotation (**C**).

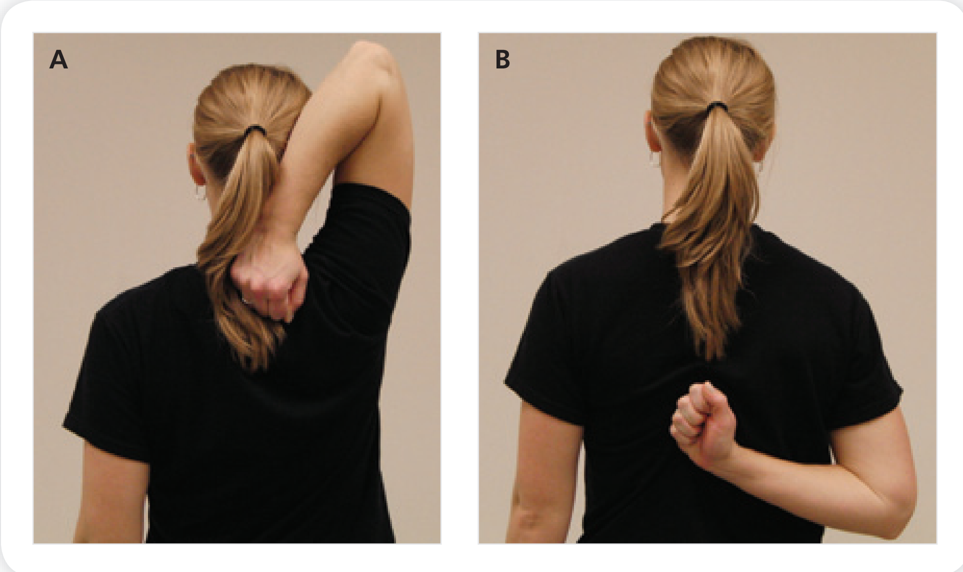


Figure 17-15 **Shoulder mobility tests**

A. Internal rotation, adduction, and extension. **B.** External rotation, abduction, and flexion.

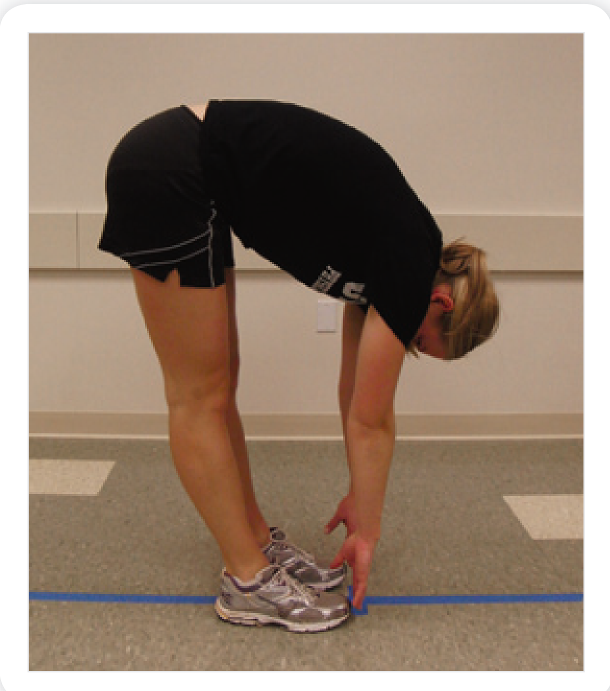


Figure 17-16 **Multisegmental flexion test: end of maneuver**

Note the straight legs, posterior weight shift, and distributed spinal curves.

Upper Extremity Movement Pattern Assessments (Figure 17-15)

- The UE movement pattern assessments check for total ROM in the shoulder.
- Pattern 1 assesses internal rotation-extension, and adduction of the shoulder (Figure 17-15*A*).
- Pattern 2 assesses external rotation, flexion, and abduction of the shoulder (Figure 17-15*B*).

Multisegmental Flexion Assessment (Figure 17-16)

- The multisegmental flexion assessment tests for normal flexion in the hips and spine. The patient assumes the starting position by standing erect with the feet together and the toes pointing forward. The patient then bends forward at the hips and spine and attempts to touch the ends of the fingers to the tips of the toes without bending the knees.
- Observe for the following criteria to be met:
  - Posterior weight shift
  - Touching the toes
  - Uniform curve of the lumbar spine
  - No lateral spinal bending

Multisegmental Extension Assessment (Figure 17-17)

- The multisegmental extension assessment tests for normal extension in the shoulders, hips, and spine. The patient assumes the starting position by standing erect with the feet together and the toes pointing forward. The patient should raise the arms directly overhead and observe the response.
- The arms are then lowered back to the starting position while the examiner looks for synchrony and symmetry of scapular motion.
  - The ability to move one body part independently of another is called *dissociation.* Dissociation problems can be caused by poor stabilizing patterns that do not allow full mobility and stability at the same time. If the patient can maintain stability only by limiting limb or trunk movement, the patient is functionally rigid rather than dynamically stable. The patient may appear to have a restriction in mobility when in fact the true dysfunction is inadequate postural or motor control. As the patient raises the arms overhead, the clinician observes for the ability to move only one body part and that bilateral symmetry is present. The ideal response is for the patient to raise the arms 180 degrees with the pelvis maintaining a neutral position.
- The patient raises the arms back up to over the head with the elbows in line with the ear. The midhand line should clear the posterior aspect of the shoulder at the end range of shoulder flexion. The elbows should remain extended and in line with the ears. At this point have the patient bend backwards as far as possible while making sure that the hips go forward and the arms go back simultaneously. The spine of the scapula should move posteriorly enough to clear the heels. Both anterior superior iliac spines should move anteriorly, past the toes.
- Observe for the following criteria to be met:
  - The anterior superior iliac spine must clear the toes. Forward rotation of the pelvis will pull the lumbar spine out of a neutral position into extension. The pelvis slides forward by shifting body weight toward the front of the feet and again pulls the lumbar spine out of neutral.
  - Symmetric spinal curves should be present and the spine of the scapula must clear a vertical line drawn from the patient's heels.
  - Arms/elbows in line with the ears represent 180 degrees of shoulder flexion.

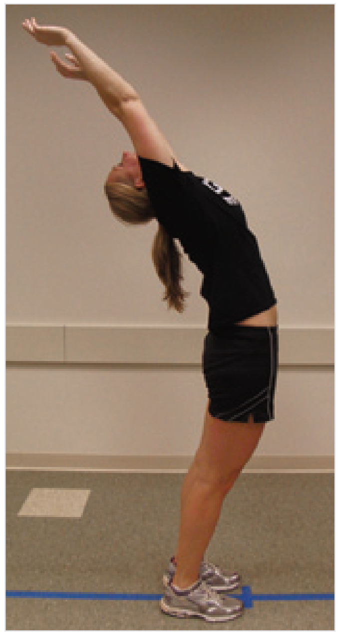


Figure 17-17 Multisegmental extension test: end of maneuver

Note the anterior shift of the pelvis, extension of the upper extremities, and distribution of spinal curves.

