Clinical Assessment and Rehabilitation of Shoulder and Knee Sensorimotor Control

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The orthopedic surgeon must perform a thorough evaluation of an unstable joint to derive the accurate diagnosis. One component of this examination is evaluation of the sensorimotor system. This article provides an overview of techniques and methodology used to assess the sensorimotor system. Rehabilitation concepts are presented to assist the physician during patient consultation following injury or surgery.

Joint stability is a complex interaction dependent on static and dynamic components. Mechanical damage to these components can lead to instability. However, recent evidence has suggested the neural control of the joint can significantly impact joint stability.1-2 Clinical research has demonstrated proprioceptive deficits associated with joint instabilities in the ankle, knee, and shoulder.2-4 The somatosensory input is provided by peripheral sensory receptors that convey afferent information through the various proprioceptive pathways of the skin, joint, and muscle receptors and provide the central nervous system (CNS) with continuous information regarding position sense, movement, balance, and muscular tension.5-11

Proprioceptive control is the continuous integration between somatosensory afferent input and efferent muscular output necessary to stabilize a joint and the entire extremity.12-13 Decreased proprioceptive input from injured joint capsules and ligaments has been suggested to attenuate sensorimotor control.1,14-15 The term “sensorimotor system” describes the mechanisms involved with the acquisition of the sensory stimulus and conversion of the stimulus to a neural signal with subsequent transmission to the central nervous system.13 Clinical assessment of the sensorimotor system includes joint position sense, kinesthesia, balance, and reflex muscle testing.13 The evaluation of these deficits should be incorporated into a complete orthopedic examination of an injured joint.

This article presents techniques used to assess sensorimotor control during a clinical examination and suggests exercises to help reverse neuromuscular deficiencies.

SENSORIMOTOR ASSESSMENT

Shoulder

Shoulder proprioceptive deficits using joint position sense and kinesthetic testing have been reported following recurrent shoulder dislocations.8,16 These proprioceptive deficits are believed to arise from the loss of mechanical deformity of the receptors in the injured joint capsule.1,16,17 Loss of somatosensory input produces a state of partial deafferentation, decreasing the neural input to the CNS that may negatively affect sensorimotor control mechanisms.17

Measurement of joint position sense is most feasible in the clinical setting due to equipment and time restraints. Joint position sense can be performed by either passively or actively positioning the limb at a particular angle,6,18 The limb is maintained at the angle for 5-10 seconds with vision obscured. The patient then attempts to reposition his or her limb to the exact angle either actively or passively (Figure 1). The
error (absolute difference) from the initial angle and the assumed repositioned angle is recorded.

Passive shoulder reposition sense testing provides a reliable measurement that can discriminate healthy from unstable shoulders. Voight et al. using an isokinetic dynamometer with the arm in a functionally abducted 90°/90° position, reported an average error of 14°±4° in a healthy dominant arm during passive reposition testing. The arm was passively rotated 2°/second to a 75° angle. Using the same methodology, they reported an error of 3°±1° in a healthy dominant arm during active reposition testing.

Jerosch used video analysis to perform active reposition tests at multiple angles to compare proprioceptive differences between patients with shoulder anterior instability and individuals without pathology. He found significant differences at 150° of flexion and abduction and 45° of internal rotation between the anterior unstable group and healthy group (P<.05). He reported significant differences between the unstable shoulder and healthy shoulder of the injured group at 50° of forward flexion (10.3°±8.1° versus 7.5°±4.5°, respectively [P=.05]) and at 45° of internal rotation with the arm abducted to 90° (15.1°±10.1° versus 10.4°±7.7°, respectively [P<.01]). Using a standard goniometer to perform this active reposition sense testing would be a simple clinical modification that could provide objective information regarding the neurological control of the injured shoulder (Figure 1).

Active and passive testing using an isokinetic dynamometer is another viable option as long as the cutaneous feedback from the skin in contact with the attachment arm can be minimized by an ace wrap or air splint.

