Assessing the Influence of Sensory Interaction on Balance

Suggestion from the Field

ANNE SHUMWAY-COOK
and FAY BAHLING HORAK

Assessment of standing balance is essential to the treatment of instability in the neurologic patient. The development of clinical techniques for evaluating instability is dependent on a thorough understanding of sensory and motor processes underlying normal balance control. Motor processes in balance control coordinate the action of trunk and leg muscles into discrete synergies that minimize sway and maintain the body’s center of mass within its base of support.1,2

Sensory processes in balance control involve interaction among orientation inputs from somatosensory (proprioceptive, cutaneous, and joint), visual, and vestibular systems. Despite the availability of multiple sensory inputs, the central nervous system generally relies on only one sense at a time for orientation information.3 For healthy adults, the preferred sensory input for the control of balance is somatosensory information from the feet in contact with the support surface. The CNS must be adaptable, however, so that, when reduced or inaccurate information results from the somatosensation, an alternative sensory input is used for orientation. In cases where there is conflict among the senses, the CNS uses orientationally accurate inputs from the vestibular system to resolve the conflict.3 An example of intersensory conflict occurs when a person stands near a moving bus. In this situation, visual input, which reports relative self-to-object motion, conflicts with both somatosensory and vestibular inputs, which report no self-to-object motion. To resolve this conflict, the normal CNS disregards the visual motion input and relies on the orientationally accurate vestibular and somatosensory inputs; consequently, no equilibrium response is generated.

Research has shown that instability in the patient with neurologic problems can result from inappropriate interaction among the three sensory inputs that provide orientation information to the postural control system.4,5 A patient may be dependent inappropriately on one sense for situations presenting intersensory conflict.6 In the example of the moving bus, a patient inappropriately reliant on visual information generates an unnecessary equilibrium response to the perceived loss of balance and becomes posturally unstable.

Fig. 1. Visual-conflict dome worn by patient during balance testing to produce inaccurate visual orientation inputs.

It is important for the therapist designing a treatment program for the unstable patient to know 1) which sense a patient is most dependent on for sway orientation information and 2) how well a patient can adapt to reliance on the various senses in situations of intersensory conflict. To provide this information, we designed a method for the clinical assessment of the influence of sensory interaction on postural stability in the standing patient with neurologic problems. The method requires the patient to maintain standing balance under six different intersensory conditions that either eliminate input or produce inaccurate visual and surface orientation inputs. Changes in amount and direction of sway then are observed.

MATERIALS

The technique uses combinations of three visual and two support-surface conditions. Visual conditions include the use of a blindfold for eliminating visual input and a visual-conflict dome for producing inaccurate input (Fig. 1). The dome that we use was constructed from a paper lantern and a dental headband at a total cost of about $40. A white, 16-in* diameter paper lantern (with horizontal ribs) was purchased for about $5. An opening for the patient’s neck and head was

---

4. This article was submitted January 24, 1986, and was accepted January 28, 1986. Potential Conflict of Interest: 4.

5. 1 in = 2.54 cm.
Fig. 2. Sequence of six conditions for testing the influence of sensory interaction on balance.
OBJECTIVE ASSESSMENT BASED ON A NUMERIC RANKING SYSTEM (E.G., 1-2)

Changes in the patient's perceptions (e.g., as indicated by daily grids and a plumb line to record body displacement. When the patient maintains erect standing in each condition, or 3) use of an apparatus to evaluate sway in conditions 1-6. The therapist observes the patient for changes in the amount of sway in each condition. Using condition 1 as a baseline reference, the patient's stance—whether normal, one foot, or heel-to-toe—should be similar in each condition. Using condition 1 as a baseline reference, the therapist observes the patient for changes in the amount and direction of sway over the subsequent five conditions.

Specific techniques for quantifying sway may include 1) subjective assessment based on a numeric ranking system (e.g., 1 = minimal sway, 2 = mild sway, 3 = moderate sway, 4 = fall), 2) use of a stopwatch to record the amount of time the patient maintains erect standing in each condition, or 3) use of grids and a plum line to record body displacement. Changes in the patient's perceptions (e.g., as indicated by nausea or dizziness) and in movement strategy used to maintain stability also should be recorded.2 We suggest that the therapist test the apparatus on healthy subjects first to determine normal responses and to establish both interrater and test-retest reliability.

INTERPRETATION AND USES

Most healthy adults and children above the age of 9 years easily maintain stability under all six conditions.3,5 Most show gradually increasing amounts of anterior-posterior sway over the six conditions with greatest sway in conditions 5 and 6, in which primarily vestibular inputs mediate postural control.3,4

Analysis of the patterns of instability over the six conditions provides therapists with insight into which sense a patient depends on to maintain stability. For example, postural instability while wearing the visual-conflict dome (condition 3) suggests abnormal reliance on vision for posture control, which is characteristic of patients with postconcussion vestibular syndrome or benign paroxysmal positional nystagmus.6,8 Marked increases in sway or falls under conditions of sensory conflict (conditions 3–6) may indicate a sensory interaction problem.3

Therapists should be cautious in interpreting performance, however, because many underlying sensory, motor, and orthopedic problems may contribute to instability. Documentation of improvements in ability to organize sensory information for balance can be obtained by periodic reassessment using this system. In addition, standing, walking, swaying, and functional movements under the most difficult of these conditions (3–6) may be practiced by patients as a therapeutic treatment approach to improve flexible use of the senses for posture control. This method alone does not represent a comprehensive approach to balance assessment but should be viewed as an adjunct to current clinical techniques used to assess postural instability.

REFERENCES


† Dynamic Systems Inc, Rte 2, Box 182B, Leicester, NC 28748.
§ Alimed, Inc, 68 Harrison Ave, Boston, MA 02111.