Multisegmental Rotation Assessment (Figure 17-18)

- The multisegmental rotation assessment examines the total rotational motion available from the foot to the top of the spine. Usually, rotation occurs as a result of many parts contributing to the total motion. This assessment tests rotational mobility in the trunk, pelvis, hips, knees, and feet. The patient assumes a starting position by standing erect with the feet together, toes pointing forward, and arms relaxed to the sides at about waist height.

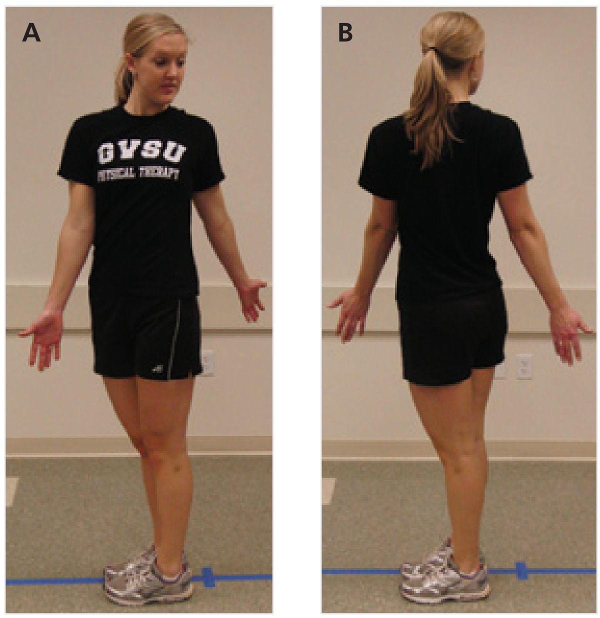


Figure 17-18 Multisegmental rotation test

Start of maneuver (**A**) and end of maneuver (**B**). Note the rotation at the pelvis and trunk and the upright posture.

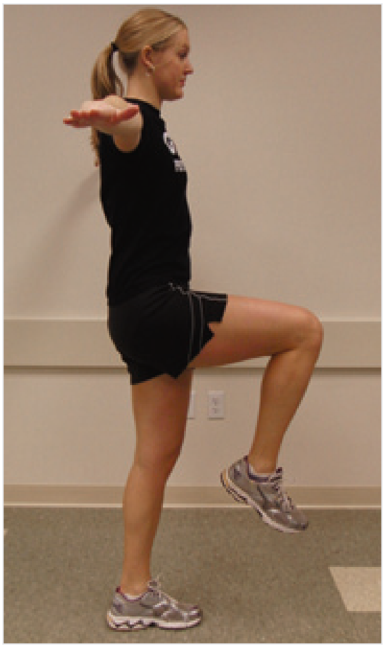


Figure 17-19 Single-limb stance, eyes open

Figure 17-20 Overhead deep squat

The patient then rotates the entire body as far as possible to the right while the foot position remains unchanged. The patient returns to the starting position and then rotates toward the left.

- There should be at least 50 degrees of rotation from the starting position of the pelvis and lower quarter bilaterally.
- In addition to the 50 degrees of pelvic rotation, there should also be at least 50 degrees of rotation from the thorax bilaterally, for a combined total of 100 degrees of total-body rotation from the starting position.

- Observe for the following criteria to be met:
  - Pelvis rotating greater than 50 degrees
  - Trunk rotating greater than 50 degrees
  - No loss of body height with the rotation testing
  - *Note:* Because both sides are tested simultaneously with the feet together, the externally rotating hip is also extending and can thus limit motion. Close attention should be paid to each segment of the body. One area may be hypermobile because of restriction in an adjacent segment. Rotation should be symmetric on each side (within 10 degrees).

Single-Leg Stance (Standing Knee Lift) Assessment (Figure 17-19)

- The single-leg stance assessment evaluates the ability to independently stabilize on each leg in a static and dynamic posture. The static portion of the test looks at the fundamental foundation for control of movement. The patient assumes the starting position by standing erect with the feet together, toes pointing forward, and arms raised out to the side at shoulder height. The patient should be instructed to stand tall before testing. The patient should lift the right leg up so that the hip and knee are both flexed to 90 degrees. The patient should maintain this posture for 10 seconds. The test is repeated on the left leg. The examiner should look to see whether the patient maintains a level pelvis (no Trendelenburg position present).
- The test is repeated again with the eyes closed. The body has 3 main systems that contribute to balance: visual, vestibular, and somatosensory. When the eyes are closed and vision is eliminated, the patient must rely on the other 2 systems to maintain an upright posture.
  - Foot position should remain unchanged throughout the movement, and the hands should remain resting on the hips.
  - Look for loss of posture or height when moving from 2 to 1 leg. Any of the 3 portions of the test are scored as dysfunctional if the patient loses posture.

Overhead Deep Squat Assessment (Figure 17-20)

- Same as used in the FMS.
- The overhead deep squat assessment tests for bilateral mobility of the hips, knees, and ankles. When combined with the overhead UE position, this test also assesses bilateral mobility of the shoulders, as well as extension of the thoracic spine.

- The patient assumes the starting position by placing the instep of the feet in vertical alignment with the outside of the shoulders. The feet should be in the sagittal plane, with no external rotation of the feet. The patient then raises the arms overhead, arms abducted slightly wider than shoulder width and the elbows fully extended. The patient slowly descends as deeply as possible into a full squat position. The squat position should be attempted while maintaining the heels on the floor, the head and chest facing forward, and the hands overhead. The knees should be aligned over the feet with no valgus collapse.
  - Hand width should not increase as the patient descends into the squat position.
  - The UEs and hands should not deviate from the plane of the tibias as the squat is performed.
  - The ability to perform this test requires closed chain dorsiflexion of the ankles, flexion of the hips and knees, extension of the thoracic spine, and flexion abduction of the shoulders.

Each movement is graded with a notation of functional nonpainful, functional painful, dysfunctional painful, or dysfunctional nonpainful (see Table 17-5). All responses other than functional nonpainful are then assessed in greater detail to help refine the movement information and direct the clinical testing. Detailed algorithmic SFMA breakouts are available for each of the movement patterns, but they are beyond the scope of this chapter to describe in detail.

Optional Movements of the Selective Functional Movement Assessment

In addition to the SFMA top-tier or base assessments, four optional assessments have recently been added to further refine the movement dysfunction. They serve to illuminate movement dysfunction in higher-functioning patients.

Once dysfunction, or symptoms, or both, have been provoked in a functional manner, it is necessary to work backwards to more specific assessments of the component parts of the functional movement by using special tests or ROM comparisons. As the gross functional movement is broken down into its component parts, the clinician should examine for consistencies and inconsistencies, as well as the level of dysfunction, in each test with respect to the optimal movement pattern. Provocation of symptoms, as well as limitations in movement or an inability to maintain stability during movements, should be noted.