**Knee**

Evaluation of sensorimotor control of the lower extremity has been assessed using a number of methods, many of which require sophisticated equipment to be valid and reproducible. With the advancement in technologies, several devices are available to healthcare providers to assess sensorimotor control such as the Neurocom Balance Systems (Clackamas, Ore); however, common inexpensive clinical assessments are the Romberg test and single-leg hop test.

The Romberg test was introduced in 1851 and has been the most commonly used test to measure static postural stability. The test consists of a patient standing with the feet together with the eyes open and the eyes closed on a stable base of support. The Tandem Romberg test is a modification that involves having patients stand heel to toe with the eyes open and the eyes closed. Further modification of the Romberg test includes having a patient stand on one leg with both eyes open and closed. The evaluation of the test is subjective and involves determining whether a patient is able to maintain a stable base of support without swaying or falling. The clinician assesses the ability to stand for a maximum of 10 seconds, first with the eyes open and then with the eyes closed. Patients are ranked as “normal,” “maintains balance through both conditions with compensatory movements,” or “cannot finish test.” This is a gross measurement of sensorimotor control under relatively static conditions. Researchers have used the above protocols but document stability by assessing the amount of sway via force calculations.

Dynamic clinical tests involve the active motion of the support surface or limb through space. Hop tests have been shown to be clinically sensitive and reliable. Hop tests cannot provide the sophisticated analysis of limb function that can be obtained with force plates and gait analysis; however, the single-leg hop for distance test is a valuable general screening test. In our laboratory, we have found that while performing single-leg hop for distance tests, anterior cruciate ligament (ACL) reconstructed patients perform differently between trials and often build confidence as the trials progress. Therefore, we suggest using a maximum test when assessing single-leg hop for ACL-reconstructed patients because the mean of three trials may not be representative of maximum performance.

Noyes et al. assessed the sensitivity of four single-leg hop tests in a group of ACL-deficient patients. The four-hop tests were the single-leg hop for distance, the timed hop (the time to hop 6 m), the triple hop for distance, and the cross-over hop for distance. Noyes et al. described a deficiency of limb symmetry of >15% on at least two tests as abnormal. These functional tests help the physician identify a sensorimotor deficiency that indicates the need for an intervention.

**REHABILITATION INTERVENTION**

Rehabilitation should concentrate on restoring sensorimotor and kinesthetic control, dynamic stability, reactive neuromuscular control, and functional activity. Restoration of sensorimotor and kinesthetic control or the knowledge of where the limb is in space can be accomplished by asking patients to perform repositioning activities with the injured joint to elevate their conscious awareness (Figure 2). Adding light weights distally and removing visual feedback increases the difficulty of the exercises. Proprioceptive neuromuscular facilitation techniques of rhythmic initiation and rhythmic stabilization stimulate conscious sensory awareness of joint position and motion. The rehabilitation specialist can provide resistance and tactile feedback to ensure that the joint is being activated in smooth and correct patterns. This rehabilitation technique facilitates activation of agonist/antagonist musculature in functional movement patterns, which incorporates dynamic stability and functional activity. Dynamic stability is obtained by prescribing exercises that encourage preparatory agonist/antagonist coactivation, such as closed chain balance exercises on various platforms and surfaces. Coactiva-
tion is further stimulated if the patient exercises with the use of an external load (Figure 3).

As dynamic control of the injured joint is demonstrated by the patient, progression to reactive neuromuscular training should be incorporated. These exercises induce anticipated and unanticipated joint perturbations\textsuperscript{12,30} such as attempting to balance on one leg and catching a ball, or while the rehabilitation specialist disturbs the patient’s balance (Figure 4). Reactive eccentric activities such as plyometric exercises for both upper and lower extremities can be incorporated to mimic functional demands that will be placed on the extremity such as hurrying down a flight of stairs or removing a bag of food from a shelf. The exercises can be made more challenging by performing activities on an unstable surface and without knowledge of oncoming perturbation. The perturbations should challenge but not place the joint in a position for further injury. Return to normal functional activities should progress based on each individual patient’s demands. For athletes, incorporating acceleration, deceleration, and cutting movements integrates all components of the aforementioned sensorimotor rehabilitation program, requiring the joint to function at its highest level.

REFERENCES


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