Balance Testing with the Modified Clinical Test of Sensory Interaction on Balance: Is It Enough?

Case Scenario: Jack is a 76-year-old man who loves to hike and do yardwork. One day while standing in a rocky area of his yard and looking up slightly to clip an overhanging branch, he lost his balance and fell. Is the mCTSIB, a commonly used balance screening, enough to challenge balance and identify subtle impairments in healthy older adults? Can the skills required to stand on uneven or unstable ground while tracking a bird flying overhead with binoculars be replicated by this screening?

What is the mCTSIB?

Most therapists are familiar with the modified Clinical Test of Sensory Interaction on Balance (mCTSIB).[1] It offers an inexpensive and quick screening tool and has been studied in various populations. Since it is an adaptation of a more extensive test, let's take a closer look at a sample of the research supporting what it can and cannot tell us about our patients.

The mCTSIB was developed as a quick and easy alternative to the full Sensory Organization Test (SOT)[2] contained within Computerized Dynamic Posturography (CDP) as originally developed by Neurocom. The goal of the SOT is to systematically manipulate visual and/or somatosensory input, to reduce its reliability or availability, in an attempt to measure the contributions of the somatosensory, visual, and vestibular systems, or of central processing. Such measurements will meet the ideal 3-fold goals of balance testing: identifying those at risk for falls, identifying causes of the impairments, and establishing management plans.

Whereas the SOT contained 6 different test conditions, the mCTSIB contains only 4. Original SOT conditions are as follows:

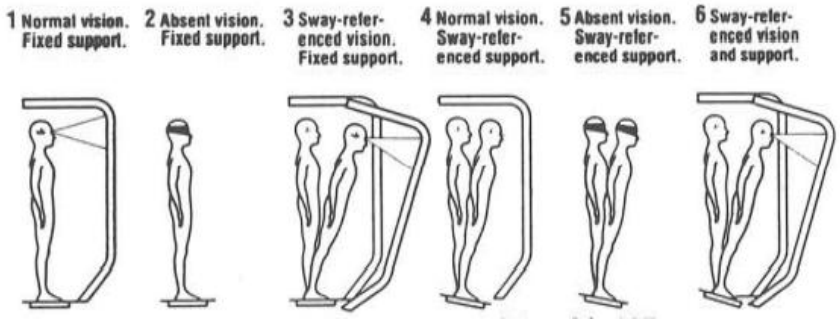

Figure 1. The six balance tasks of the SOT (Nashner 1990)

<u>Firm surface:</u>
1. Eyes open. 2. Eyes closed. 3. Sway-referenced vision (inaccurate and conflicting)

<u>Sway-referenced surface (inaccurate somatosensory):</u>
4. Eyes open. 5. Eyes closed. 6. Sway-reference vision (inaccurate and conflicting)

The mCTSIB omits tests 3 and 6, the visually referenced conditions, which instead of removing vision, renders it unreliable. This article, therefore, will focus on whether 3 and 6 add information that is clinically useful.

Other differences to be aware of:

- In the mCTSIB, the foam pad replaces the sway-referenced platform with the same goal of reducing reliability of somatosensory input.

- In the full SOT the results are quantified as sway measures, ratios are given for each sensory condition and for central processing, and an overall equilibrium score is given, whereas in the mCTSIB, the score is timed based on how long you can successfully balance out of 30 seconds.

Note: In this article, we'll stick with the condition # of the original SOT. However, in publications about mCTSIB, conditions 4 and 5 are renamed 3 and 4.

In the SOT, condition 5 is known as the "vestibular" condition because it removes vision and accurate somatosensory input, thereby forcing use of the vestibular system. It should be noted however, that it is not a diagnostic test for a vestibular disorder.

Correlation with the original test

Research has shown varying degrees of correlation between the mCTSIB and the corresponding conditions on the full test.[1,3] Stronger correlations have been found when the mCTSIB was performed with feet together than with feet apart,[1] however, others have shown higher correlations with an open-stance[4] Other studies performed on patients with vestibular disorders showed that comparing the mCTSIB to the gold-standard SOT revealed very high sensitivity and specificity (95% and 90% respectively),[3] but again stance was shown to affect specificity (50% or 44% depending on foot position) but not sensitivity (88%).[1]

An instrumented version of the mCTSIB using a Smart Balance Master has also been tested[5], where Instead of the timed score of the regular mCTSIB the results were given in sway velocity. This study showed poor, fair, or moderate correlation with SOT depending on the condition[4].

Fall Prediction

Sensitivity of the mCTSIB for fall prediction has been conflicting[6,7] but can be related to population studied. In the Buolgarides[6] study, the mCTSIB alone only predicted 1 of the 20 falls that occurred in the 1-year follow-up. However, Nitz[7] found that the inability to maintain standing on foam with eyes closed (SOT Cond 5, mCTSIB Cond 4, or "the vestibular condition") predicted future multiple falls (Odds Ratio 4.2%) based on a 10-year prospective study involving 449 women aged 40-80.