Further Refinement of Movement Dysfunction: Using the Breakouts

Once dysfunction is noted, the clinician can use the SFMA to systematically dissect each of the major pattern dysfunctions with breakout algorithms. The breakouts provide an algorithmic approach to testing all areas potentially involved in the dysfunction to isolate limitations or determine dysfunction by the process of elimination. The breakouts include active and passive movements, weightbearing and non-weightbearing positions, multiple-joint and single-joint functional movement assessments, and unilateral and bilateral challenges. By performing parts of the test movements in both loaded and unloaded conditions, the clinician can draw conclusions about the interplay between the patient's available mobility and stability. If any of the top-tier movements are restricted when performed in the loaded position (eg, limited or in some way painful before the end of ROM), a clue is provided regarding functional movement. For example, if a movement is performed easily (does not provoke symptoms or have any limitation) in an unloaded situation, it would seem logical that the appropriate joint ROM and muscle flexibility exist and therefore a stability problem may be the reason why the patient cannot perform the movement in a loaded position. In this case, a patient has the requisite available biomechanical ability to go through the necessary ROM to perform the task, but the neurophysiologic response needed for stabilization that creates dynamic alignment and postural support is not available when the functional movement is performed.

If the patient is observed to have limitation, restriction, or pain when unloaded, the patient displays consistent abnormal biomechanical behavior of one or more joints and would therefore require specific clinical assessment of each relevant joint and muscle complex to identify the barriers that are restricting movement and may be responsible for the provocation of pain. Consistent limitation and provocation of symptoms in both the loaded and unloaded conditions may be indicative of a mobility problem. True restrictions in mobility often require appropriate manual therapy in conjunction with corrective exercise.

The SFMA breakout testing applies the same categorizations as its top-tier assessment, with isolated focus on each pattern demonstrating pain or dysfunction. This focus helps identify gross limitations in mobility and stability. Recall that the SFMA uses specific descriptors to identify dysfunction in both mobility and stability, as described earlier in this chapter.

- Tissue extensibility dysfunction involves tissues that are extraarticular. Examples can include active or passive muscle insufficiency, neural tension, fascial tension, muscle shortening, scarring, and fibrosis.
- Joint mobility dysfunction involves structures that are articular or intraarticular. Examples can include osteoarthritis, fusion, subluxation, adhesive capsulitis, and intraarticular loose bodies.

Figure 17-21 provides an example of the overhead deep squat pattern breakout. As can be seen on the algorithm, the clinician is directed to move from a weighted to an unweighted posture, and active and passive movements are used to systematically isolate all the different variables that could cause dysfunction during the overhead deep squat.

How to Interpret the Results of Selective Functional Movement Assessment

Once the SFMA has been completed, the clinician should be able to: (a) Identify the major sources of dysfunction and movements that are affected. (b) Identify patterns of movement that cause pain, with reproduction of pain indicating either mechanical deformation or an inflammatory process affecting nociceptors in the symptomatic structures. The key follow-up question must be, "Which of the functional movements caused the tissue to become painful?" (c) Once the pattern of dysfunction has been identified, the problem is classified as dysfunction of either mobility or stability to determine where intervention should commence.

With the SFMA, treatment is not about alleviating mechanical pain; rather, the SFMA guides the clinician to begin by choosing interventions designed to improve the dysfunctional nonpainful patterns first. This philosophy of intervention does not ignore the source of pain; instead, it takes the approach of removing the mechanical dysfunction that caused the tissues to become symptomatic in the first place.

Pain-free functional movement is the goal for all. It is requisite for work performance, athletic success, and healthy aging. The pain-free functional movement necessary to allow participation in activities of daily living, work, and athletics has many components: posture, ROM, muscle performance, and motor control. Impairments in any of these components can potentially alter functional movement. The authors believe that the SFMA incorporates the essential elements of many daily, work, and sports activities and provides a schema for addressing movement-related dysfunction. (More information can be found at www.Rehabeducation.com.) Appendices A5 to A-7 are examples of score sheets used with the SFMA.

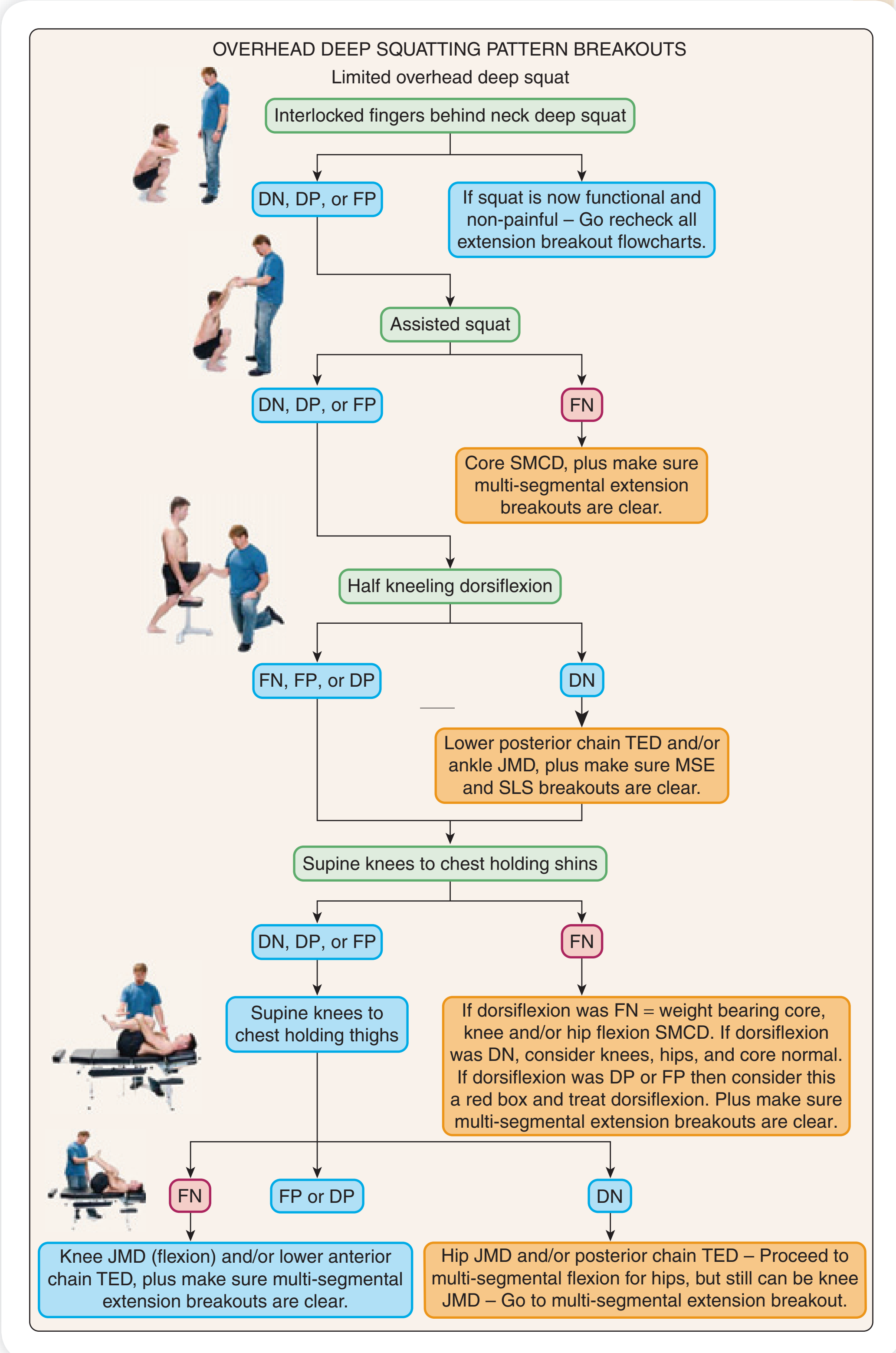


Figure 17-21

Overhead deep squat pattern breakout. DN, Dysfunctional nonpainful; DP, dysfunctional painful; FN, functional nonpainful; FP, functional painful; JMD, joint mobility dysfunction; MSE, multisegmental extension; SLS, single leg stance; SMCD, stability motor control dysfunction; TED, tissue extensibility dysfunction.

