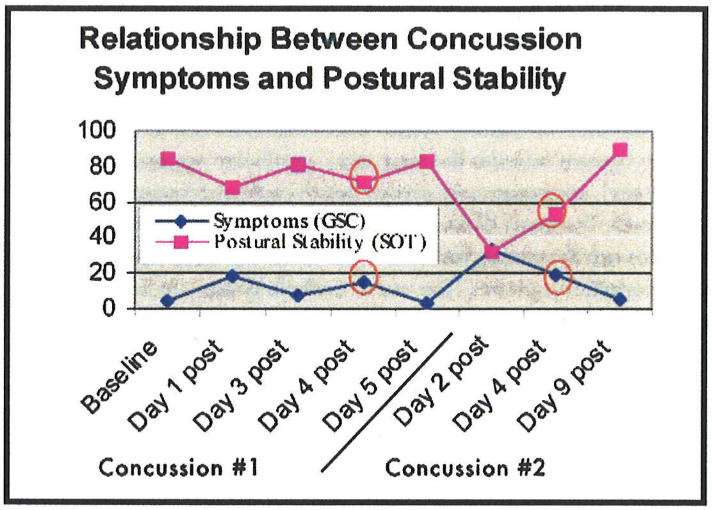
Why the Clinical Test of Sensory Integration of Balance (CTSIB) for concussion baseline balance testing?

Maintaining postural balance involves complex coordination and integration of multiple sensory, motor and biomechanical components as graphically represented below.

"Sensory feedback from visual, vestibular and somatosensory systems is not properly processed during the first few days after a concussion; therefore, the motor domain of neurological function should be assessed along with cognitive domain after concussions." [1]

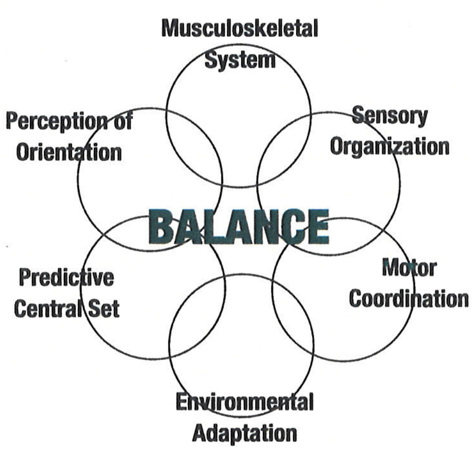
Guskiewicz KM, Ross SE, Marshall SW. J Athl Train 2001



Guskiewicz et al demonstrated persistent decreases in postural stability for three to five days after injury in athletes with MHI using the CTSIB. [2-4]

Components of Balance [5]

Postural balance involves special sensory receptors that provide information in regards to various environmental and physiological conditions that may affect a person's ability to maintain equilibrium. They are as follows:



Clinical Test of Sensory Integration of Balance – CTSIB or m-CTSIB (modified CTSIB)

The Modified Clinical Test of Sensory Integration of Balance (m-CTSIB) is an accepted test protocol for Balance assessment on a static surface and is an ideal assessment for concussion baseline screening for the following reasons. [1-11]

1. The breadth of the existing studies supporting and accepting the CTSIB as a valid clinical assessment of balance.
2. Well documented definitive correlations for mild traumatic brain injury.
3. The comprehensiveness of the test to address each of the systems that contributes to balance: visual, vestibular and somatosensory.
4. Ease and efficiency of performing the test and high inter and intra rater reliability.
5. Clinician familiarity with the test.

The m-CTSIB consists of four conditions. This test provides a generalized assessment of how well a patient can integrate various senses with respect to balance, and compensate when one or more of those senses are compromised. Postural stability is measured by recording postural sway. [6] The four conditions tested are as follows.

1. **Eyes open, firm surface** – provides a baseline. Information is available by all three sensory inputs: visual, vestibular and somatosensory.

2. **Eyes closed, firm surface** – visual not available; somatosensory and vestibular are available. If the athlete/patient performs poorly, the vestibular or somatosensory may be compromised, with an increase in visual dependency.