This is supported by Agrawal[8], who reported on results from the 2001–2004 National Health and Nutrition Examination Survey (NHANES), which assessed balance in a cross-section of over 5,000 US adults age 40-89. In their first report, they noted that those who failed eyes closed on foam, were 6.3x more likely to report "difficultly with falling" in the prior 12 months. In a later analysis of results[9] they were able to break down risk by time to failure. Compared to participants who passed the test, participants who failed in 20–29 seconds, 10–19 seconds, and fewer than 10 seconds had a 2.0-, 3.4- and 3.6-fold increase in odds of falling, respectively.

Does omitting the visual conflict matter?

The original Neurocom normative values reflect that across the 6 tests sway becomes increasingly unstable, so there is more sway with visual conflict (Conditions 3 and 6) than absent vision (Conditions 2 and 5). If standing on foam with eyes closed predicts falls in many studies, does having a score for all tests, especially 6, give you that much more information?

In early studies describing SOT, Black and Nashner[10] noted that in patients with vestibular loss, only the most severe cases of vestibular loss (as determined by diagnostic tests) were unable to stand on the "vestibular" test. However, ability to stand on an unstable support surface and with *conflicting* visual

orientation (test condition 6) was poor even in those with mild vestibular losses. In fact, instability was roughly proportional to vestibular loss. They concluded that the ability to *reorganize sensory inputs* was key to understanding the surprising results – patients did worse with eyes open than eyes closed because they were unable to suppress the inaccurate information. They were *visually dependent* so functional difficulties likely stemmed from central nervous system processing dysfunction.

The original CTSIB used a dome fastened to the patient's head to mimic conditions 3 and 6. In a study with 4 groups, 3 groups separated by age ranges, and the 4th comprising an all-age group with vestibular dysfunction, Cohen[11] found that condition 6 distinguished between older adults and those with vestibular dysfunction of any age (who did worse than the older adults), whereas condition 5 (eyes closed on foam) did not. Again, this study was completed with the dome, not the original visual conflict.

Other studies described in Mirka[12] and Wagner[13] in adults without known impairments, show there is a gradual increase in unsteadiness with age, but actual falls on the test are most associated with conditions 3 and 6, or just 6, depending on the study. These studies replicate the findings that performance is worse with conflicting visual information than with absent visual information.

In a large study of adults over 65 aiming to identify future fallers[14], loss of balance during the last trial of the SOT condition 6, when visual and somatosensory inputs were conflicting, was the best predictor of recurrent fall risk (OR = 3.6, 95% CI = 1.3–10.11)

Inappropriate sensory weighting of the visual system, i.e. visual dependence even when it is unreliable, is associated with poor performance on conditions 3 and 6 of the SOT. To examine the postural effects of visual dependency, Lee[15] first used a rod and frame test to establish visual dependence in older adults who were screened for other sensory impairments. The visually dependent group was compared to an age-matched older adult group who was visually independent. Condition 6 was the only test that differentiated the 2 older adult groups. In fact, the older group that was not visually dependent was more similar to the younger adults, who they had also tested. The conclusion was that age alone does not predict results on the test, but rather it is related to impairment, and impairment could be a central processing difficulty (or subclinical sensory dysfunction).

Beyond posturography, recent studies testing sensory threshold perception and processing of visual-vestibular information have shown that older adults decline in ability. In one study[16], 27% of older adults could not discriminate their heading (direction) at all using only visual information. This and many other studies show that compromised thresholds for perception of self-motion and visual motion are associated with aging.

The inability to integrate incongruent sensory cues has a multitude of functional corollaries. Perception of self-movement and perception of movement in the visual environment are impaired. Tasks such as walking in a crowded environment, performing overhead tasks, or driving can be affected. That brings us back to the question of whether a test requiring only eyes closed would be sensitive to detect an impairment in someone like Jack. In this case, it wasn't. He did fine on foam with eyes closed but fell with conflicting vision on foam.*

Fortunately, retraining these functions is possible! Certainly, there is overwhelming evidence that peripheral vestibular disorders can be treated[17] but likewise there is also evidence for treatment of central impairments and functional improvements in a general older adult population. Ability to re-weight sensory information and visual-vestibular conflict can be improved, and sensory thresholds can also be improved. In fact, in the study cited above, the adults who could not discriminate heading at all improved after training. These studies will be explored in another article, so stay tuned.

UprightVR's balance assessment features all 6 tests in the original SOT plus another 2 test conditions that provides optic flow, creating a dynamic visual-vestibular conflict. Optic flow has been heavily studied in terms of effect on balance, and virtual reality is the treatment of choice for capitalizing on its benefits. For more information on UprightVR's balance assessment visit our website www.UprightVR.com.

* tested using Upright VR's "Sensory Integration in Balance test

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