Movement Screening versus Specific Functional Performance Tests

The fundamental movement screening tests described in this chapter do not assess the whole of function. They do not include power tasks, running, jumping, acceleration, or deceleration, which are important facets of almost all sports and must therefore be examined before return of an athlete to practice or competition. The following section discusses the evidence that is available and the current utility of several common specific functional performance tests.

Professionals involved with athletes perform a wide variety of functional performance tests. Objective, quantitative assessment of functional limitations by the use of functional performance testing has been described in the literature for more than 20 years.[18-24] Functional performance assessment may be used in an attempt to describe an athlete's aptitude, identify talent, monitor performance, describe asymmetry or dysfunction, and determine readiness to participate in sports. Before sports participation athletes are frequently timed in a 40-yard dash, measured for vertical jump abilities, or assessed for performance on agility tests such as the timed T-test. This often occurs as part of a preparticipation examination. After progressing through postinjury or postsurgical rehabilitation, patients are assessed for their ability to perform functional tasks such as step-downs, hopping, jumping, landing, and cutting. Functional tests such as these are frequently used to simulate sporting activities or actions in the context of whole-body dynamic movement to contribute to the decision regarding whether an athlete is "fit" or physically prepared to begin sport participation or ready to return to play. It is our assertion that these specific functional tests should be performed only after movement screening has taken place and successful mastery of the fundamental movements previously described has been demonstrated.

Functional performance testing should examine athletes under conditions that imitate the necessary functional demands of their sports. Functional performance tests use dynamic skills or tasks to assess multiple components of function, including muscular strength, neuromuscular control/coordination, and joint stability.[25,26] They can be used for assessment of patients after LE injury, surgery, muscular contusions, overuse conditions such as tendinopathy or patellofemoral dysfunction, anterior cruciate ligament reconstruction (ACLR), and ankle instability.[19-21,26,27] Ideally, such tests should be time efficient and simple, require little or inexpensive equipment, and be able to be performed in a clinical setting.[11,21,28] If at all possible, such tests should be able to identify subjects at risk for injury or reinjury.[28-31] Above all, functional performance tests should be objective, reliable, and sensitive to change.[19,24,27,29,32] The root requirement for establishing the objectivity and reliability of any functional test is the use of standardized protocols and instructions.[27]

The validity of functional performance tests is difficult to establish. Many tests assess or examine only a portion of the requirements for the composite performance of a complex sporting activity. Single-limb assessments may have advantages in evaluating athletes who rely on unilateral limb performance, such as runners,[33] or athletes for whom running accounts for a large part of their sport demands. Single-limb tasks or "hops" offer considerable information regarding functional readiness in a wide variety of athletes because many sports entail single-limb weight acceptance, hopping, or landing as a part of their performance. Single-limb assessments offer specific benefits in the realm of objectivity because of their ability to provide within-subject, between-limb comparisons, described as a "biologic baseline," versus having to use population-derived norms. Tests such as the single-limb leg press (Figure 17-22), step-down performed either to the front or laterally (Figure 17-23),[27,34] squat,[35] hop for distance, triple hop for distance, crossover hop for distance (Figure 17-24),[18,20,21] stair hop,[29,30] and the 6-meter timed single-limb hop[20,21] are examples of commonly used single-limb tests that allow establishment of the limb symmetry index (LSI), which helps identify existing or residual postoperative asymmetry between limbs.[20,21,25,29,30] The functional status of the knee has been categorized as "compromised" if the LSI is less than 85%.[18,20,21] Single-limb tasks offer a wide variety of imposed demands on the LE that can be used at various times during the rehabilitation process for assessment of symmetry, recovery, and readiness to resume sports participation.[27,29,30] The triple hop for distance has been demonstrated to be a strong predictor of both power (as measured by vertical jump) and isokinetic strength.[22,25,36] Sekir et al[26] describe a lateral single-limb hop test that may be an important facet of functional assessment for athletes who rely on repetitive lateral movements for sport proficiency. Several researchers also advocate assessment of lateral movement during single-limb hop testing or the side-cutting maneuver because it may be more valid for athletes who move and cut laterally.[37,38] Several authors[18,20,21,29,30] have related the LSI to functional status; for example, a lower LSI after ACLR is related to poorer function, and improvements in raw scores on the single-limb hop test, as well as the LSI, represent functional recovery over 52 weeks after ACLR. Noyes et al[20,21] suggested that the LSI should be higher than 85% before return to sport. Loudon et al[27] suggested that in the case of patellofemoral pain syndrome, the LSI should be closer to 90% to prevent reinjury. Bilateral assessments, including squats, leg presses, and 2-legged "jumps" such as the drop jump (Figure 17-25) or tuck jump (Figure 17-26), may be more valid for assessing athletes in whom 2-legged jumping and landing tasks are important.[31,33]