3. **Eyes open, unstable surface (foam)** – somatosensory compromised; visual and vestibular are available. If the athlete/patient performed poorly, visual or vestibular may be compromised, with an increase in somatosensory dependency. Somatosensory input consists of proprioception and touch and allows the muscles to make constant automatic adjustments to maintain balance and avoid falls. This condition is least likely to be affected by concussion.

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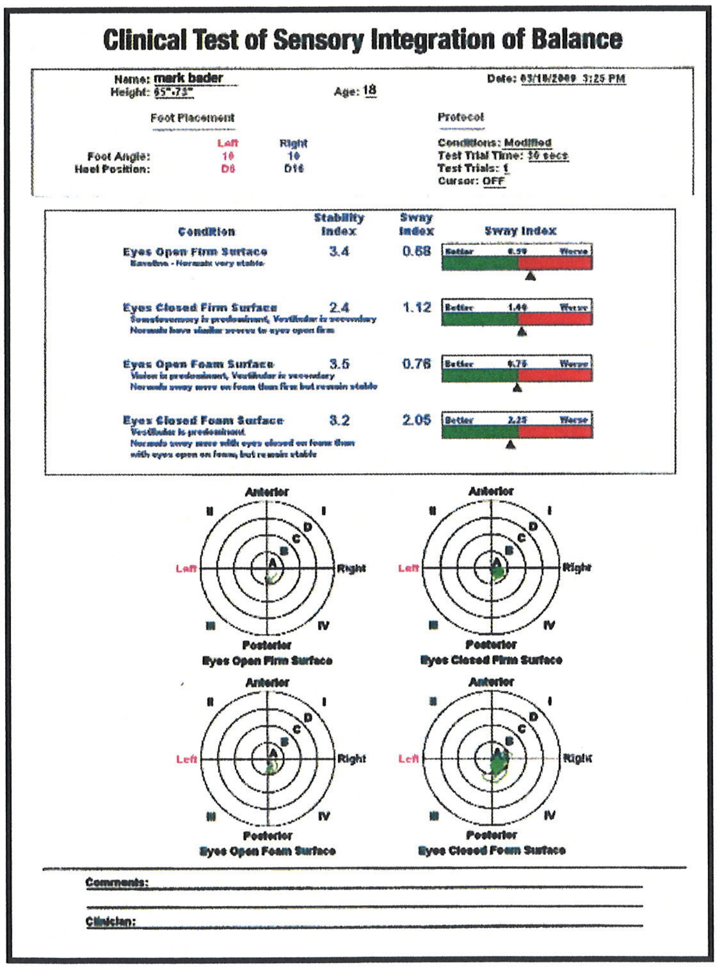
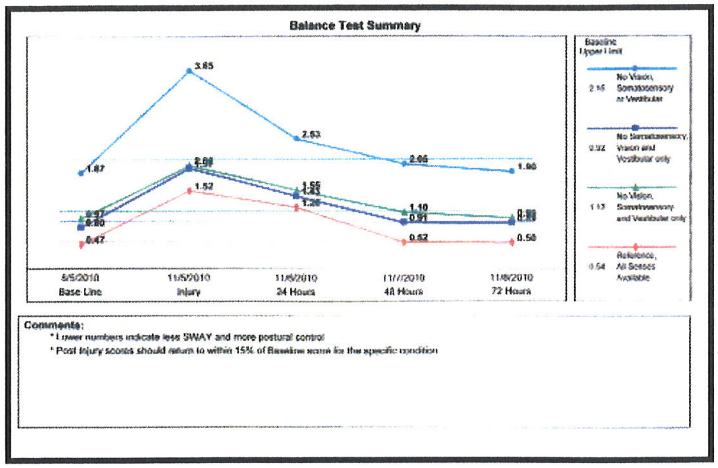
4. **Eyes closed, unstable surface (foam)** – visual not available, somatosensory compromised; only vestibular is available. Concussed athletes/patients are most likely to present problems in this condition. If performance is reduced, the vestibular system may be disrupted. The vestibular system is responsible for processing information about movement with respect to gravity; more specifically rotation, acceleration/deceleration, head stabilization and works with the visual system to stabilize the eyes and maintain posture during exertion. Vestibular disorders cause a feeling of dizziness and unsteadiness.