Figure 17-22 Single-leg press

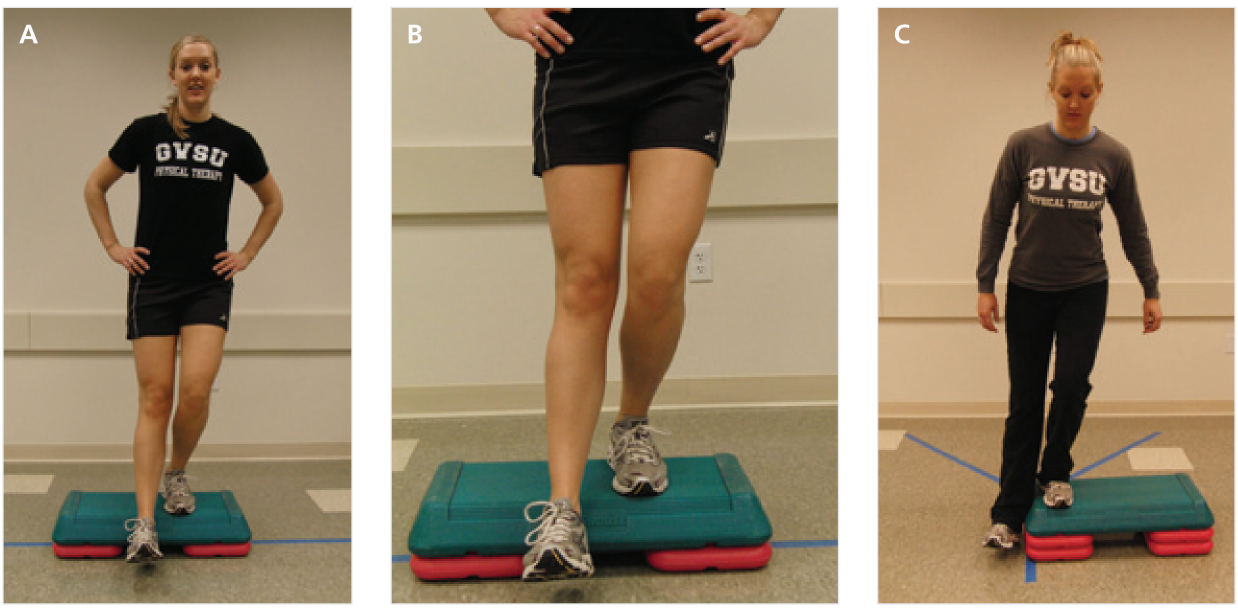


Figure 17-23 Step-down test

Monitor for LE biomechanics and control. **A.** Front step down; note the trunk and hands. **B.** Front step-down close-up; note the alignment of the stance knee. **C.** Lateral step-down with same qualitative criteria.

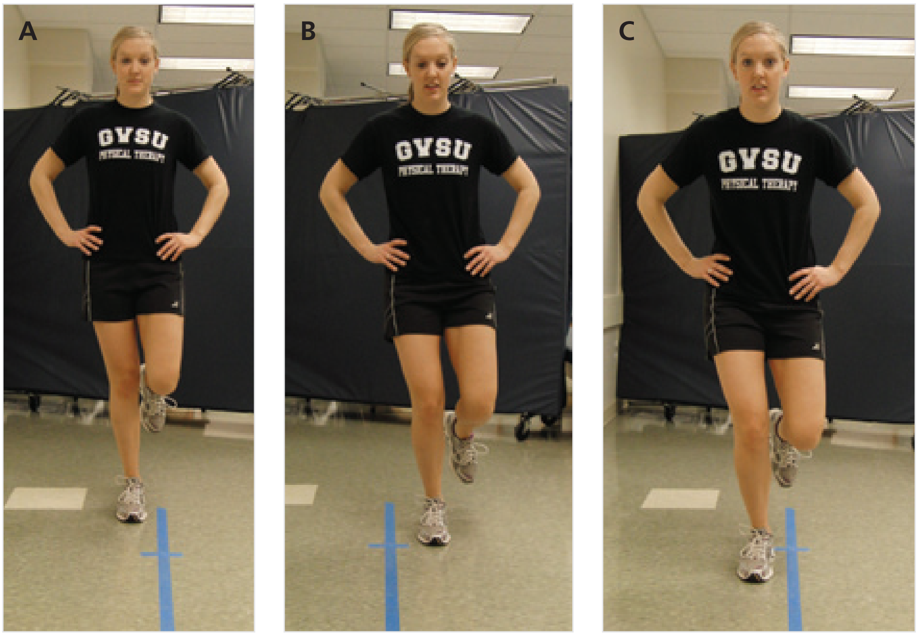


Figure 17-24 **Crossover hop for distance**

Start (**A**), lateral movement (**B**), and final lateral movement (**C**). *Note:* The athlete must "stick" or control the landing. The athlete attempts to go as far as possible in the combined 3 hops.

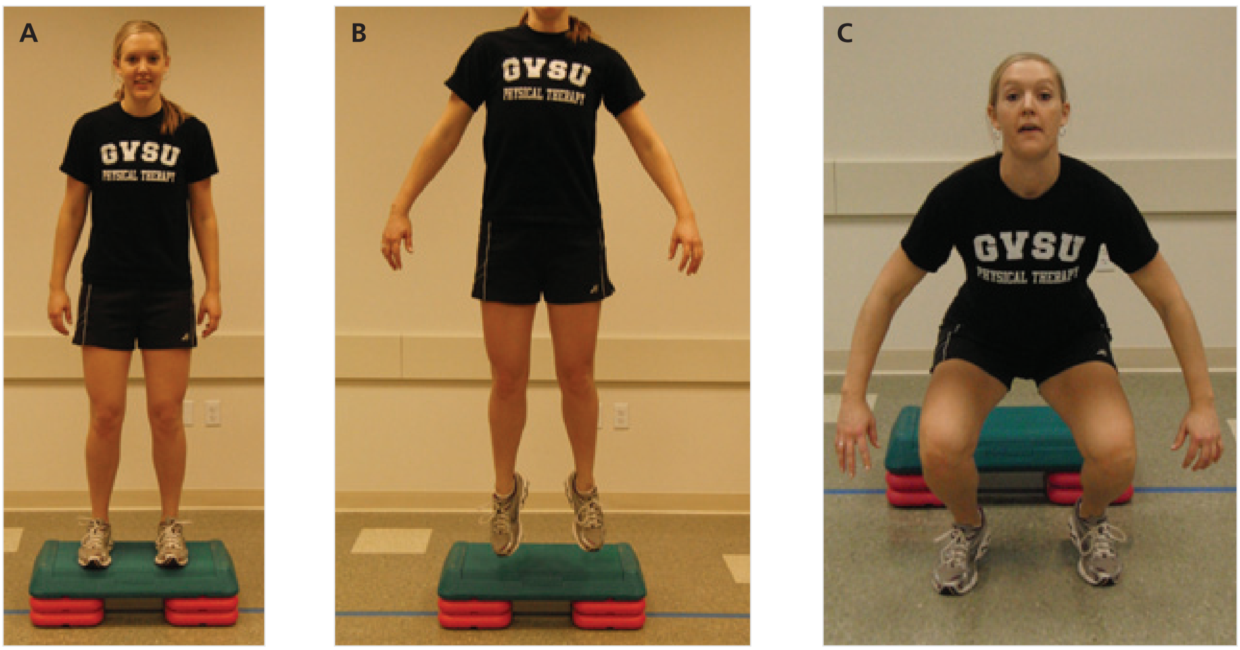


Figure 17-25 **Drop jump assessment**

Start position (**A**), midposition (**B**), and landing (**C**). Note the deep flexion angle in landing and alignment of the hips and knees.

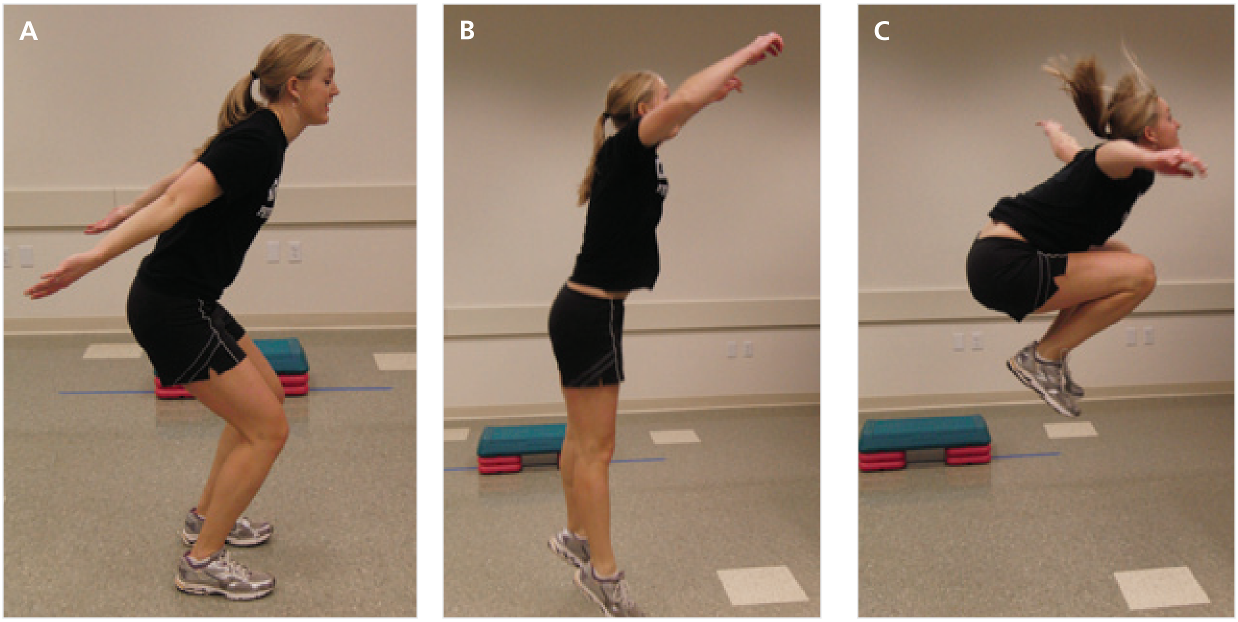


Figure 17-26 **Tuck jump assessment**

Beginning of movement (**A**), midmovement (**B**), and in air in a tucked position (**C**). Note that this test must be observed from the side and the front to analyze performance.

Most athletic skills require a combination of vertical, horizontal, and lateral movement by 1 or both LEs. Probably the most important requirement for successful sport performance is a series of highly developed motor control strategies to allow speed and agility during performance.[33] If an LE reach, jump, hop, or agility test could be used to objectively screen athletes' neuromuscular performance and suggest intervention before either sport participation or return to sport, that functional performance test would be valuable for preventing injury or decreasing the likelihood of reinjury.[12,21,28,31,37]

We know of no single optimal, valid, and reliable test that can determine an athlete's readiness for participation or return to sport. Given the wide variation and complexity of the demands of sport, this is not surprising. Many professionals suggest the use of functional test batteries or a series of functional tests that are related to the specific demands of a specific sport or that can be related to the probable mechanisms of injury for a specific pathology. A combination of 2 or more tests is recommended for relevant, sensitive, responsive functional assessment.[18,20,21,39,40] Bjorklund et al[39] proposed a functional test instrument (battery) named the Test for Athletes with Knee Injuries that they describe as valid, reliable, and sensitive for use after ACLR. The Test for Athletes with Knee Injuries is composed of 8 evaluations, including jogging, running, single-limb squat, rising from sitting (single leg), bilateral squat, single-limb hop for distance, single-limb vertical jump (performed plyometrically), and the single-limb crossover hop (8 meters). The authors present suggested scoring criteria for each test that take into account qualitative assessment of performance of the 8 tests. This is just one such example of combining several functional performance tests into a series for examination of a group of patients. Clearly, all functional performance tests are not relevant for all athletes, and it is the role of the rehabilitation professional to select valid, reliable, sensitive, and relevant functional performance tests.

SUMMARY

Movement Scoring Systems

1. One of the most difficult decisions that must be made by rehabilitation providers is whether an athlete is ready to participate in sports or safely return to sport participation.
2. Acceptance plus use of fundamental movement screening systems such as the FMS and the SFMA is sweeping across the country. These screens offer valuable information to professionals regarding the fundamental functional abilities of an athlete in the realm of *movement* by identifying compensatory movements or deficits in mobility or stability.

Functional Performance Tests

1. Functional performance tests or test batteries can be used to assess athletes of all ages and skill levels who participate in a wide variety of sports.
2. Frequently, functional performance tests assess a facet or single part the vast demands of any given sport, and therefore the validity of such tests is hard to determine. Although not providing a complete picture of athletic function, these tests are essential tools for the rehabilitation professional. It is critical that the rehabilitation professional be familiar with the use of such screens and tests to discern readiness for participation.
3. Skillful combinations of movement screening, functional performance testing, and sport-specific movement testing offer the best assessment of an athlete's readiness for return to sport.

Future Research

1. Although evidence regarding tests and systems that are objective, valid, and reliable is beginning to mount (Minick, DiMattia, Loudon, and others), many questions regarding the big picture of return to function exist. Does the FMS relate to core stability? Does it predict performance in athletics or merely identify potential for injury? Which functional performance measures are best used for athletes who participate in certain sports? Normative scores for the FMS and other functional performance tests by age and gender would be very helpful for comparison between athletes.
2. As the published evidence on functional testing continues to accumulate, rehabilitation professionals will have to keep abreast of changes and adapt their use of screens and tests accordingly.

REFERENCES

1. Fuller C, Drawer S. The application of risk management in sports. *Sports Med.* 2004;19:2108-2114.
2. Paterno MV, Schmitt LC, Ford KR, et al. Biomechanical measures during landing and postural stability predict second anterior cruciate ligament injury after anterior cruciate ligament reconstruction and return to sport. *Am J Sports Med.* 2010;38:1968-1978.
3. Reed FE. The preparticipation athletic exam process. *South Med J.* 2004;97:871-872.
4. Van Mechelen W, Hlobil H, Kemper HC, et al. Incidence, severity, etiology and prevention of sports injuries. *Sports Med.* 1992;14:82-89.
5. Van Mechelen W, Twisk J, Molendjk A, et al. Subject related risk factors for sports injuries: a 1-year prospective study in young adults. *Med Sci Sports Exerc.* 1996;28:1171-1179.