The Sway Index [3] is measured during the m-CTSIB test. The Sway Index is an objective quantification of postural sway and indicates the standard deviation of the athlete/patient's average position from center. A higher Sway Index indicates a reduction in the athlete/patient's ability to remain steady during the test.

Baseline Test



The Biodex Concussion Summary Report clearly compares subsequent tests relative to baseline.



Understanding the sensory organization for balance [8-11]
Perhaps the most confusing part of a balance evaluation is the part that examines the sensory system and its contribution to balance. The sensory system includes the eyes, ears, vestibular apparatus (inner ear), somatosensory system (touch and proprioception), taste and smell. The parts of the sensory system that contribute directly to balance are the visual, vestibular and somatosensory (touch and proprioception) systems. The use of multiple systems in balance allows us to learn new movements quickly and to fine-tune and easily repeat familiar movements.

The sensory system receives input from the environment through specialized receptors located in the sensory end-organs in the eyes, vestibular apparatus of the inner ear, muscle spindles, Golgi tendon organs and touch receptors in the skin. Sensory input is transmitted to the spinal cord via afferent nerve fibers and then to the brain via spinal nerve tracts.

Sensory input provides a continuous flow of information to the CNS, which in turn utilizes this incoming information to make decisions about movement. The CNS sifts, compares, weighs, stores and processes sensory input and uses this information to alter the force, speed and range of a movement.

Vision
Vision is a critical part of our balance system. It allows us to identify objects and determine their movement and tells us where we are in relation to other objects (object-to-object orientation). When we use vision to gather information about the position of our body in the environment or to determine the position of one body part vis à vis another, then vision is providing proprioceptive information to the CNS as well (visual proprioception).

Vision works in conjunction with the vestibular system, comparing information about velocity and rotation from the vestibular system with actual visual information. The visual system is a combination of both central and peripheral vision, although some research has suggested that peripheral vision is more important for postural control and balance than central vision.

The visual system may provide inaccurate information to the nervous system. For example, a person sitting at a stoplight in a car may think she has started to move when the car next to her starts to move. The visual system "goes along" with the movement of the neighboring car and tells the brain that both cars are moving. The CNS mediates this sensory conflict by instructing the leg to slam on the brake to stop the car from moving forward. As soon as the foot touches the brake the somatosensory and vestibular systems realize that the car is, in fact, not moving. For a split second, input from the visual system was given preference by the brain, even though the information turned out to be inaccurate.

Vestibular Input

The vestibular system is responsible for processing information about movement with respect to gravity—specifically, rotation, acceleration/deceleration and head stabilization during gait. The vestibular system works in conjunction with the visual system to stabilize the eyes and maintain posture during walking (vestibulo-ocular reflex). Vestibular disorders cause a feeling of dizziness and unsteadiness. Vestibular dysfunction also affects the ability of the CNS to mediate intersensory conflicts such as that in the example given above.

Because a concussion will disturb the vestibular apparatus, it is very common for concussed athletes/patients to exhibit nystagmus (eyetwitch) as well as problems balancing with eyes closed.

Lehmann et al Arch Physical Med Nov 1990, noted that TBI populations rely more on visual cues for balance than able-bodied populations. When visual is removel MTBI patients have a difficult time balancing. [7]

Somatosensory Input

Somatosensory input consists of touch and proprioception. Input from these two sensory sources provides critical feedback to the CNS regarding positioning in space, body sway and changes in terrain. The sensory input from touch and proprioception allows the muscles to make constant, automatic adjustments to maintain balance and avoid falls.

In the example where the person in the stationary car slams on the brake, only to realize through somatosensory input that her car has not moved, the feeling that the car is moving when it is not is an example of a visual intersensory conflict. The conflict is resolved quickly by pressing on the brake and feeling that the car has not moved.

In summary, athletes with cerebral concussion demonstrate acute balance deficits, which are likely the result of not using information from the vestibular and visual systems effectively. [1]

The CTSIB test is a valuable tool for baseline balance testing and post injury assessments to distinguish symptomatic versus asymptomatic athletes prior to making the return-to-play decision.

References

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