6. Watson AW. Sports injuries related to flexibility, posture, acceleration, clinical deficits, and previous injury in high-level players of body contact sports. *Int J Sports Med.* 2001;22:220-225.
7. Kendall FP. *Muscle Testing and Function*. 5th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2005.
8. Page P, Frank CC, Lordner R. *Assessment and Treatment of Muscle Imbalance: The Janda Approach.* Champaign, IL: Human Kinetics; 2011.
9. Sahrmann SA. *Diagnosis and Treatment of Movement Impairment Syndromes*. St. Louis, MO: Mosby; 2002.
10. Chorba RS, Chorba DJ, Bouillon LE, et al. Use of a functional movement screening tool to determine injury risk in female collegiate athletes. *N Am J Sports Phys Ther.* 2010;5:47-54.
11. Kiesel K, Plisky PJ, Voight ML. Can serious injury in professional football be predicted by a preseason functional movement screen? *N Am J Sports Phys Ther.* 2007;2:147-152.
12. Plisky PJ, Rauh MJ, Kaminski TW, Underwood FB. Star excursion balance test as a predictor of lower extremity injury in high school basketball players. *J Orthop Sports Phys Ther.* 2006;36:911-919.
13. Cook G, Burton L, Hoogenboom B. Pre-participation screening: the use of fundamental movements as an assessment of function—part 1. *N Am J Sports Phys Ther.* 2006;1:62-72.
14. Cook G, Burton L, Hoogenboom B. Pre-participation screening: the use of fundamental movements as an assessment of function—part 2. *N Am J Sports Phys Ther.* 2004;1:132-139.
15. Minick KI, Kiesel KM, Burton L, et al. Interrater reliability of the functional movement screen. *J Strength Cond Res.* 2010;24:479-486.
16. Okada T, Huxel KC, Nesser TW. Relationship between core stability, functional movement, and performance. *J Strength Cond Res.* 2011;25:252-261.
17. Richardson C, Hodges P, Hides J. *Therapeutic Exercise for Lumbopelvic Stabilization: A Motor Control Approach for the Treatment and Prevention of Low Back Pain*. 2nd ed. Philadelphia, PA: Churchill Livingstone; 2004.
18. Barber SD, Noyes FR, Mangine RE, et al. Quantitative assessment of functional limitation in normal and anterior cruciate ligament-deficient knees. *Clin Orthop Relat Res.* 1990;255:204-214.
19. Bolgla LA, Keskula DR. Reliability of lower extremity functional performance tests. *J Orthop Sports Phys Ther.* 1997;26:138-142.
20. Noyes FR, Barber SD, Mangine RE. Abnormal lower limb symmetry determined by functional hop tests after anterior cruciate ligament rupture. *Am J Sports Med.* 1991;19:513-518.
21. Noyes FR, Barber-Westin SD, Fleckenstein C, et al. The drop-jump screening test: difference in lower limb control by gender and effect of neuromuscular training in female athletes. *Am J Sports Med.* 2005;33:197-207.
22. Petschnig R, Baron R, Albrecht M. The relationship between isokinetic quadriceps strength test and hop tests for distance and one-legged vertical jump test following anterior cruciate ligament reconstruction. *J Orthop Sports Phys Ther.* 1998;28:23-31.
23. Risberg MA, Ekeland A. Assessment of functional tests after anterior cruciate ligament surgery. *J Orthop Sports Phys Ther.* 1994;19:212-217.
24. Ross MD, Langford B, Whelan PJ. Test-retest reliability of 4 single-leg hop tests. *J Strength Cond Res.* 2002;16:617-622.
25. Hamilton RT, Shultz SJ, Schmitz RJ, Perrin DH. Triple-hop distance as a valid predictor of lower limb strength and power. *J Athl Train.* 2008;43:144-151.
26. Sekir U, Yildiz Y, Hazneci B, et al. Reliability of a functional test battery evaluating functionality, proprioception, and strength in recreational athletes with functional ankle instability. *Eur J Phys Rehabil Med.* 2008;44:407-415.
27. Loudon JK, Waiesner D, Goist-Foley LH, et al. Intrarater reliability of functional performance tests for subjects with patellofemoral pain syndrome. *J Athl Train.* 2002;37:256-261.
28. Myer GD, Ford KR, Hewett TE. Tuck jump assessment for reducing anterior cruciate ligament injury risk. *Athl Ther Today.* 2008;13:(5):39-44.
29. Hopper DM, Goh SC, Wentworth LA, et al. Test-retest reliability of knee rating scales and functional hop tests one year following anterior cruciate ligament reconstruction. *Phys Ther Sport.* 2002;3:10-18.
30. Hopper DM, Strauss GR, Boyle JJ, Bell J. Functional recovery after anterior cruciate ligament reconstruction: a longitudinal perspective. *Arch Phys Med Rehabil.* 2008;89:1535-1541.
31. Padua DA, Marshall SW, Boling MC, et al. The landing error scoring system (LESS) is a valid and reliable clinical assessment tool of jump-landing biomechanics: the JUMP-ACL study. *Am J Sports Med.* 2009;37:1996-2002.
32. Brosky J, Nitz A, Malone T, et al. Intrarater reliability of selected clinical outcome measures following anterior cruciate ligament reconstruction. *J Orthop Sports Phys Ther.* 1999;29:39-48.
33. Meylan C, McMaster T, Cronin J, et al. Single-leg lateral, horizontal, and vertical jump assessment: reliability, interrelationships, and ability to predict sprint and change-of-direction performance. *J Strength Cond Res.* 2009;23:1140-1147.
34. Piva SR, Fitzgerald K, Irrgang JJ, et al. Reliability of measures of impairments associated with patellofemoral pain. *BMC Musculoskelet Disord.* 2006;7:33-46.
35. DiMattia MA, Livengood AL, Uhl TL, et al. What are the validity of the single-leg-squat test and its relationship to hip abduction strength? *J Sport Rehabil.* 2005;14: 108-123.
36. Wilk KE, Romaniello WT, Soscia SM, et al. The relationship between subjective knee scores, isokinetic testing and functional testing in the ACL-reconstructed knee. *J Orthop Sports Phys Ther.* 1994;20:60-73.

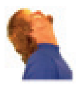
37. Hewett TE, Myer GD, Ford KR, Slauterbeck JR. Preparticipation physical examination using a box drop vertical jump test in young athletes: the effects of puberty and sex. *Clin J Sport Med.* 2006;16:298-304.

38. Zebis MK, Andersen LL, Bencke J, et al. Identification of athletes at future risk of anterior cruciate ligament ruptures by neuromuscular screening. *Am J Sports Med.* 2009;37:1967-1973.

39. Bjorklund K, Andersson L, Dalen N. Validity and responsiveness of the test of athletes with knee injuries: the new criterion based functional performance test instrument. *Knee Surg Sports Traumatol Arthrosc.* 2009;17:435-445.

40. Gustavsson A, Neeter C, Thomee P, et al. A test battery for evaluation of hop performance in patients with ACL injury and patients who have undergone ACL reconstruction. *Knee Surg Sports Traumatol Arthrosc.* 2006;14:778-788.

THE SELECTIVE FUNCTIONAL MOVEMENT ASSESSMENT

SFMA SCORING			FN	FP	DP	DN
Active Cervical Flexion						
Active Cervical Extension						
Cervical Rotation-Lateral Bend		L R				
Upper Extremity Pattern 1 (MRE)		L R				
Upper Extremity Pattern 2 (LRF)		L R				
Multi-Segmental Flexion						
Multi-Segmental Extension						
Multi-Segmental Rotation		L R				
Single Leg Stance		L R				
Overhead Deep Squat						

THE SELECTIVE FUNCTIONAL MOVEMENT ASSESSMENT

Name **Date** **Total Score**

Cervical Flexion ☐ Primary ☐ Secondary
☐ Can't Touch Sternum__________
Cervical Extension
☐ Greater than 10 Degrees of Parallel__________
Cervical Rotation
☐ *RIGHT* – Can't Touch Chin to Mid-Clavicle__________
☐ *LEFT* - Can't Touch Chin to Mid-Clavicle__________
Upper Extremity ☐ Primary ☐ Secondary ☐ *RIGHT* ☐ *LEFT*
☐ *RIGHT* ☐ *LEFT* Can't Touch Inferior Angle of the Contralateral Scapula
☐ *RIGHT* ☐ *LEFT* Can't Touch Spine of the Contralateral Scapula
Multi-Segmental Flexion ☐ Primary ☐ Secondary
☐ Can't Touch Toes and Return to Standing Position__________
☐ < 70 Degrees Sacral Angle__________
☐ No Posterior Weight Shift (T-L Junction over foot) __________
☐ Non-Uniform Spinal Curves__________
Multi-Segmental Extension ☐Primary ☐ Secondary
☐ ASIS Doesn't Clear the Toes__________
☐ Can't Maintain Normal (≥ 170 degrees) Shoulder Flexion__________
☐ Spine of Scapula Doesn't Clear the Heels__________
☐ Non-Uniform Spinal Curves__________
Multi-Segmental Rotation ☐ Primary ☐ Secondary ☐ *RIGHT* ☐ *LEFT*
☐ *RIGHT* ☐ *LEFT* Pelvis Rotation < 50 degrees__________
☐ *RIGHT* ☐ *LEFT* Trunk/shoulder < 50 degrees more than pelvis_________
☐ *RIGHT* ☐ *LEFT* Spinal/Pelvic Deviation__________
☐ *RIGHT* ☐ *LEFT* Excessive Knee Flexion__________
Single Leg Stance ☐ Primary ☐ Secondary ☐ *RIGHT* ☐ *LEFT*
☐ *RIGHT* ☐ *LEFT* Eyes Open Standing < 10 seconds__________
☐ *RIGHT* ☐ *LEFT* Eyes Closed Standing < 10 seconds__________
☐ *RIGHT* ☐ *LEFT* Loss of Height__________
Overhead Squating ☐ Primary ☐ Secondary
☐ Loss of Shoulder Flexion__________
☐ Thoracic Flexes__________
☐ Hips Don't Break Parallel__________
☐ Sagittal Plane Deviation of Lower Extremity Rt.__________ Lt, __________

SFMA

Name: ____________________

Date: ____________________

	R	L	R	L	R	L	R	L
	FN		DP		FP		DN	
Cervical Flexion								
Active Supine Cervical Flexion								
Passive Supine Cervical Flexion								
Active Supine OA Flexion								
Cervical Extension								
Supine Cervical Extension								
Shoulder Pattern One								
Active Prone Shoulder Pattern One								
Passive Prone Shoulder Pattern One								
Supine Reciprocal Shoulder								
Active Prone 90/90 Shoulder IR (70°)								
Passive Prone 90/90 Shoulder IR (70°)								
Active Prone Shoulder Extension (50°)								
Passive Prone Shoulder Extension (50°)								
Active Prone Elbow Flexion (70°)								
Passive Prone Elbow Flexion (80°)								
Lumbar Lock Chest (50°)								
Shoulder Pattern Two								
Active Prone Shoulder Pattern Two								
Passive Prone Shoulder Pattern Two								
Supine Reciprocal Shoulder								
Active Prone 90/90 Shoulder ER (90°)								
Passive Prone 90/90 Shoulder ER (90°)								
Active Prone Shoulder Flex/Abd (170°)								
Passive Prone Shoulder Flex/Abd (170°)								
Active Prone Elbow Flexion (70°)								
Passive Prone Elbow Flexion (80°)								
Lumbar Lock Chest (50°)								
Multi-Segmental Flexion								
Single Leg Forward Bend								
Long Sitting								
Active Straight Leg Raise								
Passive Straight Leg Raise								
Prone Rocking								
Supine Knee to Chest Holding Thighs								
UB Rolling - Supine to Prone								
LB Rolling - Supine to Prone								
Multi-Segmental Extension								
Spine Extension	FN		DP		FP		DN	
Backward Bend w/o UE								
Single Leg Backward Bend								
Prone Press Up								
Lumbar Lock (IR) - Active Rot./Ext. (50°)								
Lumbar Lock (IR) - Passive Rot./Ext. (50°)								
Prone on Elbow Unilateral Extension (30°)								
Lower Body Extension	FN		DP		FP		DN	
Faber								
Modified Thomas								
Prone Active Hip Extension (10°)								
UB Rolling - Prone to Supine								
LB Rolling - Prone to Supine								
Upper Body Extension	FN		DP		FP		DN	
Unilateral Shoulder Backward Bend								
Supine Lat Stretch Hips Flexed								
Supine Lat Stretch Hips Extended								
Lumbar Lock (ER) - Unilateral Ext (50°)								
Lumbar Lock (IR) - Active Rot./Ext. (50°)								
Lumbar Lock (IR) - Passive Rot./Ext. (50°)								

	R	L	R	L	R	L	R	L
	FN		DP		FP		DN	
Cervical Rotation								
Active Supine Cervical Rotation								
Passive Supine Cervical Rotation								
C1-C2 Cervical Rotation								
Multi-Segmental Rotation								
Spine Rotation	FN		DP		FP		DN	
Seated Rotation (50°)								
Lumbar Lock (ER) - Unilateral Ext (50°)								
Lumbar Lock (IR) - Active Rot./Ext. (50°)								
Lumbar Lock (IR) - Passive Rot./Ext. (50°)								
Prone on Elbow Unilateral Extension (30°)								
UB Rolling - Supine to Prone								
LB Rolling - Supine to Prone								
UB Rolling - Prone to Supine								
LB Rolling - Prone to Supine								
Hip Rotation	FN		DP		FP		DN	
Seated Active External Hip Rotation (40°)								
Seated Passive External Hip Rotation (40°)								
Prone Active External Hip Rotation (40°)								
Prone Passive External Hip Rotation (40°)								
Seated Active Internal Hip Rotation (30°)								
Seated Passive Internal Hip Rotation (30°)								
Prone Active Internal Hip Rotation (30°)								
Prone Passive Internal Hip Rotation (30°)								
Tibia Rotation	FN		DP		FP		DN	
Seated Active Internal Tibia Rotation (20°)								
Seated Passive Internal Tibia Rotation (20°)								
Seated Active External Tibia Rotation (20°)								
Seated Passive External Tibia Rotation (20°)								
Single Leg Stance								
Vestibular & Core	FN		DP		FP		DN	
CTSIB (Static Head Movement)								
CTSIB (Dynamic Head Movement)								
Half-Kneeling Narrow Base								
UB Rolling - Supine to Prone								
LB Rolling - Supine to Prone								
UB Rolling - Prone to Supine								
LB Rolling - Prone to Supine								
Quadruped Diagonals								
Ankle	FN		DP		FP		DN	
Heel Walks								
Prone Passive Dorsiflexion								
Toe Walks								
Prone Passive Plantarflexion								
Seated Ankle Inversion/Eversion								
Seated Passive Ankle Inversion/Eversion								
Overhead Deep Squat								
Interlocking Fingers Behind the Neck Squat								
Assisted Squat								
Half Kneeling Dorsiflexion								
Supine Knee to Chest Holding Shins								
Supine Knee to Chest Holding Thighs								